# UNIVERSITY OF CALICUT

# SCHEME AND SYLLABI FOR

# M-Tech

# in

# COMMUNICATION ENGINEERING AND SIGNAL PROCESSING

(2010 Admission onwards)

# Scheme of M-Tech programme in Communication Engineering and Signal Processing

## SEMESTER I

| Sl. no | Course code | Subject | Hours / week | | | ICA | ESE | Total | Credits |
|---|---|---|---|---|---|---|---|---|---|
| | | | L | T | P | | | | |
| 1 | ECS10 101 | Mathematics for Communication Engineering | 3 | 1 | 0 | 100 | 100 | 200 | 4 |
| 2 | ECS10 102 | Advanced Digital Communication | 3 | 1 | 0 | 100 | 100 | 200 | 4 |
| 3 | ECS10 103 | Advanced Digital Signal Processing | 3 | 1 | 0 | 100 | 100 | 200 | 4 |
| 4 | ECS10 104 | Design of Digital Signal Processing Systems | 3 | 1 | 0 | 100 | 100 | 200 | 4 |
| 5 | ECS10 105 | Elective I | 3 | 1 | 0 | 100 | 100 | 200 | 4 |
| 6 | ECS10 106(P) | Signal Processing Lab | 0 | 0 | 2 | 100 | | 100 | 2 |
| 7 | ECS10 107(P) | Seminar | 0 | 0 | 2 | 100 | | 100 | 2 |
| Total | | | 15 | 5 | 4 | 700 | 500 | 1200 | 24 |

L-Lecture; T-Tutorial ; P-Practical; ICA-Internal Continuous Assessment; ESE-End Semester Examination

**ELECTIVE I**

ECS10 105 (A): Information Theory

ECS10 105 (B): Adaptive Signal Processing

ECS10 105 (C): Radio Frequency Integrated Circuits and Systems

ECS10 105 (D): Digital Image Processing

**Note:** 6 hours/week is meant for departmental assistance by students.

# SEMESTER II

| Sl. no | Course code | Subject | Hours / week | | | ICA | ESE | Total | Credits |
|---|---|---|---|---|---|---|---|---|---|
| | | | L | T | P | | | | |
| 1 | ECS10 201 | Estimation and Detection | 3 | 1 | 0 | 100 | 100 | 200 | 4 |
| 2 | ECS10 202 | Wireless Communication | 3 | 1 | 0 | 100 | 100 | 200 | 4 |
| 3 | ECS10 203 | Coding Theory | 3 | 1 | 0 | 100 | 100 | 200 | 4 |
| 4 | ECS10 204 | Elective II | 3 | 1 | 0 | 100 | 100 | 200 | 4 |
| 5 | ECS10 205 | Elective III | 3 | 1 | 0 | 100 | 100 | 200 | 4 |
| 6 | ECS10 206(P) | Advanced Communication Lab | 0 | 0 | 2 | 100 | | 100 | 2 |
| 7 | ECS10 207(P) | Seminar | 0 | 0 | 2 | 100 | | 100 | 2 |
| Total | | | 15 | 5 | 4 | 700 | 500 | 1200 | 24 |

L-Lecture; T-Tutorial; P-Practical; ICA-Internal Continuous Assessment; ESE-End Semester Examination

**ELECTIVE II**

ECS10 204 (A): Multirate Signal Processing and Filter Banks

ECS10 204 (B): Spectral Analysis of Signals

ECS10 204 (C): Spread Spectrum and CDMA Systems

ECS10 204 (D): Markov Modeling and Queuing Theory

**ELECTIVE III**

ECS10 205 (A): Communication Switching Theory

ECS10 205 (B): Wavelets

ECS10 205 (C): Communication Networks

ECS10 205 (D): System design Using Embedded Processors

**Note:** 6 hours/week is meant for departmental assistance by students.

# SEMESTER III

| Sl. no | Course code | Subject | Hours / week | | | ICA | ESE | Total | Credits |
|---|---|---|---|---|---|---|---|---|---|
| | | | L | T | P | | | | |
| 1 | ECS10 301 | Elective IV | 3 | 1 | 0 | 100 | 100 | 200 | 4 |
| 2 | ECS10 302 | Elective V | 3 | 1 | 0 | 100 | 100 | 200 | 4 |
| 3 | ECS10 303(P) | Industrial Training | 0 | 0 | 30 | | 50 | 50 | 1 |
| 4 | ECS10 304(P) | Master Research Project Phase I | 0 | 0 | 22 | 150 | 150 | 300 | 6 |
| Total | | | 6 | 2 | 52 | 350 | 400 | 750 | 15 |

L-Lecture; T-Tutorial; P-Practical; ICA-Internal Continuous Assessment; ESE-End Semester Examination

**ELECTIVE IV**

ECS10 301 (A): Signal Compression – Theory and Methods

ECS10 301 (B): Speech and Audio Processing

ECS10 301(C): Biomedical Signal Processing

ECS10 301 (D): DSP Algorithms and Architectures

**ELECTIVE V**

ECS10 302 (A): Linear Systems Theory

ECS10 302 (B): Linear and Nonlinear Optimization

ECS10 302 (C): Transform Theory

ECS10 302 (D): Information Hiding and Data Encryption

Note: The student has to undertake the departmental work assigned by HOD

# SEMESTER IV

| Sl no | Course code | Subject | Hours / week | | | ICA | | ESE | | Total | Credits |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | L | T | P | Guide | Evaluation Committee | External Examiner | Viva Voce | | |
| 1 | ECS10 401 | Master Research Project Phase II | 0 | 0 | 30 | 150 | 150 | 150 | 150 | 600 | 12 |

L-Lecture; T-Tutorial; P-Practical; ICA-Internal Continuous Assessment; ESE-End Semester Examination

Note: The student has to undertake the departmental work assigned by HOD

## GRAND TOTAL FOR ALL SEMESTERS

| | |
|---|---|
| **Total credits** | **75** |
| **Total Marks** | **3750** |

## CORE SUBJECTS

| | | |
|---|---|---|
| **ECS10 101** | **MATHEMATICS FOR COMMUNICATION ENGINEERING**<br>*Hours/Week: Lecture – 3 hours Tutorial – 1 hour* | **Credits – 4** |

*Objective: This course is intended to provide the necessary Mathematical foundation needed for the subjects to be dealt with in the program. After the completion of the course, the student should have a thorough understanding of Linear Algebra , Random Processes and their applications.*

**Module I (14 hours)**

Linear Algebra: Vector spaces, subspaces, Linear dependence, Basis and Dimension, Inner product spaces, Gram- Schmidt Orthogonalization Procedure, Linear transformations, Kernels and Images , Matrix representation of linear transformation, Change of basis, Eigen values and Eigen vectors of linear operator, Quadratic form.

**Module II (14 hours)**

Operations on random variables: Random Variables, Distributions and Density functions, Moments and Moment generating function, Multivariate distributions, Independent Random Variables, Marginal and Conditional distributions , Conditional Expectation, Transformation of Random Variables , Elements of stochastic processes, Classification of general stochastic processes.

**Module III (13 hours)**

Random Processes: Markov Chains- Definition, Examples, Transition Probability Matrices of a Markov Chain, Classification of states and chains, Basic limit theorem, Limiting distribution of Markov chains.

Continuous Time Markov Chains: General pure Birth processes and Poisson processes, Birth and death processes, Finite state continuous time Markov chains

**Module IV (13 hours)**

Second Order Processes: Second Order Stochastic Processes, Linear operations and second order calculus, Stationary processes, Wide sense Stationary processes, Spectral density function, Low pass and band pass processes, White noise and white noise integrals, Linear Predictions and Filtering.

**References:**


1. Kenneth Hoffman and Ray Kunze, Linear Algebra, 2nd Edition, PHI.
2. Erwin Kreyszig, Introductory Functional Analysis with Applications, John Wiley & Sons.
3. Irwin Miller and Marylees Miller, John E. Freund's Mathematical Statistics, 6th Edition, PHI.
4. S. Karlin & H.M Taylor, A First Course in Stochastic Processes, 2nd edition, Academic Press, New York.
5. S. M. Ross, Introduction to Probability Models, Harcourt Asia Pvt. Ltd. and Academic Press.
6. J. Medhi, Stochastic Processes, New Age International, New Delhi.
7. A Papoulis, Probability, Random Variables and Stochastic Processes, 3rd Edition, McGraw Hill.
8. John B Thomas, An Introduction to Applied Probability and Random Processes, John Wiley & Sons.


**Examination pattern**

The question paper shall contain 7 questions, choosing at least one from each module but not exceeding two from any one of the modules. 5 full questions out of 7 questions are to be answered

**Internal continuous assessment: 100 marks**
Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of these. There will be a minimum of two tests in each subject.

**End semester Examination: 100 marks**
Answer any 5 questions by choosing at least one question from each module.

| Module 1 | Module 2 | Module 3 | Module 4 |
|---|---|---|---|
| Question 1:20 marks<br><br>Question 2:20 marks | Question 3:20 marks<br><br>Question 4:20 marks | Question 5:20 marks<br><br>Question 6:20 marks | Question 7:20 marks<br><br>Question 8:20 marks |

| ECS10 102 | **ADVANCED DIGITAL COMMUNICATION**<br>*Hours/Week: Lecture – 3 hours Tutorial – 1 hour* | **Credits – 4** |
|---|---|---|

*Objectives: This course provides a thorough understanding of the principles of Digital Communication. It addresses the issues related the recent developments in the area of Modern Communication.*

**Module I (12 hours)**

Random Process: Review of Random Process: Moment generating function, Chernoff bound, Markov's inequality, Chebyshev's inequality, Central limit Theorem, Chi square, Rayleigh and Rician distributions, Correlation, Covariance matrix, Stationary processes, wide sense stationary processes, ergodic process, cross correlation and autocorrelation functions, Gaussian process

**Module II (14 hours)**

Communication over Additive Gaussian Noise Channels, Characterization of Communication Signals and Systems: Signal space representation-Overview, Signal detection in Gaussian channels.

Optimum receiver in additive white Gaussian noise (AWGN) channels, Cross correlation receiver, Matched filter receiver and error probabilities.

Optimum Receiver for Signals with random phase in AWGN Channels, Optimum receiver for Binary Signals, Optimum receiver for M-ary Orthogonal signals, Probability of error for envelope detection of M-ary Orthogonal signals.

**Module III (14 hours)**

Digital Communication over Fading Channels: Characterization of Fading Multipath Channels: Statistical Models for Fading Channels, Time Varying Channel Impulse response, Narrow band Fading Models, Wideband Fading Models, Channel Correlation Functions, Key Multi path parameters, Rayleigh and Rician Fading Channels. Optimum non-coherent receiver in random amplitude, random phase channels: Performance of non-coherent receiver in random amplitude, random phase channels, Performance in Rayleigh and Rician channels, Performance of digital Modulation schemes such as BPSK, QPSK, FSK, DPSK etc over wireless Channels.

**Module IV (14 hours)**

Communication over band limited Channels: Optimum pulse shaping and equalization. Receiver synchronization: Frequency and phase synchronization-symbol synchronization.

**References:**


1. J.G. Proakis, "Digital Communication", MGH 4TH edition.
2. Edward. A. Lee and David. G. Messerschmitt, "Digital Communication", Allied Publishers (second edition).
3. J Marvin.K.Simon, Sami. M. Hinedi and William. C. Lindsey, "Digital Communication Techniques", PHI.
4. William Feller, "An introduction to Probability Theory and its applications", Wiley.
5. Sheldon.M.Ross, "Introduction to Probability Models", Academic Press, 7th edition.


**Internal continuous assessment: 100 marks**

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of these. There will be a minimum of two tests in each subject.

**End semester Examination: 100 marks**

**Question pattern:**

Answer any 5 questions by choosing at least one question from each module.

| **Module 1** | **Module 2** | **Module 3** | **Module 4** |
|---|---|---|---|
| Question 1:20 marks<br><br>Question 2:20 marks | Question 3:20 marks<br><br>Question 4:20 marks | Question 5:20 marks<br><br>Question 6:20 marks | Question 7:20 marks<br><br>Question 8:20 marks |

| ECS10 103 | ADVANCED DIGITAL SIGNAL PROCESSING<br>*Hours/Week: Lecture – 3 hours Tutorial – 1 hour* | Credits – 4 |
|---|---|---|

*Objectives: This is an extension of the principles of Digital Signal Processing, introduced in the undergraduate level. Upon completion of the course, the student must be able to design and implement various systems like filter banks, implement different means of spectral estimation and apply Digital Signal Processing principles to process speech and Radar signals.*

**Module I (14hours)**
Review of fundamentals of the Discrete Time Systems: Design of FIR Digital filters- Window method, Park-McClellan's method. Design of IIR Digital Filters- Butterworth, Chebyshev and Elliptic Approximations; Lowpass, Bandpass, Bandstop and High pass filters. Effect of finite register length in FIR filter design.

**Module II (14 hours)**
Multirate system fundamentals: Basic multirate operations – up-sampling and down sampling, Time domain and frequency domain analysis– Identities of multirate operations– Interpolator and decimator design– Rate conversion– Polyphase representation. Multirate filter banks.

**Module III (14 hours)**
Parametric and non-parametric spectral estimation: Estimation of the Autocorrelation and power spectrum of random signals: periodogram- DFT in power spectrum estimation
Non-parametric spectral estimation: Barlett method, Welch method, Blackman and Tukey Method-Performance characteristics-Computational requirements.
Parametric spectral estimation: Yule-Walker method for AR model parameters, Burg method, Selection of AR model order- MA and ARMA models.

**Module IV (12 hours)**
Application of DSP to Speech and Radar signal processing : Fourier analysis of non-stationary signals-speech and radar signals. Fourier analysis of stationary signals using Periodogram.

**References:**

1. A.V. Oppenheim and Schafer, Discrete Time Signal Processing, Prentice Hall.
2. John G. Proakis and D.G. Manolakis, Digital Signal Processing: Principles, Algorithms and Applications, Prentice Hall.
3. L.R. Rabiner and B. Gold, Theory and Application of Digital Signal Processing, Prentice Hall.
4. J.R. Johnson, Introduction to Digital Signal Processing, Prentice Hall.
5. D. J.DeFatta, J. G. Lucas and W. S. Hodgkiss, Digital Signal Processing, J Wiley and Sons, Singapore.

**Internal continuous assessment: 100 marks**

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of these. There will be a minimum of two tests in each subject.

**End semester Examination: 100 marks**

**Question pattern:**

Answer any 5 questions by choosing at least one question from each module.

| **Module 1** | **Module 2** | **Module 3** | **Module 4** |
|---|---|---|---|
| Question 1:20 marks<br><br>Question 2:20 marks | Question 3:20 marks<br><br>Question 4:20 marks | Question 5:20 marks<br><br>Question 6:20 marks | Question 7:20 marks<br><br>Question 8:20 marks |

| ECS10 104 | **DESIGN OF DIGITAL SIGNAL PROCESSING SYSTEMS**<br>*Hours/Week: Lecture – 3 hours Tutorial – 1 hour* | **Credits – 4** |
|---|---|---|

*Objectives: Upon completion of this course, the student will be able to design systems using the popular Digital Signal Processor Family TMS 320 C64X.*

**Module I (14 Hours)**
Introduction to a popular DSP from Texas Instruments, CPU Architecture, CPU Data Paths and Control, Timers, Interrupts, Internal Data/ Program Memory, External Memory Interface, pipelining
**Module II (14 Hours)**
Programming : Instruction Set and Addressing Modes ,TMS 320C64X CPU Simple programming examples using C and assembly.
Typical DSP development system, support tools and files , compiler, assembler, Code composer studio, CODECs
**Module III (13 Hours)**
Digital Signal Processing Applications: Filter Design , FIR & IIR Digital Filter Design, filter Design programs using MATLAB , Fourier Transform: DFT, FFT programs using MATLAB , Real Time Implementation: Implementation of Real Time Digital filters using DSP , Implementation of FFT applications using DSP , DTMF Tone Generation and Detection
**Module IV (13 Hours)**
DSP Application examples in CODEC : PLL ,Image processing, FSK modems, Voice detection and reverse playback, Multirate filters, PID controllers.
Current Trends in Digital Signal Processors , DSP Controllers

## References:


1. Digital Signal Processing and Application with C6713 and C6416 DSK, Rulph Chassaing, Worcester Polytechnic Institute, A Wiley-Interscience Publication
2. Digital Signal Processing Implementation using the TMS320C6000 DSP Platform, 1st Edition; Naim Dahnoun
3. Digital Signal Processing - A Student Guide,1st Edition; T.J. Terrel and Lik-Kwan Shark; Macmillan Press Ltd.
4. Digital Signal Processing: A System Design Approach, 1st Edition; David J Defatta J, Lucas Joseph G & Hodkiss William S ; John Wiley
5. Digital Signal Processing-A Practical Guide for Engineers and Scientists by Steven K Smith, Newnes, An imprint of Elsevier Science

6. DSP Applications using 'C' and the TMS320C6X DSK, 1st Edition; Rulph Chassaing
7 . Digital Signal Processing Design, 1st Edition, Andrew Bateman, Warren Yates

**Internal continuous assessment: 100 marks**

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of these. There will be a minimum of two tests in each subject.

**End semester Examination: 100 marks**

**Question pattern:**

Answer any 5 questions by choosing at least one question from each module.

| Module 1 | Module 2 | Module 3 | Module 4 |
|---|---|---|---|
| Question 1:20 marks<br><br>Question 2:20 marks | Question 3:20 marks<br><br>Question 4:20 marks | Question 5:20 marks<br><br>Question 6:20 marks | Question 7:20 marks<br><br>Question 8:20 marks |

# ELECTIVE I

| ECS10 105(A) | INFORMATION THEORY<br>*Hours/Week: Lecture – 3 hours Tutorial – 1 hour* | Credits – 4 |
|---|---|---|

*Objectives: Gives a detailed concepts in Information Theory. Upon completion of this course, the student will have a deep understanding of*

- *Information and its measurement*
- *Various source coding schemes*
- *Concept of Channel capacity for both discrete and continuous channels and Shannon's theorems*
- *Rate distortion theory and its applications*

**Module I (13 hours)**

Information and Sources: Zero Memory sources- Concepts of entropy-Extension of a Zero memory source-Markov information sources- Entropy calculation- Entropy of a discrete Random variable- Joint, conditional and relative entropy- Mutual Information and conditional mutual information.

**Module II (13 hours)**

Source Coding: Uniquely decodable codes- Instantaneous codes- Kraft's inequality – McMillan's inequality-Average length of a code- Optimal codes- Shannon codes- Fano codes-Huffman Coding –Optimality of Huffman Codes-Lempel Ziv codes- Shannon's source coding theorem–Arithmetic coding.

**Module III (14 hours)**

Channel Capacity**:** Properties-Data transmission over Discrete Memoryless Channels-Capacity of Binary symmetric and Binary Erasure channels-Computing channel capacity- Arimoto-Blahut algorithm- Fano's inequality- Shannon's Channel Coding Theorem

**Module IV (14 hours)**

Continuous Sources and Channels: Information measure for Continuous sources and channels-Differential Entropy- Joint, relative and conditional differential entropy- Mutual information- Waveform channels- Gaussian channels- Mutual information and Capacity calculation for Band limited Gaussian channels- Shannon limit.

Rate Distortion Theory: Rate Distortion Function - Properties – Calculation of Rate Distortion Function for binary source Gaussian

**References:**


1. T. Cover and Thomas, "Elements of Information Theory", John Wiley & Sons
2. Robert Gallager, "Information Theory and Reliable Communication", John Wiley & Sons.
3. R. J. McEliece, "The theory of information & coding", Addison Wesley Publishing Co.
4. T. Bergu, "Rate Distortion Theory a Mathematical Basis for Data Compression" PH Inc.
5. Special Issue on Rate Distortion Theory, IEEE Signal Processing Magazine, November 1998.


**Internal continuous assessment: 100 marks**

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of these. There will be a minimum of two tests in each subject.

**End semester Examination: 100 marks**

**Question pattern:**

Answer any 5 questions by choosing at least one question from each module.

| Module 1 | Module 2 | Module 3 | Module 4 |
|---|---|---|---|
| Question 1:20 marks<br><br>Question 2:20 marks | Question 3:20 marks<br><br>Question 4:20 marks | Question 5:20 marks<br><br>Question 6:20 marks | Question 7:20 marks<br><br>Question 8:20 marks |

| ECS10 105 (B) | ADAPTIVE SIGNAL PROCESSING<br>*Hours/Week: Lecture – 3 hours Tutorial – 1 hour* | Credits – 4 |
|---|---|---|

*Objectives: This course is intended to impart to the students the principles of*

- *Adaptive signal processing,*
- *different algorithms used for design of Adaptive Filters,*
- *Performance evaluation of systems*
- *Modelling systems like multipath communication channel*
- *Synthesis of filters.*

**Module I (14 Hours)**:

Adaptive systems - definitions and characteristics - applications - properties-examples - adaptive linear combiner-input signal and weight vectors - performance function-gradient and minimum mean square error - introduction to filtering-smoothing and prediction - linear optimum filtering-orthogonality - Wiener - Hopf equation-performance surface

**Module II (14 Hours)**:

Searching performance surface-stability and rate of convergence - learning curve-gradient search - Newton's method - method of steepest descent - comparison - gradient estimation - performance penalty - variance - excess MSE and time constants - maladjustments

**Module III (13 Hours)**:

LMS algorithm convergence of weight vector-LMS/Newton algorithm - properties - sequential regression algorithm - adaptive recursive filters - random-search algorithms - lattice structure - adaptive filters with orthogonal signals

**Module IV (13 Hours)**:

Applications-adaptive modelling and system identification-adaptive modelling for multipath communication channel, geophysical exploration, FIR digital filter synthesis, inverse adaptive modelling, equalization, and deconvolution-adaptive equalization of telephone channels-adapting poles and zeros for IIR digital filter synthesis

**References:**

1. Bernard Widrow and Samuel D. Stearns, Adaptive Signal Processing, Pearson Education, 2005.
2. Simon Haykin, Adaptive Filter Theory, Pearson Education.
3. John R. Treichler, C. Richard Johnson, Michael G. Larimore, Theory and Design of Adaptive Filters, Prentice-Hall of India, 2002

4. S. Thomas Alexander, Adaptive Signal Processing - Theory and Application, Springer-Verlag.
5. D. G. Manolokis, V. K. Ingle and S. M. Kogar, Statistical and Adaptive Signal Processing, Mc Graw Hill International Edition, 2000.

**Internal continuous assessment: 100 marks**

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of these. There will be a minimum of two tests in each subject.

**End semester Examination: 100 marks**

**Question pattern:**

Answer any 5 questions by choosing at least one question from each module.

| Module 1 | Module 2 | Module 3 | Module 4 |
|---|---|---|---|
| Question 1:20 marks<br><br>Question 2:20 marks | Question 3:20 marks<br><br>Question 4:20 marks | Question 5:20 marks<br><br>Question 6:20 marks | Question 7:20 marks<br><br>Question 8:20 marks |

| ECS10 105(C) | **VLSI CIRCUITS FOR SIGNAL PROCESSING**<br>*Hours/Week: Lecture – 3 hours Tutorial – 1 hour* | **Credits – 4** |
|---|---|---|

*Objectives: Provides a detailed theory of the VLSI implementation of circuits used in Signal processing. Upon completion of the course, the student will have a thorough understanding of*

- *Modelling a MOS transistor at low and high frequencies*
- *Analysis and design of CMOS amplifiers, Opamps and switches*
- *Theory, application and implementation of switched capacitor circuits.*

**Module I (12 Hours)**

Analog, Digital and Sampled analog signals and systems, Transformation methods, Design of Sampled data filters from Continuous time models. The MOS transistor, small signal equivalent, short channel effects, Low frequency and High frequency models.

**Module II (14 Hours)**

Analog CMOS sub circuits: MOS switch, Current sinks and sources, Current mirrors, Current and Voltage references, Bandgap references, CMOS Amplifiers: Inverters, Differential amplifiers, Cascode amplifiers, Current amplifiers, Output amplifiers, High gain amplifier architectures.

**Module III (14 Hours)**

CMOS Operational Amplifiers: Design of CMOS Op Amps, Stability and Compensation of Op Amps, Design of two stage Op Amps, Cascode Op Amps, High performance CMOS Op Amps.

**Module IV (14 Hours)**

Switched Capacitor Circuits: Switched Capacitor Filters, Integrated Filters, Switched Capacitor Integrators, Stray insensitive integrators, Second order sections; cascade filter design, Switched capacitor filter design, Switched Capacitor Amplifiers and Integrators. Application of Switched Capacitor circuits in Data modems/ Digital voice transmission systems.

**References :**


1. Analog MOS Integrated Circuits for Signal Processing; Roubik Gregorian, Gabor C. Temes , John Wiley and Sons.
2. CMOS Analog Circuit Design; Phillip E. Allen, Douglas R. Holberg; Oxford Univesity Press
3. Analysis and Design of Analog Integrated Circuits; Gray, Hurst, Lewis and Meyer; Wiley, India.
4. Design of Analog CMOS Integrated Circuits; Behzad Razavi; Tata Mc Graw hill.

**Internal continuous assessment: 100 marks**

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of these. There will be a minimum of two tests in each subject.

**End semester Examination: 100 marks**

**Question pattern:**

Answer any 5 questions by choosing at least one question from each module.

| **Module 1** | **Module 2** | **Module 3** | **Module 4** |
|---|---|---|---|
| Question 1:20 marks<br><br>Question 2:20 marks | Question 3:20 marks<br><br>Question 4:20 marks | Question 5:20 marks<br><br>Question 6:20 marks | Question 7:20 marks<br><br>Question 8:20 marks |

| ECS10 105(D) | **DIGITAL IMAGE PROCESSING**<br>*Hours/Week: Lecture – 3 hours Tutorial – 1 hour* | **Credits – 4** |
|---|---|---|

*Objectives: Upon completion of this course, the student will have an understanding of various Monochrome and Colour Image processing methods, Image enhancement, Image segmentation, and image compression methods. The students are exposed to popular image compression standards like JPEG and JPEG 2000.*

**Module I (14 Hours)**

Fundamental steps in digital image processing, Components of an image processing system, Image sampling and quantization, Some basic relationships between pixels, Linear and nonlinear operations, 2D convolution- 2D FFT, 2D-wavelet, contourlet transforms.

**Module II (14 Hours)**

Image enhancement techniques : Some basic gray level transformations, Histogram processing, Smoothing and Sharpening spatial filters, Image enhancement in frequency domain- Smoothing, and Sharpening frequency domain filters, Homomorphic filtering, Image restoration : Noise models, Restoration in the presence of noise only-spatial filtering, Estimating the degradation functions, Inverse filtering.

**Module III (13 Hours)**

Colour image processing: colour models, pseudo-colour processing, image compression: image compression models, loss-less and lossy compression, JPEG and JPEG 2000 - morphological image processing: dilation and erosion, opening and closing, some basic morphological algorithms.

**Module IV (13 Hours)**

Image segmentation: Detection of discontinuities, Edge linking and boundary detection, Thresholding, Region based segmentation, applications of digital image processing in medical, recent developments, Image fusion, pseudo colouring.

**References:**


1. R. C. Gonzalez and R.E. Woods - Digital Image Processing, Pearson Education, 2006
2. K. Jain - Fundamentals of Digital Image Processing, Pearson Education, 2007
3. L. R. Rabiner and B. Gold – Theory and Application of Digital Signal Processing, Pearson Education

**Internal continuous assessment: 100 marks**

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of these. There will be a minimum of two tests in each subject.

**End semester Examination: 100 marks**

**Question pattern:**

Answer any 5 questions by choosing at least one question from each module.

| **Module 1** | **Module 2** | **Module 3** | **Module 4** |
|---|---|---|---|
| Question 1:20 marks<br><br>Question 2:20 marks | Question 3:20 marks<br><br>Question 4:20 marks | Question 5:20 marks<br><br>Question 6:20 marks | Question 7:20 marks<br><br>Question 8:20 marks |

| ECS10 106(P) | **SIGNAL PROCESSING LAB**<br>*Hours/Week: Practical 2 hours* | **Credits – 2** |
|---|---|---|

*Objectives: This course enables the students to explore the concepts of designing and implementing various systems using DSP kits, Simulate and study various systems using MATLAB.*

**Tools:**

Numerical Computing Environments – GNU Octave or MATLAB or any other equivalent tool, DSP Kits.

1. Generation of waveforms and observation of the output using the graphical display utility of integrated Development Environment (IDE)
2. Generation of a sine function and sampling of generated sine waveform. Observation of the spectrum and windowing effect.
3. Implementation of linear convolution on 1D and 2D signals .
4. Implementation of circular convolution on 1D and 2D signal
5. Implementation of FIR filter( Filter coefficients may be obtained from MATLAB)
6. Implementation of FIR filter( Filter coefficients may be obtained from MATLAB)
7. Verification of FIR and IIR filters by inputting a signal from the signal generator (configure the codec in the DSP development board)
8. Implementation of simple algorithms in audio and image processing
9. Real time data exchange between MATLAB and IDE to transfer the data from computer to Development kit.

10. Assembly language programming
    i) Implementation of linear convolution
    ii) Implementation of circular convolution
11. Mini Project- Related to the area of advanced communication /signal processing using the development kit.

**Internal continuous assessment: 100 marks**

Regularity – 30%
Record – 20%
Test and Viva – 50%

| ECS10 107(P) | **SEMINAR**<br>*Hours/Week: 2 hours* | **Credits – 2** |
|---|---|---|

*Objectives : This course is intended for*

- *Increasing the breadth of knowledge*
- *Enhancing the ability of self study*
- *Improving presentation and communication skills*
- *Augmenting the skill of Technical Report Writing.*

Each student is required to choose a topic of their interest from Communication / Signal Processing or related topics from outside the syllabus and present a topic for about 45 minutes. A committee consisting of at least three faculty members shall assess the presentation. Internal continuous assessment marks are awarded based on the relevance of the topic, presentation skill, quality of the report and participation.

**Internal continuous assessment: 100 marks**

# CORE SUBJECTS

| ECS10 201 | **ESTIMATION AND DETECTION**<br>*Hours/Week: Lecture – 3 hours Tutorial – 1 hour* | **Credits – 4** |
|---|---|---|

*Objectives: Upon completion of this course, the students will have an understanding of the different criteria and methods used in detection theory, Methods and measures of estimation, Properties and characteristics of estimators and principles of state estimation.*

**Module I (13 hours)**
Detection theory: Binary decisions - Single observation. Maximum likelihood decision criterion; Neymann-Pearson criterion; Probability of error criterion; Bayes risk criterion; Minimax criterion; Robust detection; Receiver operating characteristics.

**Module II (13 hours)**
Binary decisions - Multiple observations: Vector observations- The general Gaussian problem; Waveform observation in additive Gaussian noise; The integrating optimum receiver; Matched filter receiver.

**Module III (14 hours)**
Estimation theory: a) Methods
Maximum likelihood estimation; Bayes cost method Bayes estimation criterion - Mean square error criterion; Uniform cost function; absolute value cost function; Linear minimum variance - Least squares method; Estimation in the presence of Gaussian noise - Linear observation; Non-linear estimation.
b) Properties of estimators: Bias, E_ciency, Cramer Rao bound Asymptotic properties; Sensitivity and error analysis

**Module IV (14 hours)**
a) State estimation : Prediction; Kalman filter.
b) Sufficient statistics and statistical estimation of parameters: Concept of sufficient statistics; Exponential families of distributions; Exponential families and Maximum likelihood estimation; Uniformly minimum variance unbiased estimation.

**References:**

1. James L. Melsa and David L. Cohn, “Decision and Estimation Theory," McGraw Hill.
2. Dimitri Kazakos, P. Papantoni Kazakos, “Detection and Estimation," Computer Science Press.
3. Steven M. Kay, “Statistical Signal Processing: Vol. 1: Estimation Theory, Vol. 2: Detection Theory," Prentice Hall Inc.

4. Harry L. Van Trees, “Detection, Estimation and Modulation Theory, Part 1," John Wiley & Sons Inc.
5. Jerry M. Mendel, “Lessons in Estimation Theory for Signal Processing, Communication and Control," Prentice Hall Inc.
6. Sophocles J. Orfanidis, “Optimum Signal Processing," 2 nd edn., McGraw Hill.
7. Monson H. Hayes, “Statistical Digital Signal Processing and Modelling," John Wiley & Sons Inc.

**Internal continuous assessment: 100 marks**

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of these. There will be a minimum of two tests in each subject.

**End semester Examination: 100 marks**

**Question pattern:**

Answer any 5 questions by choosing atleast one question from each module.

| Module 1 | Module 2 | Module 3 | Module 4 |
|---|---|---|---|
| Question 1:20 marks<br><br>Question 2:20 marks | Question 3:20 marks<br><br>Question 4:20 marks | Question 5:20 marks<br><br>Question 6:20 marks | Question 7:20 marks<br><br>Question 8:20 marks |

| ECS10 202 | **WIRELESS COMMUNICATION**<br>*Hours/Week: Lecture – 3 hours Tutorial – 1 hour* | **Credits – 4** |
|---|---|---|

*Objectives: This course gives a thorough treatment of the principles of Wireless Mobile communication. Upon completion of the course, the student will have knowledge about*

- *Different types of fading in wireless channels and their mitigation*
- *Diversity schemes*
- *MIMO channels*
- *Cellular communication systems – GSM and CDMA*
- *Cellular communication standards*

**Module I (13 hours)**

Fading and Diversity: Wireless Channel Models- path loss and shadowing models- statistical fading models- Narrow band and wideband Fading models- Review of performance of digital modulation schemes over wireless channels- Diversity- Repetition coding and Time Diversity- Frequency and Space Diversity- Receive Diversity- Concept of diversity branches and signal paths- Combining methods- Selective diversity combining - Switched combining- maximal ratio combining- Equal gain combining- performance analysis for Rayleigh fading channels.

**Module II (13 hours)**

Fading Channel Capacity: Capacity of Wireless Channels- Capacity of flat and frequency selective fading channels- Multiple Input Multiple output (MIMO) systems- Narrow band multiple antenna system model- Parallel Decomposition of MIMO Channels- Capacity of MIMO Channels.

**Module III (13 hours)**

Cellular Communication: Cellular Networks- Multiple Access: FDM/TDM/FDMA/TDMA- Spatial reuse- Co-channel interference Analysis- Hand over Analysis- Erlang Capacity Analysis- Spectral efficiency and Grade of Service- Improving capacity - Cell splitting and sectoring.

**Module IV (15 hours)**

Spread spectrum and CDMA: Overview of CDMA systems: Direct sequence and frequency hoped systems-spreading codes-code synchronization-Channel estimation-power control-Multiuser detection- Spread Spectrum Multiple Access- CDMA Systems- Interference Analysis for Broadcast and Multiple Access Channels- Capacity of cellular CDMA networks- Reverse link power control- Hard and Soft hand off strategies.

Cellular Wireless Communication Standards
Second generation cellular systems: Brief discussion specifications on GSM, CDMA, Wideband CDMA, Wi-Fi, Wi-max
Introduction to multicarrier Communication: OFDM, MCCDMA

**References:**


1. Andrea Goldsmith, "Wireless Communications", Cambridge University press.
2. Simon Haykin and Michael Moher, " Modern Wireless Communications", Pearson Education.
3. T.S. Rappaport, "Wireless Communication, principles & practice".
4. G.L Stuber, "Principles of Mobile Communications", 2nd edition, Kluwer Academic Publishers.
5. Kamilo Feher, 'Wireless digital communication', PHI.
6. R.L Peterson, R.E. Ziemer and David E. Borth, "Introduction to Spread Spectrum Communication", Pearson Education.
7. A.J.Viterbi, "CDMA- Principles of Spread Spectrum", Addison Wesley.


**Internal continuous assessment: 100 marks**
Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of these. There will be a minimum of two tests in each subject.

**End semester Examination: 100 marks**
**Question pattern:**
Answer any 5 questions by choosing atleast one question from each module.

| Module 1 | Module 2 | Module 3 | Module 4 |
| --- | --- | --- | --- |
| Question 1:20 marks<br><br>Question 2:20 marks | Question 3:20 marks<br><br>Question 4:20 marks | Question 5:20 marks<br><br>Question 6:20 marks | Question 7:20 marks<br><br>Question 8:20 marks |

| ECS10 203 | **CODING THEORY**<br>*Hours/Week::Lecture – 3 hours Tutorial – 1 hour* | **Credits – 4** |
|---|---|---|

*Objectives: Provides a thorough understanding of the theory and design of Channel codes for error control. The course begins with an introduction to the basic Mathematical concepts and develops systematically through Linear block codes to the Convolutional Codes.*

**Module I (13 hours)**

Introduction to algebra: Groups- Rings- Fields- Binary Field arithmetic-Arithmetic of Galois Field- Integer Ring- Finite Field based on Integer Ring- Polynomial Rings- Finite Field based on Polynomial Rings-Primitive elements- Construction and basic properties of Finite Fields- Computations using Galois Field arithmetic- Vector spaces- Vector subspaces- Linear independence.

**Module II (13 hours)**

Linear Block Codes Matrix description of Linear Block codes- Minimum Distance of a Block code-- Error detecting and correcting capabilities of a Block code- Standard Array and Syndrome decoding- Hamming codes- Perfect and Quasi-perfect codes- Extended codes- Hadamard codes.

**Module III (13 hours)**

Cyclic Codes: Polynomial description-Minimal polynomial and conjugates- Generator and parity-Check matrices of cyclic codes- Encoding of cyclic codes- Syndrome computation- Error detection - decoding of cyclic codes- Cyclic Hamming codes- Binary Golay codes- BCH codes-Performance- Decoding of BCH codes, Reed Solomon codes-Encoding and Decoding

**Module IV (15 hours)**

Convolutional Coding: Structural properties-Encoders for convolutional coding – State representation and the state diagram- The Tree diagram - The Trellis diagram- Transfer function of a Convolutional code – Systematic and Non-systematic Convolutional codes – Catastrophic error propagation in Convolutional codes – Maximum likelihood decoding of Convolutional codes – Hard versus Soft decision decoding - The Viterbi Algorithm – Sequential decoding – Concept of interleaving – Block interleaving –Convolutional interleaving – Concatenated codes – Turbo codes – Basic concepts – Encoding with recursive systematic codes.

**References :**

1. Shu Lin and Daniel. J. Costello Jr., "Error Control Coding: Fundamentals and applications", Prentice Hall Inc.
2. R.E. Blahut, "Theory and Practice of Error Control Coding", MGH.
3. W.C. Huffman and Vera Pless, "Fundamentals of Error correcting codes", Cambridge University Press.
4. Rolf Johannesson, Kamil Sh. Zigangirov, "Fundamentals of Convolutional Coding", Universities Press (India) Ltd.
5. Sklar, ' Digital Communication', Pearson Education.

**Internal continuous assessment: 100 marks**

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of these. There will be a minimum of two tests in each subject.

**End semester Examination: 100 marks**

**Question pattern:**

Answer any 5 questions by choosing atleast one question from each module.

| **Module 1** | **Module 2** | **Module 3** | **Module 4** |
|---|---|---|---|
| Question 1:20 marks<br><br>Question 2:20 marks | Question 3:20 marks<br><br>Question 4:20 marks | Question 5:20 marks<br><br>Question 6:20 marks | Question 7:20 marks<br><br>Question 8:20 marks |

**ELECTIVE II**

| ECS10 204(A) | MULTIRATE SIGNAL PROCESSING AND FILTER BANKS<br>*Hours/Week: Lecture – 3 hours Tutorial – 1 hour* | Credits – 4 |
|---|---|---|

*Objectives: Upon completion this course, the student will have deep understanding of the theory, design and applications of*

- *QMF banks*
- *Perfect Reconstruction filters*
- *Cosine modulated Filter banks.*

**Module I (14 Hours)**

Fundamentals of Multirate Theory: The sampling theorem - sampling at sub-Nyquist rate - Basic Formulations and schemes - Basic Multirate operations-Decimation and Interpolation - Digital Filter Banks- DFT Filter Bank- Identities-Polyphase representation - Maximally decimated filter banks: Polyphase representation - Errors in the QMF bank- Perfect Reconstruction (PR) QMF Bank - Design of an alias free QMF Bank

**Module II (14 Hours)**

M-channel perfect reconstruction filter banks: Uniform band and non uniform filter bank - tree structured filter bank- Errors created by filter bank system- Polyphase representation- perfect reconstruction systems

**Module III (13 Hours)**

Perfect reconstruction (PR) filter banks: Para-unitary PR Filter Banks- Filter Bank Properties induced by paraunitarity- Two channel FIR paraunitary QMF Bank-Linear phase PR Filter banks- Necessary conditions for Linear phase property-
Quantization Effects: -Types of quantization effects in filter banks. - coefficient sensitivity effects, dynamic range and scaling.

**Module IV (13 Hours)**

Cosine Modulated filter banks: Cosine Modulated pseudo QMF Bank- Alas cancellation- phase - Phase distortion- Closed form expression- Polyphase structure-PR Systems.

**References:**

1. P.P. Vaidyanathan. "Multirate systems and filter banks." Prentice Hall. PTR.
2. N.J. Fliege. "Multirate digital signal processing ." John Wiley.
3. Sanjit K. Mitra. " Digital Signal Processing: A computer based approach." McGraw

Hill.
4. R.E. Crochiere. L. R. “Multirate Digital Signal Processing”, Prentice Hall. Inc.
5. J.G. Proakis. D.G. Manolakis. “Digital Signal Processing: Principles. Algorithms and Applications”, 3rd Edn. Prentice Hall India.

**Internal continuous assessment: 100 marks**

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of these. There will be a minimum of two tests in each subject.

**End semester Examination: 100 marks**

**Question pattern:**

Answer any 5 questions by choosing atleast one question from each module.

| Module 1 | Module 2 | Module 3 | Module 4 |
|---|---|---|---|
| Question 1:20 marks<br><br>Question 2:20 marks | Question 3:20 marks<br><br>Question 4:20 marks | Question 5:20 marks<br><br>Question 6:20 marks | Question 7:20 marks<br><br>Question 8:20 marks |

| ECS10 204(B) | SPECTRAL ANALYSIS OF SIGNALS<br>*Hours/Week: Lecture – 3 hours Tutorial – 1 hour* | Credits – 4 |
|---|---|---|

*Objectives: This course deals with the different methods for Power Spectrum Estimation. Upon completion of this course, students will be well versed with*

- *Power and Energy spectral density of signals*
- *Parametric and non parametric methods of estimation of PSD*
- *Filter bank methods of spectral analysis.*

**Module I (14 Hours)**

Power Spectral Density: Energy spectral density of deterministic signals, Power spectral density of random signals, Properties of PSD.

**Module II (14 Hours)**

PSD Estimation - Non-parametric methods : Estimation of PSD from finite data, Non-parametric methods : Periodogram properties, bias and variance analysis, Blackman-Tuckey method, Window design considerations, time-bandwidth product and resolution - variance trade-offs in window design, Refined periodogram methods : Bartlet method, Welch method.

**Module III (13 Hours)**

Parametric method for rational spectra :- Covariance structure of ARMA process, AR signals, Yule-Walker method, Least square method, Levinson-Durbin Algorithm, MA signals, Modified Yule-Walker method, Two stage least square method, Burg method for AR parameter estimation.

Parametric method for line spectra :- Models of sinusoidal signals in noise, Non-linear least squares method, Higher order Yule-Walker method, MUSIC and Pisayenko methods, Min-norm method, ESPIRIT method.

**Module IV (13 Hours)**

Filterbank methods: Filterbank interpolation of periodogram, Slepia base-band filters, refined filterbank method for higher resolution spectral analysis, Capon method, Introduction to higher order spectra.

**References:**

1.Introduction to Spectral Analysis, Stoica , R.L. Moses, Prentice Hall

2.Modern Spectral Estimation Theory & Applications, Kay SM, Prentice Hall

3 Marple, Introduction to Spectral Analysis, Prentice Hall

**Internal continuous assessment: 100 marks**

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of these. There will be a minimum of two tests in each subject.

**End semester Examination: 100 marks**

**Question pattern:**

Answer any 5 questions by choosing atleast one question from each module.

| Module 1 | Module 2 | Module 3 | Module 4 |
|---|---|---|---|
| Question 1:20 marks<br><br>Question 2:20 marks | Question 3:20 marks<br><br>Question 4:20 marks | Question 5:20 marks<br><br>Question 6:20 marks | Question 7:20 marks<br><br>Question 8:20 marks |

| ECS10 204(C) | **SPREAD SPECTRUM AND CDMA SYSTEMS**<br>*Hours/Week: Lecture – 3 hours Tutorial – 1 hour* | **Credits – 4** |
|---|---|---|

*Objectives: Upon completion of this course, students will have deep insight on spread spectrum communication systems. The course imparts knowledge about principle of spread spectrum and use of orthogonal codes, performance of CDMA systems under AWGN and fading channels, use of CDMA systems in cellular communication and important CDMA standards.*

**Module I (14 Hours)**

Introduction to spread spectrum communication, pulse noise jamming, low probability of detection, direct sequence spread spectrum, frequency-hopping and time-hopping spread spectrum systems, correlation functions, spreading sequences- maximal-length sequences, gold codes, Walsh orthogonal codes- properties and generation of sequences Synchronization and Tracking: delay lock and tau-dither loops, coarse synchronization- principles of serial search and match filter techniques.

**Module II (14 Hours)**

Performance of spread spectrum system under AWGN, multi-user Interference, jamming and narrow band interferences Low probability of intercept methods, optimum intercept receiver for direct sequence spread spectrum, Error probability of DS-CDMA system under AWGN and fading channels, RAKE receiver

**Module III (14 Hours)**

Basics of spread spectrum multiple access in cellular environments, reverse Link power control, multiple cell pilot tracking, soft and hard handoffs, cell coverage issues with hard and soft handoff, spread spectrum multiple access outage, outage with imperfect power control, Erlang capacity of forward and reverse links.

Multi-user Detection -MF detector, decorrelating detector, MMSE detector. Interference Cancellation: successive, Parallel Interference Cancellation, performance analysis of multiuser detectors and interference cancellers.

**Module IV (14 Hours)**

General aspects of CDMA cellular systems, IS-95 standard, Downlink and uplink, Evolution to Third Generation systems, WCDMA and CDMA-2000 standards, Principles of Multicarrier communication, MCCDMA and MC-DS-CDMA.

**References:**

1. R. L. Peterson, R. Ziemer and D. Borth, "Introduction to Spread Spectrum Communications," Prentice Hall.
2. A. J. Viterbi, "CDMA - Principles of Spread Spectrum Communications," Addison-Wesley.

3. Vijay K. Garg, Kenneth Smolik, Joseph E. Wilkes, Applications of CDMA in Wireless/Personal Communications, Prentice Hall.
4. S. Verdu, " Multiuser Detection" , Cambridge University Press.
5. M. K. Simon, J. K. Omura, R. A. Scholts and B. K. Levitt, " Spread Spectrum Communications Handbook", McGraw- Hill.
6. Cooper and McGillem, "Modern Communications and Spread Spectrum" McGraw- Hill.
7. J. G. Proakis, "Digital Communications," McGraw Hill, 4th ed.
8. S. Glisic and B. Vucetic, "Spread Spectrum CDMA Systems for Wireless Communications," Artech House,


**Internal continuous assessment: 100 marks**

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of these. There will be a minimum of two tests in each subject.

**End semester Examination: 100 marks**

**Question pattern:**

Answer any 5 questions by choosing atleast one question from each module.

| **Module 1** | **Module 2** | **Module 3** | **Module 4** |
|---|---|---|---|
| Question 1:20 marks<br><br>Question 2:20 marks | Question 3:20 marks<br><br>Question 4:20 marks | Question 5:20 marks<br><br>Question 6:20 marks | Question 7:20 marks<br><br>Question 8:20 marks |

| ECS10 204(D) | **MARKOV MODELING AND QUEUEING THEORY**<br>*Hours/Week: Lecture – 3 hours Tutorial – 1 hour*<br>*(Common with PMS01204(D))* | **Credits – 4** |
|---|---|---|

*Objectives: This course is a thorough treatment of Markov chains and Markov models of systems. It also deals with the essential queuing theory and application of Markov models in the analysis of queuing networks.*

**Module I (14 Hours)**

Stochastic Processes: Renewal Processes - Reward and Cost Models, Poisson Process; Point Processes; Regenerative Processes; Renewal Theorems.

**Module II (14 Hours)**

Markov Models: Discrete Time Markov Chain - Transition Probabilities, Communication Classes, Irreducible Chains; Continuous Time Markov Chain - Pure-Jump Continuous-Time Chains, Regular Chains, Birth and Death Process, Semi-Markov Processes.

**Module III (13 Hours)**

Single Class & Multi-class Queuing Networks: Simple Markovian queues; M/G/1 queue; G/G/1 queue; Open queuing networks; Closed queuing networks; Mean value analysis; Multi-class traffic model; Service time distributions; BCMP networks; Priority systems.

**Module IV (13 Hours)**

Time Delays and Blocking in Queuing Networks: Time delays in single server queue; Time delays in networks of queues; Types of Blocking; Two finite queues in a closed network; Aggregating Markovian states.

**References:**

1. Ronald W. Wolff, Stochastic Modeling and The Theory of Queues, Prentice-Hall International.
2. Peter G. Harrison and Naresh M. Patel, Performance Modeling of Communication Networks and Computer Architectures, Addison-Wesley.
3. Gary N. Higginbottom, Performance Evaluation of Communication Networks, Artech House.
4. Anurag Kumar, D. Manjunath, and Joy Kuri, Communication Networking: An Analytical Approach, Morgan Kaufman Publ.
5. D. Bertsekas and R. Gallager, Data Networks, Prentice Hall of India.
6. Ross, K.W., Multiservice Loss Models for Broadband Telecommunication Networks, Springer-Verlag.
7. Walrand, J., An Introduction to Queueing Networks, Prentice Hall.

8. Cinlar, E., Introduction to Stochastic processes, Prentice Hall.
9. Karlin, S. and Taylor, H., A First course in Stochastic Processes, 2nd edition Academic press.

**Internal continuous assessment: 100 marks**

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of these. There will be a minimum of two tests in each subject.

**End semester Examination: 100 marks**

**Question pattern:**

Answer any 5 questions by choosing atleast one question from each module.

| Module 1 | Module 2 | Module 3 | Module 4 |
|---|---|---|---|
| Question 1:20 marks<br><br>Question 2:20 marks | Question 3:20 marks<br><br>Question 4:20 marks | Question 5:20 marks<br><br>Question 6:20 marks | Question 7:20 marks<br><br>Question 8:20 marks |

**ELECTIVE III**

| ECS10 205(A) | COMMUNICATION SWITCHING THEORY<br>*Hours/Week: Lecture – 3 hours Tutorial – 1 hour* | Credits – 4 |
|---|---|---|

*Objectives: Upon completion of this course, the students will have a deep knowledge about the Communication switching methods, blocking in switching networks, traffic analysis and multiplexing systems.*

**Module I (14 Hours)**

Switching: Performance and architectural issues: Packet switches- Circuit switches.

Time and Space division switching - Point to point circuit switching - multistage switching network - Paull's matix for representing connections - Strict sense non-blocking Clos network.

Generalized circuit switching- Cross Point Complexity (CPC)- Fast packet switching- Self routing Banyan networks- Combinatorial limitations of Banyan networks.

**Module II (14 Hours)**

Types of blocking for a packet switch- Output conflicts- HOL blocking.

Traffic analysis: Traffic measurements, arrival distributions, Poisson process, holding/service time distributions, loss systems, lost calls cleared – Erlang-B formula, lost calls returning and lost calls held models, lost calls cleared and held models with finite sources, delay systems, Little's theorem, Erlang-C formula , M/G/1 model.

Blocking probability: Analysis of single stage and multistage networks –Blocking for Unique path routing- Alternate path routing- The Lee approximation – The Jacobaeus method.

**Module III (13 Hours)**

Multiplexing: Network performance and source characterization; Stream sessions in packet networks - deterministic analysis, stochastic analysis, circuit multiplexed networks.

**Module IV (13 Hours)**

Statistical multiplexing: blocking analysis in circuit multiplexed networks, with single rate or Multirate traffic- Models for performance analysis of integrated packet networks; deterministic models, worst case analysis; stochastic models, large deviations analysis.

The effective Bandwidth approach for Admission control - Models for traffic flow in packet networks, long range dependence and self similar processes.

**References:**

1. A. Kumar, D. Manjunath, J. Kuri, Communication Networking: An Analytical

Approach, Morgan Kaufman Publishers.
2. Hui, J.Y., Switching and Traffic Theory for Integrated Broadband Networks, Kluwer.

**Internal continuous assessment: 100 marks**

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of these. There will be a minimum of two tests in each subject.

**End semester Examination: 100 marks**

**Question pattern:**

Answer any 5 questions by choosing atleast one question from each module.

| **Module 1** | **Module 2** | **Module 3** | **Module 4** |
|---|---|---|---|
| Question 1:20 marks<br><br>Question 2:20 marks | Question 3:20 marks<br><br>Question 4:20 marks | Question 5:20 marks<br><br>Question 6:20 marks | Question 7:20 marks<br><br>Question 8:20 marks |

| ECS10 205(B) | **WAVELETS THEORY**<br>*Hours/Week: Lecture – 3 hours Tutorial – 1 hour* | **Credits – 4** |
|---|---|---|

*Objectives: This course provides the students with a thorough foundation of Wavelet theory, construction of wavelets and their applications in signal analysis.*

**Module I (14 Hours)**

Fourier and Sampling Theory, Generalized Fourier theory, Fourier transform, Short-time (windowed) Fourier transform, Time-frequency analysis, Fundamental notions of the theory of sampling. Theory of Frames: Bases, Resolution of unity, Definition of frames, Geometrical considerations and the general notion of a frame, Frame projector, Example – windowed Fourier frames.

**Module II (14 Hours)**

Wavelets: The basic functions, Specifications, Admissibility conditions, Continuous wavelet transform (CWT), Discrete wavelet transform (DWT). The multiresolution analysis , MRA axioms, Construction of an MRA from scaling functions - The dilation equation and the wavelet equation, Compactly supported orthonormal wavelet bases - Necessary and sufficient conditions for orthonormality.

Regularity and selection of wavelets: Smoothness and approximation order - Analysis in Soboleve space, Criteria for wavelet selection with examples.

**Module III (13 Hours)**

Splines, Cardinal B-spline MRA, Subband filtering schemes, Compactly supported orthonormal wavelet bases. Wavelet decomposition and reconstruction of functions in $L^2(\mathbb{R})$. Fast wavelet transform algorithms - Relation to filter banks, Wavelet packets – Representation of functions, Selection of basis.

**Module IV (13 Hours)**

Biorthogonality and biorthogonal basis, Biorthogonal system of wavelets - construction, The Lifting scheme.

**References:**

1. Stephen G. Mallat, “A wavelet tour of signal processing” 2nd Edition Academic Press.
2. M. Vetterli, J. Kovacevic, “Wavelets and subband coding” Prentice Hall Inc.
3. Gilbert Strang and Truong Q. Nguyen, “Wavelets and filter banks” 2nd Edition Wellesley- Cambridge Press.
4. Gerald Kaiser, “A friendly guide to wavelets” Birkhauser/Springer International Edition.

5. L. Prasad and S. S. Iyengar, “Wavelet analysis with applications to image processing” CRC Press.
6. J. C. Goswami and A. K. Chan, “Fundamentals of wavelets: Theory, Algorithms and Applications” Wiley-Interscience Publication, John Wiley & Sons.
7. Mark A. Pinsky, “Introduction to Fourier Analysis andWavelets” Brooks/Cole Series in Advanced Mathematics.
8. Christian Blatter, “Wavelets: A primer” A. K. Peters, Massachusetts.
9. M. Holschneider, “Wavelets: An analysis tool” Oxford Science Publications.
10. R. M. Rao and A. Bopardikar, “Wavelet transforms: Introduction to theory and applications” Addison-Wesley.
11. Ingrid Daubechies, “Ten lectures on wavelets” SIAM.
12. H. L. Resnikoff and R. O. Wells, Jr., “Wavelet analysis: The scalable structure of information”

**Internal continuous assessment: 100 marks**

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of these. There will be a minimum of two tests in each subject.

**End semester Examination: 100 marks**

**Question pattern:**

Answer any 5 questions by choosing atleast one question from each module.

| Module 1 | Module 2 | Module 3 | Module 4 |
|---|---|---|---|
| Question 1:20 marks<br><br>Question 2:20 marks | Question 3:20 marks<br><br>Question 4:20 marks | Question 5:20 marks<br><br>Question 6:20 marks | Question 7:20 marks<br><br>Question 8:20 marks |

| ECS10 205(C) | **COMMUNICATION NETWORKS**<br>*Hours/Week: Lecture – 3 hours Tutorial – 1 hour* | **Credits – 4** |
|---|---|---|

*Objectives: This course provides a deep knowledge on Internet architecture, Quality of service issues in broad band networks, and Statistical multiplexing of communication networks.*

**Module I (14 Hours)**

Internet Architecture: Architectural concepts in ISO's OSI layered model, layering in the Internet. TCP/IP protocol stack. Transport layer - TCP and UDP. Network layer - IP, routing, internetworking. Data link layer - ARQ schemes, multiple access, LANs.

**Module II (14 Hours)**

Broadband services and QoS issues: Quality of Service issues in networks- Integrated service architecture- Queuing Disciplines- Weighted Fair Queuing- Random Early Detection- Differentiated Services- Protocols for QS support- Resource reservation-RSVP- Multi protocol Label switching- Real Time transport protocol.

**Module III (13 Hours)**

Introduction to Queuing theory: Markov chain- Discrete time and continuous time Markov chains- Poisson process- Queuing models for Data gram networks- Little's theorem- M/M/1 queuing systems- M/M/m/m queuing models- M/G/1 queue- Mean value analysis.

**Module IV (13 Hours)**

Statistical Multiplexing in Communication Networks: Multiplexing: Network performance and source characterization; Stream sessions in packet networks - deterministic analysis, stochastic analysis, circuit multiplexed networks.

**References:**

1. James. F. Kurose and Keith.W. Ross, "Computer Networks, A top-down approach featuring the Internet", Addison Wesley.
2. D. Bertsekas and R. Gallager, "Data Networks".
3. S. Keshav, "An Engineering Approach to Computer Networking", Addison Wesley
4. Peterson L.L. & Davie B.S., "Computer Networks: A System Approach", Morgan Kaufman Publishers.
5. Anurag Kumar, D. Manjunath, and Joy Kuri, Communication Networking: An Analytical Approach, Morgan Kaufman Publ.

**Internal continuous assessment: 100 marks**

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of these. There will be a minimum of two tests in each subject.

**End semester Examination: 100 marks**

**Question pattern:**

Answer any 5 questions by choosing atleast one question from each module.

| Module 1 | Module 2 | Module 3 | Module 4 |
|---|---|---|---|
| Question 1:20 marks<br><br>Question 2:20 marks | Question 3:20 marks<br><br>Question 4:20 marks | Question 5:20 marks<br><br>Question 6:20 marks | Question 7:20 marks<br><br>Question 8:20 marks |

| ECS10 205(D) | SYSTEM DESIGN USING EMBEDDED PROCESSORS<br>*Hours/Week: Lecture – 3 hours Tutorial – 1 hour* | Credits – 4 |
|---|---|---|

*Objectives: Upon completion of this course, the students will be able to program and interface PIC microcontroller, design and implement systems using PIC microcontrollers, development of embedded systems, gain knowledge about real time operating systems.*

**Module I (14 hours)**

Microcontroller: Brief history of the PIC microcontroller - PIC18 features and block diagram-PIC18 Architecture and assembly language Programming, SFRs, RISC architecture in the PIC, Branch, Call, Time delay loop, PIC I/O Port programming, addressing modes, look-up table and table processing, Bank switching in the PIC18, Data types and time delays in C, I/O Port programming in C, Bit-addressable I/O programming, logic operations in C, Data conversion programs in C.

**Module II (14 hours)**

PIC Peripherals and Interfacing: PIC18 timer programming in assembly and C, Serial Port programming in assembly and C, Interrupt programming in assembly and C, ADC and DAC interfacing, CCP and ECCP programming, DC Motor interfacing and PWM.

**Module III (13 hours)**

Introduction to Embedded Systems: Characteristics of Embedded systems, Software embedded into a system- Device Drivers and Interrupt Servicing mechanisms.

Inter-process Communication and Synchronisation of Processes, Tasks and Threads: Multiple Processes in an Application - Data sharing by multiple tasks and routines- Inter Process Communication

**Module IV (13 hours)**

Real Time Operating Systems:

Operating System Services, I/O Subsystems - Network Operating Systems - Real Time and Embedded System Operating systems

Interrupt routines in RTOS Environments - RTOS Task Scheduling models, Interrupt Latency and response Times - Standardization of RTOS - Ideas of Embedded Linux. Case study using ARM processor/PIC microcontroller

**References:**


1. PIC Microcontroller and Embedded Systems using assembly and C for PIC18 – Muhammad Ali Mazidi, Roind D. Mckinay, Danny Causey; Pearson Education.
2. Design with PIC microcontroller – John Peatman; Printice Hall
3. Rajkamal; "Embedded Systems Architecture; Programming and Design"; Tata McGraw Hill Publications.

4. Real-time Systems - Jane Liu, PH 2000
5. Real-Time Systems Design and Analysis : An Engineer's Handbook: Phillip A Laplante
6. Embedded Software Primer - Simon, David E.
7. Tornado API Programmers guide

**Internal continuous assessment: 100 marks**

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of these. There will be a minimum of two tests in each subject.

**End semester Examination: 100 marks**

**Question pattern:**

Answer any 5 questions by choosing atleast one question from each module.

| Module 1 | Module 2 | Module 3 | Module 4 |
|---|---|---|---|
| Question 1:20 marks<br><br>Question 2:20 marks | Question 3:20 marks<br><br>Question 4:20 marks | Question 5:20 marks<br><br>Question 6:20 marks | Question 7:20 marks<br><br>Question 8:20 marks |

| ECS10 206(P) | **ADVANCED COMMUNICATION LAB**<br>*Hours/Week: Practical -2 hours* | **Credits – 2** |
|---|---|---|

*Objectives: Upon completion, the students will*

- *Be able to design enlisted experiments and implement using hardware*
- *Acquire sufficient expertise in simulating these systems using MATLAB*
- *Be able to design and implement self standing systems of their choice with sufficient complexity.*

**Tools :**

Numerical Computing Environments – GNU Octave or MATLAB or any other equivalent tool

**Lab:**

1. Implementation of digital modulation schemes – BASK, BFSK, BPSK. Plot BER vs $E_b$ / $N_0$. in AWGN channels.
2. Performance comparison of QPSK, DPSK, MSK & GMSK.
3. Communication over fading channels – Rayleigh fading & Rician fading channels.
4. Comparison of diversity combining techniques – SC, EGC & MRC.
5. Simulation of CDMA systems.
6. Implementation of Matched filter, Correlation receiver & Equalizer.
7. Gram Schmidt Orthogonalization of waveforms.
8. Carrier recovery and bit synchronization.
9. Implementation of multicarrier communication.
10. Plotting Eye pattern.
11. Constellation diagram of various digital modulation schemes.

**Miniproject:**

12. Miniproject in the area of advanced communication/signal processing

**Internal continuous assessment: 100 marks**

Regularity – 30%

| **Lab** | **Miniproject** |
|---|---|
| Record – 10% | Report – 10% |
| Test and Viva – 25% | Demonstration and presentation – 25% |

| ECS10 207(P) | **SEMINAR**<br>*Hours/Week: 2 hours* | **Credits – 2** |
|---|---|---|

*Objectives : This course is intended for*

- *Increasing the breadth of knowledge*
- *Enhancing the ability of self study*
- *Improving presentation and communication skills*
- *Augmenting the skill of Technical Report Writing.*

Each student is required to choose a topic of their interest from Communication / Signal Processing or related topics from outside the syllabus and present a topic for about 45 minutes. A committee consisting of at least three faculty members shall assess the presentation. Internal continuous assessment marks are awarded based on the relevance of the topic, presentation skill, quality of the report and participation.

**Internal continuous assessment: 100 marks**

# ELECTIVE IV

| ECS10 301(A) | SIGNAL COMPRESSION – THEORY AND METHODS<br>*Hours/Week: Lecture – 3 hours Tutorial – 1 hour* | Credits – 4 |
| --- | --- | --- |

*Objectives: Upon completion of this course, the students will get a deep understanding about the various source coding techniques used for signal compression. The course also provides knowledge about important data, audio, image and video compression standards.*

**Module I (14 Hours)**

Review of Information Theory: The discrete memoryless information source - Kraft inequality; optimal codes Source coding theorem. Compression Techniques - Lossless and Lossy Compression - Mathematical Preliminaries for Lossless Compression -Huffman Coding - Optimality of Huffman codes - Extended Huffman Coding – Adaptive Huffman Coding - Arithmetic Coding - Adaptive Arithmetic coding, Run Length Coding, Dictionary Techniques - Lempel-Ziv coding, Applications - Predictive Coding - Prediction with Partial Match - Burrows Wheeler Transform, Dynamic Markov Compression.

**Module II (13 Hours)**

Rate distortion theory: Rate distortion function R(D),Properties of R(D); Calculation of R(D) for the binary source and the Gaussian source, Rate distortion theorem, Converse of the Rate distortion theorem, Quantization - Uniform & Non-uniform - optimal and adaptive quantization, vector quantization and structures for VQ, Optimality conditions for VQ, Predictive Coding - Differential Encoding Schemes

**Module III (13 Hours)**

Mathematical Preliminaries for Transforms: Karhunen Loeve Transform, Discrete Cosine and Sine Transforms, Discrete Walsh Hadamard Transform, Lapped transforms - Transform coding - Subband coding - Wavelet Based Compression - Analysis/Synthesis Schemes

**Module IV (14 Hours)**

Data Compression standards: Zip and Gzip, Speech Compression Standards: PCM, ADPCM, SBC, CELP, MPC-MLQ, MELP, LPC. Audio Compression standards: MPEG.

Image Compression standards: JBIG, GIF, JPEG & JFIF, SPIHT, EZW, JPEG 2000. Video Compression Standards: MPEG, H.261, H.263 & H264.

**References:**

1.Khalid Sayood, "Introduction to Data Compression", Morgan Kaufmann Publishers., Second Edn.,
2.David Salomon, "Data Compression: The Complete Reference", Springer Publications, 4th Edn.,
3.Thomas M. Cover, Joy A. Thomas, "Elements of Information Theory," John Wiley & Sons, Inc.
4.N. S Jayant, Peter Noll, Digital Coding of Waveforms: Principles and Applications to Speech and Video, Prentice Hall Inc.
5.Toby Berger, Rate Distortion Theory: A Mathematical Basis for Data Compression, Prentice Hall, Inc.
6.K.R.Rao, P.C.Yip, "The Transform and Data Compression Handbook", CRC Press.
7.R.G.Gallager, "Information Theory and Reliable Communication", John Wiley & Sons, Inc.

**Internal continuous assessment: 100 marks**

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of these. There will be a minimum of two tests in each subject.

**End semester Examination: 100 marks**

**Question pattern:**

Answer any 5 questions by choosing at least one question from each module.

| Module 1 | Module 2 | Module 3 | Module 4 |
|---|---|---|---|
| Question 1:20 marks<br><br>Question 2:20 marks | Question 3:20 marks<br><br>Question 4:20 marks | Question 5:20 marks<br><br>Question 6:20 marks | Question 7:20 marks<br><br>Question 8:20 marks |

| ECS10 301(B) | **SPEECH & AUDIO PROCESSING**<br>*Hours/Week: Lecture – 3 hours Tutorial – 1 hour* | **Credits – 4** |
|---|---|---|

*Objectives: This course imparts a detailed knowledge of modelling of speech signals, subband coding of speech, vocoders, Homomorphic speech processing, Voice morphing, speaker identification and speaker recognition systems, and processing of music.*

**Module I (13 Hours)**

Digital models for the speech signal - mechanism of speech production - acoustic theory - lossless tube models - digital models - linear prediction of speech - auto correlation - formulation of LPC equation - solution of LPC equations - Levinson Durbin algorithm - Levinson recursion - Schur algorithm – lattice formulations and solutions - PARCOR coefficients - Spectral analysis of speech - Short Time Fourier analysis - filter bank design. Auditory Perception : Psychoacoustics- Frequency Analysis and Critical Bands – Masking properties of human ear :

**Module II (14 Hours)**

Speech coding -subband coding of speech - transform coding - channel vocoder - formant vocoder – cepstral vocoder - vector quantizer coder- Linear predictive Coder. Speech synthesis - pitch extraction algorithms - Gold Rabiner pitch trackers - autocorrelation pitch trackers - voiced/unvoiced detection - homomorphic speech processing - homomorphic systems for convolution - complex cepstrums - pitch extraction using homomorphic speech processing. Sound Mixtures and Separation - CASA, ICA & Model based separation.

**Module III (13 Hours)**

Speech Transformations - Time Scale Modification - Voice Morphing. Automatic speech recognition systems - isolated word recognition - connected word recognition -large vocabulary word recognition systems - pattern classification - DTW, HMM - speaker recognition systems - speaker verification systems – speaker identification Systems.

**Module IV (14 Hours)**

Audio Processing : Non speech and Music Signals - Modeling -Differential, transform and subband coding of audio signals and standards - High Quality Audio coding using Psychoacoustic models - MPEG Audio coding standard. Music Production - sequence of steps in a bowed string instrument - Frequency response measurement of the bridge of a violin. Audio Data bases and applications - Content based retrieval.

**References:**

1.Rabiner L.R. & Schafer R.W., "Digital Processing of Speech Signals", Prentice Hall Inc.
2.O'Shaughnessy, D. "Speech Communication, Human and Machine". Addison-Wesley.
3.Thomas F. Quatieri , "Discrete-time Speech Signal Processing: Principles and Practice" Prentice Hall, Signal Processing Series.
4.Deller, J., J. Proakis, and J. Hansen. "Discrete-Time Processing of Speech Signals." Macmillan.
5.Ben Gold & Nelson Morgan , " Speech and Audio Signal Processing", John Wiley & Sons, Inc.
6.Owens F.J., "Signal Processing of Speech", Macmillan New Electronics
7.Saito S. & Nakata K., "Fundamentals of Speech Signal Processing", Academic Press, Inc.
8.Papamichalis P.E., "Practical Approaches to Speech Coding", Texas Instruments, Prentice Hall
9.Rabiner L.R. & Gold, "Theory and Applications of Digital Signal Processing", Prentice Hall of India
10.Jayant, N. S. and P. Noll. "Digital Coding of Waveforms: Principles and Applications to Speech and Video. Signal Processing Series", Englewood Cliffs: Prentice-Hall
11.Thomas Parsons, "Voice and Speech Processing", McGraw Hill Series
12.Chris Rowden, "Speech Processing", McGraw-Hill International Limited
13.Moore. B, "An Introduction to Psychology of hearing"Academic Press, London, 1997
14.E. Zwicker and L. Fastl, "Psychoacoustics-facts and models", Springer-Verlag., 1990

**Internal continuous assessment: 100 marks**

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of these. There will be a minimum of two tests in each subject.

**End semester Examination: 100 marks**

**Question pattern:**

Answer any 5 questions by choosing atleast one question from each module.

| Module 1 | Module 2 | Module 3 | Module 4 |
|---|---|---|---|
| Question 1:20 marks<br><br>Question 2:20 marks | Question 3:20 marks<br><br>Question 4:20 marks | Question 5:20 marks<br><br>Question 6:20 marks | Question 7:20 marks<br><br>Question 8:20 marks |

| ECS10 301(C) | **BIOMEDICAL SIGNAL PROCESSING**<br>*Hours/Week: Lecture – 3 hours Tutorial – 1 hour* | **Credits – 4** |
|---|---|---|

*Objectives: Upon completion of this course, students will have thorough understanding of the various biomedical signals, their processing using standard signal processing tools, cardio vascular and neurological applications of signal processing, modeling of EEG, EEG segmentation and Medical image formats.*

**Module I (14 Hours)**
Introduction to Biomedical Signals - Examples of Biomedical signals - ECG, EEG, EMG - Tasks in Biomedical Signal Processing - Computer Aided Diagnosis. Origin of bio potentials - Review of linear systems - Fourier Transform and Time Frequency Analysis (Wavelet) of biomedical signals- Processing of Random & Stochastic signals - spectral estimation – Properties and effects of noise in biomedical instruments - Filtering in biomedical instruments

**Module II (13 Hours)**
Concurrent, coupled and correlated processes - illustration with case studies - Adaptive and optimal filtering - Modeling of Biomedical signals - Detection of biomedical signals in noise - removal of artifacts of one signal embedded in another -Maternal-Fetal ECG - Muscle-contraction interference. Event detection - case studies with ECG & EEG - Independent component Analysis - Cocktail party problem applied to EEG signals - Classification of biomedical signals.

**Module III (13 Hours)**
Cardio vascular applications : Basic ECG - Electrical Activity of the heart- ECG data acquisition – ECG parameters & their estimation - Use of multiscale analysis for ECG parameters estimation - Noise & Artifacts- ECG Signal Processing: Baseline Wandering, Power line interference, Muscle noise filtering – QRS detection - Arrhythmia analysis - Data Compression: Lossless & Lossy- Heart Rate Variability – Time Domain measures - Heart Rhythm representation - Spectral analysis of heart rate variability - interaction with other physiological signals.

**Module IV (14 Hours)**
Neurological Applications : The electroencephalogram - EEG rhythms & waveform - categorization of EEG activity - recording techniques - EEG applications- Epilepsy, sleep disorders, brain computer interface. Modeling EEG- linear, stochastic models - Non linear modeling of EEG - artifacts in EEG & their characteristics and processing - Model based spectral analysis - EEG segmentation - Joint Time-Frequency analysis - correlation analysis of EEG channels - coherence analysis of EEG channels. Medical Image format - DICOM, HL-7, PACS

**References:**

1.Bruce, “Biomedical Signal Processing & Signal Modeling,” Wiley, 2001
2.Sörnmo, “Bioelectrical Signal Processing in Cardiac & Neurological Applications”, Elsevier
3.Rangayyan, “Biomedical Signal Analysis”, Wiley 2002.
4.Semmlow, Marcel Dekker “Biosignal and Biomedical Image Processing”, 2004
5.Enderle, “Introduction to Biomedical Engineering,” 2/e, Elsevier, 2005
6.D.C.Reddy , “ Biomedical Signal Processing: Principles and techniques” , Tata McGraw Hill,

**Internal continuous assessment: 100 marks**

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of these. There will be a minimum of two tests in each subject.

**End semester Examination: 100 marks**

**Question pattern:**

Answer any 5 questions by choosing atleast one question from each module.

| Module 1 | Module 2 | Module 3 | Module 4 |
|---|---|---|---|
| Question 1:20 marks<br><br>Question 2:20 marks | Question 3:20 marks<br><br>Question 4:20 marks | Question 5:20 marks<br><br>Question 6:20 marks | Question 7:20 marks<br><br>Question 8:20 marks |

| ECS10 301(D) | DSP ALGORITHMS AND ARCHITECTURES<br>*Hours/Week: Lecture – 3 hours Tutorial – 1 hour* | Credits – 4 |
|---|---|---|

*Objectives: Upon completion of this course, the students will have detailed knowledge of design of DSP algorithms, simulation of DSP systems in C and modeling using VHDL, VLSI implementation of algorithms, synthesis of DSP modules and modeling the synthesis in VHDL.*

**Module I (14 Hours)**

DSP Algorithm Design : DSP representations (data-flow, control-flow, and signal-flow graphs, block diagrams), fixed-point DSP design (A/D precision, coefficient quantization, round-off and scaling), filter structures (recursive, nonrecursive and lattice), algorithmic simulations of DSP systems in C , behavioral modeling in HDL System modeling and performance measures.

**Module II (14 Hours)**

Circuits and DSP Architecture Design: Fast filtering algorithms (Winograd's, FFT, short- length FIR), retiming and pipelining, block processing, folding, distributed arithmetic architectures, VLSI performance measures (area, power, and speed), structural modeling in VHDL, Analog signal processing for fast operation, Impact of nonideal characteristics of analog functional blocks on the system performance.

**Module III (13 Hours)**

DSP Module Synthesis: Distributed arithmetic (DA), Advantageous of using DA, Size reduction of look-up tables, Canonic signed digit arithmetic, Implementation of elementary functions Table-oriented methods, Polynomial approximation Random number generators, Linear feedback shift register, High performance arithmetic unit architectures (adders, multipliers, dividers), bit-parallel, bit-serial, digit-serial, carry-save architectures, redundant number system, modeling for synthesis in HDL, synthesis place-and-route.

**Module IV (13 Hours)**

Parallel algorithms and their dependence : Applications to some common DSP algorithms, System timing using the scheduling vector, Projection of the dependence graph using a projection direction, The delay operator and z-transform techniques for mapping DSP algorithms onto processor arrays, Algebraic technique for mapping algorithms, The computation domain, The dependence matrix of a variable, The scheduling and projection functions, Data broadcast and pipelining, Applications using common DSP algorithms.

**References:**

1. Digital Signal Processors: Architectures, Implementations, and Applications Sen M.Kuo , Woon-Seng, S. Gan Prentice Hall
2. VLSI Signal Processing Systems, Design and Implementation.Keshab K. Parhi, John Wiley & Sons.
3. Digital Signal Processing with Field Programmable Gate Array, Uwe Meyer-Baese, Springer- Verlag
4. DSP Principles, Algorithms and Applications, John G. Proakis , Dimitris Manolakis K - Prentice Hall
5. Architectures for Digital Signal Processing, Pirsch, John Wiley and Sons.
6. DSP Integrated Circuits, Lars Wanhammar, Academic Press.
7. Computer Arithmetic: Algorithms and Hardware Designs, Parhami, Behrooz, Oxford University Press,
8. Computer Arithmetic Algorithms, Israel Koren, A. K. Peters, Natick, MA.

**Internal continuous assessment: 100 marks**

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of these. There will be a minimum of two tests in each subject.

**End semester Examination: 100 marks**

**Question pattern:**

Answer any 5 questions by choosing atleast one question from each module.

| Module 1 | Module 2 | Module 3 | Module 4 |
|---|---|---|---|
| Question 1:20 marks<br><br>Question 2:20 marks | Question 3:20 marks<br><br>Question 4:20 marks | Question 5:20 marks<br><br>Question 6:20 marks | Question 7:20 marks<br><br>Question 8:20 marks |

# ELECTIVE V

| ECS10 302(A) | LINEAR SYSTEMS THEORY<br>*Hours/Week: Lecture – 3 hours Tutorial – 1 hour* | Credits – 4 |
|---|---|---|

*Objectives: Upon completion of this course, the students will have deep knowledge and insight on vector space representation of signals, bases, orthonormal bases, analysis of linear systems, eigen values and eigen vectors, infinite dimensional vector spaces and Hilbert spaces.*

**Module I (14 Hours)**
Finite Dimensional Signal Space: Vector Spaces :- Complex Numbers, Definition of Vector Space, Properties of Vector Spaces, Subspaces, Sums and Direct Sums, Span and Linear Independence, Bases, Dimension Inner-Product Spaces :- Inner Products, Norms, Orthonormal Bases, Orthogonal Projections and Minimization Problems, Linear Functionals and Adjoints Some Important Bases :- Standard Ordered Bases, DFT Bases, DCT Bases.
**Module II (13 Hours)**
Linear Systems :Linear Maps :- Definitions and Examples, Null Spaces and Ranges, The Matrix of a Linear Map, Invertibility. Eigenvalues and Eigenvectors :- Invariant Subspaces, Polynomials Applied to Operators, Upper-Triangular Matrices, Diagonal Matrices, Invariant Subspaces on Real Vector Spaces
**Module III (13 Hours)**
Linear Systems : Operators on Inner-Product Spaces :- Self-Adjoint and Normal Operators, The Spectral Theorem, Normal Operators on Real Inner-Product Spaces, Positive Operators, Isometries, Polar and Singular-Value Decompositions.
Some Important Classes of Linear Systems :- Shift Invariant systems and Toeplitz matrices. Operators and square matrices. Self adjoint operators and Hermitian matrices. Projections and idempotent matrices. Rotations and unitary matrices.
**Module IV (14 Hours)**
Infinite Dimensional Signal Spaces : Metric Spaces :- Definition, Convergence and Completeness. Hilbert spaces :- Introduction [Ref 3, Appendix]. l2 and L2 spaces. Definition and some properties. Orthogonal Complements, Orthonormal Sets, Fourier Expansion. Conjugate Space, Adjoint of an Operator, Self Adjoint Operators, Normal and Unitary operators, Projections.

**References:**
1. Sheldon Axler, Linear Algebra Done Right, Springer
2. G. F. Simmons, Introduction to Topology and Modern Analysis, Tata McGraw Hill.

3. Paul R. Halmos, Finite-Dimensional Vector Spaces, Springer
4. Todd K. Moon and Wynn C. Stirling, Mathematical Methods and Algorithms for Signal Processing, Pearson
5. Arch W. Naylor and George R. Sell, Linear Operator Theory in Engineering and Science, Springer
6. Peter D. Lax, Linear Algebra, Wiley Students Edition.
7. Michael W. Frazier, An Introduction to Wavelets Through Linear Algebra, Springer.

**Internal continuous assessment: 100 marks**

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of these. There will be a minimum of two tests in each subject.

**End semester Examination: 100 marks**

**Question pattern:**

Answer any 5 questions by choosing atleast one question from each module.

| **Module 1** | **Module 2** | **Module 3** | **Module 4** |
|---|---|---|---|
| Question 1:20 marks<br><br>Question 2:20 marks | Question 3:20 marks<br><br>Question 4:20 marks | Question 5:20 marks<br><br>Question 6:20 marks | Question 7:20 marks<br><br>Question 8:20 marks |

| ECS10 302(B) | **LINEAR & NONLINEAR OPTIMIZATION**<br>*Hours/Week: Lecture – 3 hours Tutorial – 1 hour* | **Credits – 4** |
|---|---|---|

*Objectives: The objective of this course is to provide thorough Mathematical foundation for linear and non linear optimization techniques. Upon completion of this course, the student will have deep understanding of Vector spaces, linear transformation, linear optimization algorithms, sensitivity analysis, constrained and unconstrained optimization and Engineering applications of these methods.*

**Module I (14 Hours)**

Mathematical Background: Sequences and Subsequences- Mapping and functions- Continuous functions- Infimum and Supremum of functions- Minima and maxima of functions- Differentiable functions. Vectors and vector spaces- Matrices- Linear transformation- Quadratic forms- Definite quadratic forms- Gradient and Hessian- Linear equations- Solution of a set of linear equations-Basic solution and degeneracy.

Convex sets and Convex cones- Introduction and preliminary definition- Convex sets and properties- Convex Hulls- Extreme point- Separation and support of convex sets- Convex Polytopes and Polyhedra- Convex cones- Convex and concave functions- Basic properties- Differentiable convex functions- Generalization of convex functions.

**Module II (14 Hours)**

Linear Programming: Introduction -Optimization model, formulation and applications-Classical optimization techniques: Single and multi variable problems- Types of constraints. Linear optimization algorithms: The simplex method -Basic solution and extreme point -Degeneracy-The primal simplex method -Dual linear programs - Primal, dual, and duality theory - The dual simplex method -The primal-dual algorithm-Duality applications. Post optimization problems: Sensitivity analysis and parametric programming-

**Module III (13 Hours)**

Nonlinear Programming: Minimization and maximization of convex functions- Local & Global optimum- Convergence-Speed of convergence. Unconstrained optimization: One dimensional minimization - Elimination methods: Fibonacci & Golden section search - Gradient methods - Steepest descent method. Constrained optimization: Constrained optimization with equality and inequality constraints. Kelley's convex cutting plane algorithm - Gradient projection method - Penalty Function methods.

**Module IV (13 Hours)**
Constrained optimization: Lagrangian method - Sufficiency conditions - Kuhn-Tucker optimality conditions- Rate of convergence - Engineering applications Quadratic programming problems-Convex programming problems.

**References:**

1. David G Luenberger, .Linear and Non Linear Programming., 2nd Ed, Addison-Wesley.
2. S.S.Rao, .Engineering Optimization.; Theory and Practice; Revised 3rd Edition, New Age International Publishers, New Delhi
3. S.M. Sinha, Mathematical programming: Theory and Methods, Elsevier.
4. Hillier and Lieberman Introduction to Operations Research, McGraw-Hill, 8th edition.
5. Saul I Gass, Linear programming, McGraw-Hill, 5th edition.
6. Bazarra M.S., Sherali H.D. & Shetty C.M., Nonlinear Programming Theory and Algorithms, John Wiley, New York.
7. Kalyanmoy Deb, Optimization for Engineering: Design-Algorithms and Examples, Prentice Hall (India).

**Internal continuous assessment: 100 marks**
Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of these. There will be a minimum of two tests in each subject.

**End semester Examination: 100 marks**
**Question pattern:**
Answer any 5 questions by choosing atleast one question from each module.

| Module 1 | Module 2 | Module 3 | Module 4 |
|---|---|---|---|
| Question 1:20 marks<br><br>Question 2:20 marks | Question 3:20 marks<br><br>Question 4:20 marks | Question 5:20 marks<br><br>Question 6:20 marks | Question 7:20 marks<br><br>Question 8:20 marks |

| ECS10 302(C) | **TRANSFORM THEORY**<br>*Hours/Week: Lecture – 3 hours Tutorial – 1 hour* | **Credits – 4** |
|---|---|---|

*Objectives: The primary objective is to provide deep understanding of the various transforms used in signal analysis. Upon completion of this course, the student will have sound knowledge in the methods of Lapalce transform, Z-transform, the Fourier transforms, Wavelet transform, DCT and other trsnsforms, their applications in various fields like image compression. The course also introduces new transforms like CTT and WBCT.*

**Module I (14 Hours)**
Introduction and Review: Introduction on the integral and discrete transforms and their applications- Need of reversibility- basis – Requirements of transforms- (Linear algebraic approach) - Review of Laplace Transform, Z transform, Continuous Fourier Transform, Discrete Time Fourier transform, Discrete transform-Relations between the transforms
**Module II (14 Hours)**
Integral Transforms: Short Term Fourier Transform(STFT) – Limitations of STFT - Heisenbergs uncertainty principle - Continuous wavelet transform (CWT) - Hilbert Transforms - Radon Transform - Abel Transform - Sine transform – Cosine Transform - The Mellin Transform - Hankel Transform - Hartley Transform.
**Module III (13 Hours)**
Discrete Transforms and Applictions: Discrete Cosine transform and applications in JPEG - Discrete STFT (DSTFT) – Application of DSTFT in audio signal processing,- Discrete Wavelet Transform (DWT) - lifting applied to DWT – Applications of DWT in audio signal processing - image compression (JPEG 2000) - At least one application of each transform in one dimensional, two-dimensional or three dimensional signals or multimedia signal processing (Example : compression, information security, watermarking , steganography, denoising, signal separation, signal classification).
**Module IV (13 Hours)**
New Transforms and Applications: Limitations of DWT in image processing - Contourlet transform (CTT) – Applications of CTT in image processing - Ridgelet and Curvelet transforms - New developments in DWT and CTT such as wavelet Based Contourlet Transform(WBCT)

**References:**
1. The Transforms and Applications Handbook, Second Edition - Edited by Alexander D. Poularikas, CRC Press

2. Integral and Discrete transforms with applications and error analysis, Abdul Jerri, Marcel Dekker Inc.
3. Integral Transforms and Their Applications Lokenath Debnath, Dambaru Bhatta, Taylor & Francis Inc

**Internal continuous assessment: 100 marks**

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of these. There will be a minimum of two tests in each subject.

**End semester Examination: 100 marks**

**Question pattern:**

Answer any 5 questions by choosing atleast one question from each module.

| **Module 1** | **Module 2** | **Module 3** | **Module 4** |
|---|---|---|---|
| Question 1:20 marks<br><br>Question 2:20 marks | Question 3:20 marks<br><br>Question 4:20 marks | Question 5:20 marks<br><br>Question 6:20 marks | Question 7:20 marks<br><br>Question 8:20 marks |

| ECS10 302(D) | INFORMATION HIDING AND DATA ENCRYPTION<br>*Hours/Week: Lecture – 3 hours Tutorial – 1 hour* | Credits – 4 |
|---|---|---|

*Objectives: This course deals with the principles and implementation of secure communication. It extensively covers cryptography, steganography, their methods and applications.*

**Module I (14 Hours)**

Information security – Digital rights management – copy right protection - Information integration - Digital watermarking and steganography- difference between watermarking and steganography –Classification, applications in content authentication, medical images, audio and video – requisites of watermarking and steganography – data hiding capacity, robustness and imperceptibility - Watermarking with side information - fragile watermark – benchmark for watermarking – data hiding in text

**Module II (14 Hours)**

Watermarking in spatial domain - Additive methods, spread spectrum based methods- Steganography in spatial domain - Information theoretic approach for watermarking - Watermarking and steganography in frequency domain – Based on Discrete cosine transform, Discrete Wavelet transform and Contourlet transform - different methods - Comparison between frequency domain and spatial domain methods

**Module III (13 Hours)**

Watermark detection – detection theoretic and information theoretic approach – Operating characteristics - Recovery of embedded data - Blind and non blind methods – Quality evaluation of data hidden images, audio and video. Quality evaluation with and without reference – Human visual system based methods - Weighted signal noise ratio for quality evaluation of stetgo data – Robustness measure of recovered data - steganalysis – statistical based techniques for steganalysis

**Module IV (13 Hours)**

Difference between steganography and cryptography - Encryption and decryption for Watermarks - Embedding and Extraction Procedures – Image hashing - Watermarking with Visual Cryptography - Analysis of different methods

**References:**

1. Ingemar Cox, Matthew Miller, Jeffrey Bloom, Jessica Fridrich, Ton Kalker "Digital Watermarking and Steganography, 2nd Ed., Morgan Kaufman Publishers
2. Fundamentals of Digital Image Watermarking Book Description, John Wiley & Sons Fernando Perez Gonzalez, Sviatoslav Voloshynovskiy
3. Fabien Petitcolas Stefan Katzenbeisser Information Hiding Techniques for Steganography and Digital Watermarking, Artech publihsers
4. Wang, F. Pan, J. Jain, L. C. Innovations in Digital Watermarking Techniques, Springer

**Internal continuous assessment: 100 marks**

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of these. There will be a minimum of two tests in each subject.

**End semester Examination: 100 marks**

**Question pattern:**

Answer any 5 questions by choosing atleast one question from each module.

| Module 1 | Module 2 | Module 3 | Module 4 |
|---|---|---|---|
| Question 1:20 marks<br><br>Question 2:20 marks | Question 3:20 marks<br><br>Question 4:20 marks | Question 5:20 marks<br><br>Question 6:20 marks | Question 7:20 marks<br><br>Question 8:20 marks |

| ECS10 303(P) | INDUSTRIAL TRAINING<br>*Hours/Week: 30 (During the training period)* | Credit – 1 |
|---|---|---|

*Objectives : Upon completion of Industrial Training,*

- *the student gains awareness of issues related to designing and maintaining sophisticated equipments, their management and adopting to new standards as when they are formed*
- *the student learns issues related to managing people in industries*

The students have to undergo an industrial training of minimum two weeks in an industry dealing with communication/signal processing, during the semester break between semester II and semester III, and complete within 15 calendar days from the start of semester III. The students are required to submit a report of the training undergone and present the contents of the report before the evaluation committee. Evaluation committee will award the marks based on training quality, contents of the report and presentation.

**Internal Continuous assessment: 50 Marks**

| ECS10 304(P) | MASTER RESEARCH PROJECT PHASE I<br>*Hours/Week: 22 hours* | Credits – 6 |
|---|---|---|

*Objectives: The main objective of the Master Research Project is to identify current issues in the area of Communication Engineering and Signal Processing. The ability of the student to address contemporary issues and to find practical solutions to the issues increases. Also, continued and self learning skill of the student is enhanced.*

The project work can be a design project/experimental project and/or computer simulation project on any of the topics in communication/signal processing area. The project work is allotted individually on different topics. The students shall be encouraged to do their project work in the parent institute itself. If found essential, they may be permitted to continue their project outside the parent institute, subject to the conditions in clause 10 of M. Tech regulations. Department will constitute an Evaluation Committee to review the project work. The Evaluation committee consists of at least three faculty members of which internal guide and another expert in the specified area of the project shall be two essential members.

The student is required to undertake the master research project phase I during the 3rd semester and Phase II in the 4th semester. Phase I consists of preliminary thesis work, two reviews of the work and the submission of a preliminary report. First review would highlight the topic, objectives, methodology and expected results. Second review assesses the progress of the work, preliminary report and future plan of the work to be completed in the 4th semester. The Evaluation committee consists of at least three faculty members of which internal guide and another expert in the specified area of the project shall be two essential members.

**Internal Continuous assessment:**

| | Guide | Evaluation Committee |
|---|---|---|
| First Review | 50 | 50 |
| Second Review | 100 | 100 |
| Total | 150 | 150 |

| ECS10 401 | **MASTER RESEARCH PROJECT PHASE II**<br><br>*Hours/Week: 30* | **Credits – 12** |
|---|---|---|

Master Research project phase II is a continuation of project phase I started in the 3rd semester. There would be two reviews in the 4th semester, first in the middle of the semester and the second at the end of the semester. First review is to evaluate the progress of the work. Second review would be a pre-submission presentation before the evaluation committee to assess the quality and quantum of the work done. This would be a pre qualifying exercise for the students for getting approval by the Departmental committee for the submission of the thesis. At least one technical paper is to be prepared for possible publication in journal or conferences. The technical paper is to be submitted along with the thesis. The final evaluation of the project will be external evaluation.

**Internal Continuous assessment:**

| | Guide | Evaluation Committee |
|---|---|---|
| First Review | 50 | 50 |
| Second Review | 100 | 100 |
| Total | 150 | 150 |