APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

Cluster No.10 for PG Programs

(Engineering Colleges in Kannur, Wayand & Kasaragod Districts)

Curriculum, Scheme of Examinations and Syllabi for M. Tech. Degree Program with effect from Academic Year 2015 - 2016

Electronics & Communication Engineering

M. Tech.

in

Signal Processing

(No. of Credits : 65)

Curriculum Structure for M. Tech. in Signal Processing under KTU

FIRST SEMESTER

Slot	Code	Subject	Hours/Week			Internal Marks	End Semester Examination		Credit
			L	T	P		Hrs	Marks	
A	10EC6101	Linear Algebra	3	1	-	40	3	60	4
B	10EC6103	Random Process and Applications	3	-	-	40	3	60	3
C	10EC6105	Advanced Digital Signal	3	-	-	40	3	60	3
D	10EC6401	Multi rate Signal Processing	3	-	-	40	3	60	3
E	10EC6xxxx	Elective-I	3	-	-	40	3	60	3
S	10GN6001	Research Methodology	0	2	-	100	-	0	2
T	10EC6409	Seminar 1			2	100	-	0	2
U	10EC6111	Digital Signal Processing Lab	-	-	2	100	-	0	1
	TOTAL		**15**	**3**	**4**	**500**		**300**	**21**

ELECTIVE-I

10EC6503 Signal Compression
10EC6113 Digital signal processors and Architecture
10EC6107 Advanced Digital Communication
10EC6201 High Speed Digital Design
10EC6119 Transform Theory

SECOND SEMESTER

Slot	Code	Subject	Hours/Week			Internal Marks	End Semester Examination		Credit
			L	T	P		Hrs	Marks	
A	10EC6102	Digital Image Processing	3	-	-	40	3	60	3
B	10EC6402	VLSI Signal processing	3	-	-	40	3	60	3
C	10EC6404	Adaptive Signal Processing	3	-	-	40	3	60	3
D	10EC6xxx	Elective-II	3	-	-	40	3	60	3
E	10EC6xxx	Elective-III	3	-	-	40	3	60	3
V	10EC6408	Mini Project	-	-	4	100	-	0	2
U	10EC6412	Image processing Lab	-	-	2	100	-	0	1
	TOTAL		**15**	**-**	**6**	**400**		**300**	**18**

ELECTIVE-II

10EC6414 Principles of Digital System Design
10EC6114 Biomedical Signal Processing
10EC6302 Wavelet theory
10EC6314 Optical Signal processing

ELECTIVE-III

10EC6104 Estimation & Detection
10EC6118 Statistical Signal Processing
10EC6316 Multi dimensional signal processing
10EC6106 Coding Theory

THIRD SEMESTER

Slot	Code	Subject	Hours/Week			Internal Marks	End Semester Examination		Credit
			L	T	P		Hrs	Marks	
A	10EC7xxx	Elective-IV	3	-	-	40	3	60	3
B	10EC7xxx	Elective-V	3	-	-	40	3	60	3
T	10EC7401	Seminar 2	-	-	2	100	-	0	2
W	10EC7403	Project - Phase 1	-	-	12	50	-	0	6
	TOTAL		**6**	**-**	**14**	**230**		**120**	**14**

ELECTIVE-IV

10EC7105 Audio Processing
10EC7405 Spectral estimation
10EC7109 Array signal processing
10EC7305 Computer Vision

ELECTIVE-V

10EI7107 Digital control system Design
10EC7113 Pattern Recognition
10EC7307 Multimedia systems
10EC7117 Information hiding & data encryption
10EC7213 Introduction to nano electronics

FOURTH SEMESTER

Slot	Code	Subject	Hours/Week			Internal Marks	End Semester Examination		Credit
			L	SP	P		Hrs	Marks	
W	10EC7404	Project - Phase 2	-	-	21	70	1	30	12
	TOTAL		**-**	**-**	**21**	**70**		**30**	**12**

CONTENTS

Course No.	Course Name	L - T - P - Credits	Year of Introduction
10EC6101	**LINEAR ALGEBRA**	**3 - 1 - 0 - 4**	**2015**

Course Prerequisites

(1) Basic knowledge in Matrix Theory at UG level
(2) Basic knowledge in Set Theory at UG level

Course Objectives

(1) To have an advanced level knowledge in linear algebra
(2) To throw light into the applications of linear algebra, like Multi-resolution analysis, Wavelets etc.

Syllabus

Sets, Functions, Groups, Rings, Fields, Vector spaces, Subspaces, Linear Transformations, Rank-nullity theorem, Isomorphism, Matrix representation of Linear Transformations, Linear functional, Metric space, Open sets, Closed sets, Neighborhoods, Sequences, Banach space, L^p space and l^p space, Inner product space, Hilbert space, Signal space, Gramm-Schmidt orthonormalization process, Matrix rank, Solving linear system of equations using matrices, Eigen values, Eigen vectors and spectrum, Diagonalizability, Normal matrices, Unitary matrices, Multi-resolution analysis and wavelets.

Expected Outcomes

The students are expected to :
(1) Have an advanced level knowledge in linear algebra;
(2) Know how the theory of linear algebra could be applied in specific domains, like Multi-resolution analysis, Wavelets etc.

References

1. Hoffman Kenneth and Kunze Ray, *Linear Algebra*, Prentice Hall of India.
2. Strang G, *Linear Algebra and its Applications,* 3rd edition, Saunders, 1988.
3. Erwin Kreyzig, *Introductory Functional Analysis with Applications*, John Wiley, 2006.
4. G.F.Simmons, *Topology and Modern Analysis* , McGraw Hill.
5. Frazier, Michael W., *An Introduction to Wavelets through Linear Algebra,* Springer Publications.
6. Jin Ho Kwak & Sungpyo Hong, *Linear Algebra*, Springer International, 2004.

Course plan

Module	Content	Hours	Semester Exam Marks (%)
I	Sets, Functions, Cardinality of sets, Groups, Rings, Fields.	4	15
	Vector spaces, Subspaces, Basis and dimension, Finite and infinite dimensional vector spaces.	4	
II	Linear Transformations, Sum, product and inverse of Linear Transformations, Rank-nullity theorem, Isomorphism.	5	15
	Matrix representation of Linear Transformations, Four fundamental subspaces of Linear Transformations, Change of bases, Linear functional.	5	
First Internal Examination			
III	Metric space, Open sets, Closed sets, Neighborhoods, Sequences, Convergence, Completeness, Continuous mappings, Normed space, Banach space, L^p space and l^p space.	10	15
IV	Inner product space, Hilbert space, Signal space, Properties of inner	10	15

	product space, Orthogonal compliments and direct sums, Orthonormal sets, Gramm-Schmidt orthonormalization process, Projections.		
Second Internal Examination			
V	Matrix rank, Solving linear system of equations using matrices, LDU factorization, QR decomposition, Least square approach.	5	20
	Eigen values, Eigen vectors and spectrum, Diagonalizability, Orthogonal diagonalization.	4	
VI	Properties of Eigen values and Eigen vectors of Hermitian matrices, Normal matrices, Unitary matrices.	4	20
	Multi-resolution analysis and Wavelets.	5	
Cluster Level End Semester Examination			

Course No.	Course Name	L - T - P - Credits	Year of Introduction
10EC6103	**RANDOM PROCESSES AND APPLICATIONS**	**3 - 0 - 0 - 3**	**2015**

Course Prerequisites

(1) Basic knowledge in Probability Theory at UG level

(2) Basic knowledge in Set Theory at UG level

Course Objectives

(1) To impose in-depth knowledge in probability theory.

(2) To throw light into the applications of probability and random processes.

Syllabus

Review of Set Theory, Random experiment, Sample space, Cumulative Distribution Function, Probability Density Function, conditional distribution, Expectation, moments, correlation and covariance, Random Vector, Convergence - Markov and Chebyshev inequalities, convergence in probability, convergence in mean square, Weak law of large numbers, strong law of large numbers, Central Limit Theorem for sequences of independent random variables, Random process, IID process, Poisson counting process, Markov process, Wiener process. Stationarity, power spectral density, Discrete time Markov chains, conditional independence, DTMC, Recurrence analysis, Chapman-Kolmogov theorem, Communicating classes, Continuous time Markov chains, Poisson process, simple Markovian queues.

Expected Outcomes

The students are expected to :

(1) Have an advanced level knowledge in probability theory;

(2) Know how the theory of probability and random processes could be applied in specific domains

References

1. A. Papoulis and S. UnnikrishnaPillai. *Probability, Random Variables and Stochastic Processes,* TMH
2. B. Hajek, *An Exploration of Random Processes for Engineers,* 2005.
3. D.P. Bertsekas and J. N. Tsitsiklis, *Introduction to Probability*, 2000.
4. Gray, R. M. and Davisson L. D., *An Introduction to Statistical Signal Processing.* Cambridge University Press, 2004.
5. Stark Henry, *Probability and Random Processes With Application to Signal Processing*, 3/e, Pearson Education India.
6. Steven Kay, *Intuitive probability and random processes using MATLAB*, Springer, 2006.
6. Dr. Kishor S. Trivedi. *Probability and Statistics with Reliability, Queuing, and Computer Science Applications,* John Wiley and Sons, New York, 2001.

Course plan			
Module	**Content**	**Hours**	**Semester Exam Marks (%)**
I	Review of Set Theory - Set operations, functions, countable and uncountable sets, Random experiment, Sample space, Sigma algebra, Event space, Measure, Probability measure, Borel sigma field	4	15
	Cumulative Distribution Function (CDF), Probability Density Function (PDF), PMF, Joint CDF, Joint PDF, conditional distribution.	4	
II	Expectation - Fundamental Theorem of expectation, moments, characteristic function, correlation and covariance	4	15
	Random Vector - Definition, Joint statistics, Covariance and correlation matrix, Gaussian random vectors.	4	
First Internal Examination			
III	Convergence - Markov and Chebyshev inequalities, Convergence of sequences of random variables- almost sure convergence, convergence in probability, convergence in mean square, Weak law of large numbers, Random sums, Borel Cantelli lemma, strong law of large numbers, Central Limit Theorem for sequences of independent random variables.	8	15
IV	Random process - Definition of Random process, IID process, Poisson counting process, Markov process, birth-death process, Wiener process. Stationarity, Correlation functions of random processes in linear systems, power spectral density.	8	15
Second Internal Examination			
V	Discrete time Markov chains - conditional independence, DTMC, Recurrence analysis, Foster's Theorem, Chapman-Kolmogov theorem, Stopping time.	6	20
VI	classification of states: absorbing, recurrent, transient. Communicating classes, Continuous time Markov chains, Poisson process, simple Markovian queues.	6	20
Cluster Level End Semester Examination			

Course No.	Course Name	L - T - P - Credits	Year of Introduction
10EC6105	**ADVANCED DIGITAL SIGNAL PROCESSING**	**3 - 0 - 0 - 3**	**2015**

Course Prerequisites

(1) Basic knowledge in signals and systems at UG level;
(2) Basic knowledge in transforms at UG level.

Course Objectives

(1) To attain a good analytical ability in digital filter design;
(2) To investigate the applications of digital signal processing.

Syllabus

Review of transforms, Z-Transform, Discrete Time Fourier Transform (DTFT), Discrete Fourier Transform (DFT), Discrete Cosine Transform (DCT), Short Time Fourier Transform (STFT), LTI systems as frequency selective filters, Invertibility of LTI systems, Design of digital filters by placement of poles and zeros, FIR filter structures, IIR filter structures, Design of FIR filters, Linear Phase Systems, Window method, Frequency sampling method, Finite word length effects, Design of IIR filters, Pole zero placement, Impulse invariance, Bilinear Z transformation, Finite word length effects, Adaptive Digital Filters, Wiener filter, LMS adaptive algorithm, Recursive least squares algorithm, Power Spectrum Estimation, Estimation of spectra from finite-duration signals, Non-parametric and Parametric methods for Power Spectrum Estimation.

Expected Outcomes

The students are expected to :

(1) Attain a good analytical ability in digital filter design;

(2) Know various applications of digital signal processing.

References

1. Proakis and Manolakis, *Digital Signal Processing: Principles, Algorithms, and Applications,* 4/e, Pearson Education.
2. Ifeachor and Jervis, *Digital Signal Processing, A practical Approach*, 2/e, Pearson Education.
3. Johnny R. Johnson, *Introduction to Digital Signal Processing,* PHI, 1992.
4. Ashok Ambardar, *Digital Signal Processing: A Modern Introduction,* Thomson, IE, 2007.
5. Douglas F. Elliott, *Handbook of Digital Signal Processing- Engineering Application,* Academic Press.
6. Robert J. Schilling and Sandra L. Harris, *Fundamentals of Digital Signal Processing using MATLAB*, Thomson, 2005.
7. Ingle and J. G. Proakis, *Digital Signal Processing Using MATLAB,* Thomson, 1/e.

Course plan

Module	Content	Hours	Semester Exam Marks (%)
I	**Review of transforms** : Z-Transform, ROC, Poles & Zeros, Discrete Time Fourier Transform (DTFT), Discrete Fourier Transform (DFT), DFT as a linear transformation, Frequency analysis of signals and systems using DFT, Discrete Cosine Transform (DCT), Short Time Fourier Transform (STFT).	4	15
	LTI systems as filters : Invertibility of LTI systems, Minimum phase, Maximum phase and mixed phase systems, All-pass filters, Design of digital filters by placement of poles and zeros, Linear filtering methods based on DFT.	5	
II	**Digital Filter Structures** : Generalized input-output relationship, IIR Transfer Function, FIR Transfer Function, Signal Flow Graphs, FIR filter structures, Direct Form-I, Direct Form-II, Frequency Sampling, Cascade, Lattice, IIR filter structures, Direct Form-I, Transposed, Direct Form-II, Canonical, Parallel, Cascade, Lattice-Ladder structures.	6	15
First Internal Examination			
III	**Design of FIR filters** : Linear Phase Systems, Specifications, Coefficient calculation methods, Desired impulse responses, Window method, Frequency sampling method, Comparison of methods, Filter realization, Finite word length effects, Implementation examples, FIR filter design using Octave/ MATLAB.	8	15
IV	**Design of IIR filters** : Specifications, Coefficient calculation method,	8	15

	Pole zero placement, Transformation rules, Impulse invariance, Bilinear Z transformation (BZT), Buttorworth and Chebyschev approximations, Filter realization, Finite word length effects, Implementation examples, IIR filter design using Octave/ MATLAB.		
Second Internal Examination			
V	**Adaptive Digital Filters** : Concepts, Wiener filter, LMS adaptive algorithm, Recursive least squares algorithm, Lattice Ladder filters, Application of Adaptive filters.	6	20
VI	**Power Spectrum Estimation** : Estimation of spectra from finite-duration signals, Non-parametric and Parametric methods for Power Spectrum Estimation.	5	20
Cluster Level End Semester Examination			

Course No.	Course Name	L - T - P - Credits	Year of Introduction
10EC6401	**MULTIRATE SIGNAL PROCESSING**	**3 - 0 - 0 - 3**	**2015**

Course Prerequisites

(1) Digital Signal Processing

(2) Digital Filters

Course Objectives

(1) To have an advanced level knowledge on Multirate systems

(2) To Apply the mutirate signal processing techniques to the systems which are working in different rates.

Syllabus

Fundamentals of Multirate Theory The sampling theorem Basic Multirate operations- Maximally decimated filter M-channel perfect reconstruction filter banks Polyphase representation- perfect reconstruction systems Paraunitary PR Filter Banks- Filter Bank Properties induced by paraunitarity- Quantization Effects filter banksCosine Modulated filter banks Polyphase structure-PR Systems

Expected Outcomes

The students are expected to :

(1) Have an advanced level knowledge on Multirate Signal Processing;

(2) Know how the theory of Multirate Signal Processing could be applied in specific domains, like Multi-rate systems.

References

1. P.P. Vaidyanathan. “Multirate systems and filter banks.” Prentice Hall. PTR. 1993.
2. N.J. Fliege. “Multirate digital signal processing .” John Wiley 1994.
3. Sanjit K. Mitra. “ Digital Signal Processing: A computer based approach.” McGraw Hill. 1998.
4. R.E. Crochiere. L. R. “Multirate Digital Signal Processing”, Prentice Hall. Inc.1983.
5. J.G. Proakis. D.G. Manolakis. “Digital Signal Processing: Principles. Algorithms and Applications”, 3rd Edn. Prentice Hall India, 1999.

Course plan			
Module	**Content**	**Hours**	**Semester Exam Marks (%)**
I	The sampling theorem - sampling at sub nyquist rate - Basic Formulations and schemes.	5	15
	Basic Multirate operations- Decimation and Interpolation - Digital Filter Banks- DFT Filter Bank- Identities- Polyphase representation	6	
II	Maximally decimated filter banks: Polyphase representation - Errors in the QMF bank- Perfect reconstruction (PR) QMF Bank - Design of an alias free QMF Bank	6	15
First Internal Examination			
III	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	6	15
IV	**Perfect reconstruction (PR) filter banks** Paraunitary 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-	7	15
Second Internal Examination			
V	Quantization Effects: -Types of quantization effects in filter banks. - coefficient sensitivity effects, dynamic range and scaling.	6	20
VI	**Cosine Modulated filter banks** Cosine Modulated pseudo QMF Bank- Alas cancellation- phase - Phase distortion- Closed form expression- Polyphase structure- PR Systems	6	20
Cluster Level End Semester Examination			

Course No.	**Course Name**	**L - T - P - Credits**	**Year of Introduction**
10EC6503	**SIGNAL COMPRESSION**	**3 - 0 - 0 - 3**	**2015**
Course Prerequisites			

Basic knowledge of signals and systems

Course Objectives

To have knowledge on different signal compression techniques

Syllabus

Review of Information Theory, Quantization, Data Compression, Data compression, Speech and Audio Compression techniques, Image Compression and Video Compression

Expected Outcomes

The students are expected to have thorough knowledge about various compression techniques in different domains.

References

1. Khalid Sayood, *Introduction to Data Compression*, Morgan Kaufmann Publishers., Second Edn. 2005.
2. David Salomon, *Data Compression: The Complete Reference*, Springer Publications, 4th Edn. 2006.
3. K.R.Rao, P.C.Yip, *The Transform and Data Compression Handbook*, CRC Press. 2001.
4. R.G.Gallager, *Information Theory and Reliable Communication*, John Wiley & Sons, Inc., 1968.
5. Ali N. Akansu, Richard A. Haddad, *Multiresolution Signal Decomposition: Transforms, Subbands and Wavelets*, Academic Press., 1992
6. Martin Vetterli, Jelena Kovacevic, *Wavelets and Subband Coding*, Prentice Hall Inc., 1995.
7. N. Jayant and P. Noll, *Digital Coding of Waveforms: Principles and Applications to Speech and Video*, Prentice Hall, USA, 1984.
8. Z. Li and M.S. Drew, *Fundamentals of Multimedia*, Pearson Education (Asia) Pte. Ltd., 2004.

Course plan

Module	Content	Hours	Semester Exam Marks (%)
I	Review of Information Theory, Compression Techniques, Lossless and Lossy Compression, Huffman Coding, its variants, Optimality, Arithmetic Coding and its variants, Run Length Coding, Dictionary Techniques , Lempel-Ziv coding, Predictive Coding, Burrows Wheeler Transform, Dynamic Markov Compression. Golomb codes, Rice codes, Tunstall codes, Facsimile encoding	8	15
II	Quantization, Uniform & Non-uniform, optimal and adaptive quantization, vector quantization, structures for VQ, Optimality conditions for VQ, Predictive Coding , Differential Encoding	6	15
First Internal Examination			

III	Image compression: Predictive techniques, DM, PCM, DPCM: Optimal Predictors and Optimal Quantization, Contour based compression, Transform Coding, JPEG Standard, Sub-band coding algorithms: Design of Filter banks, Wavelet based compression, EZW, SPIHT, JPEG 2000 standards, JBIG, JBIG2, JPEG-LS, CALIC.	10	15
IV	Audio compression techniques, Standards for audio compression in multimedia applications, MPEG audio encoding and decoding, Dolby AC-3 standard.	6	15
Second Internal Examination			
V	Speech compression techniques, Vocoders, Speech compression - quality measures, waveform coding, source coders, Speech compression standards for personal communication systems	8	20
VI	Video compression techniques and standards, Motion estimation and compensation techniques, H.261, Dolby AC-3.	4	20
Cluster Level End Semester Examination			

Course No.	Course Name	L - T - P - Credits	Year of Introduction
10EC6113	**DSP PROCESSORS AND ARCHITECTURE**	**3 - 0 - 0 - 3**	**2015**

Course Prerequisites

Basic knowledge in DSP and microprocessors at UG level

Course Objectives

To have an in depth knowledge in DSP at processor level

Syllabus

Review of Pipelined RISC Architecture and Instruction Set Design- Performance and Benchmarks - SPEC CPU 2000, EEMBC DSP benchmarks. Basic Pipeline: Implementation Details - Pipeline Hazards (based on MIPS 4000 arch). Instruction Level Parallelism (ILP): Concepts, Dynamic Scheduling -Dynamic Hardware Prediction- Limitations of ILP. Review of Memory Hierarchy: Cache design, Cache Performance Issues & Improving Techniques. Computer arithmetic- Signed Digit Numbers (SD) - Multiplier Adder Graph - Logarithmic and Residue Number System(LNS, RNS). Index Multiplier –Architecture for Pipelined Adder, Modulo Adder & Distributed Arithmetic(DA), CORDIC Algorithm and architecture. Case studies:TMS 320 C 6X Processor –sample program. Overview of BlackFin processo

Expected Outcomes

Students are expected to

1.understand pipelining hazards, resolving techniques

2.understand dsp processors and will be able to develop programs for dsp

References

1. J. L. Hennesy and D. A. Patterson, *Computer Architecture A Quantitative Approach*, 3/e, Elsivier India, Chapter 1, Appendix A, Chapter 3, Chapter 5.

2. U. Mayer-Baese, Digital Signal Processing with FPGAs, Springer, 2001.

3. RulphChassaing, Digital signal Processing and Applications with the C6713 and C6416 DSK – Wiley Interscience.

Course plan

Module	Content	Hours	Semester Exam Marks (%)
I	**Review of Pipelined RISC Architecture and Instruction Set Design.**	5	15
	Performance and Benchmarks - SPEC CPU 2000, EEMBC DSP benchmarks.	2	
II	**Basic Pipeline**: Implementation Details - Pipeline Hazards (based on MIPS 4000 arch)- structural hazards-data hazards-control hazards-branch prediction	6	15
First Internal Examination			
III	**Instruction Level Parallelism (ILP):** Concepts, Dynamic Scheduling – Tomasulo's algorithm -Reducing Data hazards	4	15
	Dynamic Hardware Prediction - Reducing Branch Hazards. Multiple Issue-Hardware-based speculation	4	
	Limitations of ILP	1	
IV	**Review of Memory Hierarchy:** Cache design	3	15
	Cache Performance Issues & Improving Techniques	4	
Second Internal Examination			
V	**Computer arithmetic:** Signed Digit Numbers (SD) - Multiplier Adder Graph - Logarithmic and Residue Number System(LNS, RNS)	3	20
	Index Multiplier –Architecture for Pipelined Adder, Modulo Adder & Distributed Arithmetic(DA), CORDIC Algorithm and architecture .	3	
VI	**Case studies:** Introduction to TMS 320 C 6X Processor – Architecture – Functional units - pipelining –Registers	3	20
	Linear and Circular addressing modes –Types of instructions –sample program,	3	
	Overview of BlackFin processor	3	
Cluster Level End Semester Examination			

Course No.	Course Name	L-T-P-Credits	Year of Introduction
10EC6107	**ADVANCED DIGITAL COMMUNICATION**	**3-0-0- 3**	**2015**

Course Prerequisites

Basic knowledge of Digital Communication at UG Level.

Course Objectives

The course is designed to provide students a strong background in Modern Digital communication techniques emphasizing on Optimized Detection, Security and Bandwidth efficiency.

Syllabus

Introduction to Signal Space, Complex envelop representation of band pass signal, Digital modulation techniques, Optimum receiver structures for AWGN channel, , Band limited channel, ISI, Pulse shaping, Adaptive Equalization techniques, Code Division Multiple Access, Random Access techniques, ALOHA protocols, CSMA. Multicarrier modulation, OFDM

Expected Outcomes

The students are expected to understand modern digital communication technologies and acquire design capabilities for the future needs.

References

1. J. G. Proakis and M. Salehi, Fundamentals of Communication Systems,Pearson Education, 2005.
2. S. Haykins, Communication Systems, 5th ed., John wiley, 2008.
3. Andrea Goldsmith, Wireless Communications, Cambridge University press.
4. S. Benedetto and E. Biglieri, Principles of Digital Transmission with Wireless Applications, Kluwer Academic/Plenum Publishers, 1999.
5. 1. Viterbi, A. J. and J. K. Omura. Principles of Digital Communication and Coding. NY: McGraw-Hill, 1979.
6. Marvin K Simon, Sami M Hinedi, William C Lindsey - Digital Communication Techniques – Signal Design & Detection, PHI
7. MIT OpenCourseWare, Electrical Engineering and Computer Science,Principles of Digital Communication II, Spring 2006
8. Aazhang B. Digital Communication Systems [Connexions Web site]. January 22, 2004. available at: http://cnx.rice.edu/content/col10134/1.3/

Module	Content	Hours	Semester Exam Marks (%)
I	**Introduction to Signal Space:** Concepts of basis, norm, inner product, signal constellation diagram. M-ary orthogonal signals.-Gram Schmidt Ortho normalization Procedure. Representations of Band pass signals: Complex baseband representation of signals. Representation Band pass Stationary Stochastic Signals.	6	15
II	**Digital Modulation Techniques:** Carrier modulation (M-ary ASK, PSK, FSK, DPSK). Continuous phase modulation (QPSK and variants, MSK, GMSK).	5	15
First Internal Examination			

III	**Optimum Receivers for additive white Gaussian noise channels:** Correlation receiver. Matched filter receiver. Maximum Likelihood sequence detector. Performance characteristics of detectors.	6	15
IV	**Optimum Receiver for Signals with random phase in AWGN Channels**: Optimum receiver for Binary Signals- Optimum receiver for M-ary orthogonal signals- Optimum waveform receiver for coloured Gaussian noise channels- Karhunen Loeve expansion approach-whitening.	7	15
Second Internal Examination			
V	**Band limited Channel:** Inter Symbol Interference (ISI).Pulse Shape designing -Nyquist Pulse, Raised Cosine Pulse.	4	20
	Adaptive Equalization: Adaptive Linear Equalizers—Zero forcing algorithm, LMS algorithm. Adaptive Decision feedback equalizers-adaptive equalization of trellis coded signal. Blind Equalizer based on maximum likelihood criterion.	5	
VI	**Multiple Access techniques:** Code Division Multiple Access –CDMA signal and Channel Model-The optimum receivers-sub optimum receivers.	3	20
	Random access methods: ALOHA system and protocols. Carrier Sense Multiple Access.	3	
	Multi Carrier Modulation: Orthogonal Frequency Division Multiplexing(OFDM), Discrete implementation of OFDM	3	
Cluster Level End Semester Examination			

Course No.	Course Name	L - T - P - Credits	Year of Introduction
10EC6201	**HIGH SPEED DIGITAL DESIGN**	**3 - 0 - 0 - 3**	**2015**

Course Prerequisites

Basic knowledge in Digital Electronics and Electromagnetic waves and transmission lines.

Course Objectives

To attain good analytical skills in digital integrated circuit.

To identify sources affecting the speed of digital circuits.

To introduce methods to improve the signal transmission characteristics

Syllabus

High Speed Digital Design: Fundamentals: Frequency and time, Time and distance, Lumped versus distributed systems, High Speed properties of Logic gates: Power, Input power, drive circuit dissipation, speed, packaging. Measurement Techniques, Infinite Uniform transmission line, Termination: End , Source , middle terminators, Power system: Stable voltage reference, choosing a bypass capacitor. Clock Distribution: Timing margin, Clock skew delay adjustments, Differential distribution.

Expected Outcomes

References

1. Howard Johnson & Martin Graham; High Speed Digital Design: A Handbook of Black Magic, Prentice Hall PTR, 1993.
2. William S. Dally & John W. Poulton, Digital Systems Engineering, Cambridge University Press, 1998.
3. Masakazu Shoji; High Speed Digital Circuits, Addison Wesley Publishing Company, 1996.
4. Jan M, Rabaey, et all; Digital Integrated Circuits: A Design perspective, Second Edition, 2003.

Course plan

Module	Content	Hours	Semester Exam Marks (%)
I	**High Speed Digital Design**: Fundamentals: Frequency and time, Time and distance,	4	15
	Lumped versus distributed systems, four kinds of reactance- ordinary capacitance and inductance, mutual capacitance and inductance, Relation of mutual capacitance and mutual inductance to cross talk.	4	
II	**High Speed properties of Logic gates**: Power, Quicent vs active dissipation, Active power driving a capacitive load, Input power,	4	15
	Internal dissipation, drive circuit dissipation: Totem pole , Emitter follower, open collector, current source, Speed, Packaging.	4	
First Internal Examination			
III	**Measurement Techniques:** Rise time and bandwidth of oscilloscope probes, self inductance of probe ground loop, spurious signal pick up from probe ground loops, special probing fixtures, Avoiding pickup from probe shield currents, slowing down of a system clock, observing metastable states.	8	15
IV	**Transmission Lines**: Problems of point to point wiring, signal distortion, EMI, cross talk.	4	15
	Infinite Uniform transmission line; ideal distortion less lossless transmission line, RC transmission line, Skin effect, Proximity effect, Dielectric loss. Effects of source and load impedance.	4	
Second Internal Examination			
V	**Termination**: End terminator, Source terminators, middle terminators , AC biasing for end terminators, Resistor selection, Cross talk in terminators.	6	20
VI	**Power system**: Stable voltage reference, Uniform voltage distribution, distribution problems, choosing a bypass capacitor.	3	20
	Clock Distribution: Timing margin, Clock skew, Using low impedance drivers, using low impedance distribution lines, delay adjustments, Differential distribution, Clock signal duty cycle, Decoupling clock receivers from the clock bus.	4	
Cluster Level End Semester Examination			

Course No.	Course Name	L - T - P - Credits	Year of Introduction
10EC6119	TRANSFORM THOERY	3 - 0 - 0 - 3	2015

Course Prerequisites

(1) Basic knowledge in transforms at UG level;
(2) Basic knowledge in digital signal processing at UG level.

Course Objectives

(1) To attain a thorough knowledge in various transforms used in signal processing;
(2) To apply transforms in various fields like coding, compression, etc.

Syllabus

Introduction on the integral and discrete transforms and their applications, Review of Laplace Transform, Z transform, Continuous Fourier Transform, Discrete Time Fourier transform, Relations between the transforms, Short Term Fourier Transform (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, Discrete Transforms and Applictions, Discrete Cosine transform and applications in JPEG, Discrete STFT (DSTFT), Discrete Wavelet Transform (DWT), lifting, Applications, image compression (JPEG 2000), 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).

Expected Outcomes

The students are expected to :

1. Attain a sound knowledge in various transforms like Lapalce transform, Z-transform, Fourier transforms, Wavelet transform, DCT, etc.
2. Apply these transforms in different areas line image compression, coding etc.
3. Understand new transforms like CTT and WBCT.

References

1. Alexander D. Poularikas, *The Transforms and Applications Handbook*, Second Edition, CRC Press.
2. Abdul Jerri, *Integral and Discrete transforms with applications and error analysis*, Marcel Dekker Inc.
3. Lokenath Debnath, Dambaru Bhatta, *Integral Transforms and Their Applications*, Taylor & Francis Inc.

Course plan

Module	Content	Hours	Semester Exam Marks (%)
I	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,	7	15
II	Review of Continuous Fourier Transform, Discrete Time Fourier transform, Discrete transform-Relations between the transforms- Integral Transforms: Short Term Fourier Transform	7	15

	(STFT) – Limitations of STFT -Heisenbergs uncertainty principle - Continuous wavelet transform (CWT) - Hilbert Transforms		
First Internal Examination			
III	Radon Transform, Abel Transform, Sine transform,,Cosine Transform, The Mellin Transform, Hankel Transform, Hartley Transform	7	15
IV	Discrete Transforms and Applications : 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	7	15
Second Internal Examination			
V	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), Limitations of DWT in image processing	6	20
VI	New Transforms and Applications : 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).	8	20
Cluster Level End Semester Examination			

Course No.	Course Name	L - T - P - Credits	Year of Introduction
10GN6001	**RESEARCH METHODOLOGY**	**0 - 2 - 0 - 2**	**2015**

Course Prerequisites

(1) Basic skill of analyzing data earned through the project work at UG level;
(2) Basic knowledge in technical writing and communication skills earned through seminar at UG level.

Course Objectives

(1) To attain a perspective of the methodology of doing research;
(2) To develop skills related to professional communication and technical report writing.

As a tutorial type course, this course is expected to be more learner centric and active involvement from the learners are expected which encourages self-study and group discussions. The faculty mainly performs a facilitator’s role

Syllabus

Overview of research methodology - research process - scientific methods -research problem and design - research design process - formulation of research task, literature review and web as a source - problem solving approaches - experimental research - ex post facto research. Thesis writing - reporting and presentation - interpretation and report writing - principles of thesis writing- format of reporting, oral presentation - seminars and conferences, Research proposals - research paper writing - publications and ethics - considerations in publishing, citation, plagiarism and intellectual property rights. Research methods – modeling and simulation - mathematical modeling – graphs - heuristic optimization - simulation modeling - measurement design – validity – reliability – scaling - sample design - data collection methods and data analysis.

Expected Outcomes

The students are expected to :

(1) Be motivated for research through the attainment of a perspective of research methodology;

(2) Analyze and evaluate research works and to formulate a research problem to pursue research;

(3) Develop skills related to professional communication, technical report writing and publishing papers.

References

1. C.R Kothari, *Research Methodology : Methods & Techniques*, New Age International Publishers
2. R. Panneerselvam, *Research Methodology*, Prentice Hall of India, New Delhi, 2012.
3. K. N. Krishnaswamy, Appa Iyer Sivakumar, and M. Mathirajan, *Management Research Methodology, Integration of Principles*, Pearson Education.
4. Deepak Chawla, and MeenaSondhi, *Research Methodology – Concepts & Cases,* Vikas Publishing House.
5. J.W. Bames, *Statistical Analysis for Engineers and Scientists*, McGraw Hill, New York.
6. Schank Fr., *Theories of Engineering Experiments*, Tata McGraw Hill Publication.
7. Willktnsion K. L, Bhandarkar P. L, *Formulation of Hypothesis*, Himalaya Publication.
8. Douglas C Montgomery, *Design and analysis of experiments,* Wiley International
9. Ranjit Kumar, *Research Methodology : A step by step guide for beginners,* Pearson Education.
10. Donald Cooper, *Business Research Methods*, Tata McGraw Hill, New Delhi.
11. Leedy P D, *Practical Research : Planning and Design,* 4th Edition, N W MacMillan Publishing Co
12. Day R A, *How to Write and Publish a Scientific Paper,* Cambridge University Press, 1989
13. Coley S M and Scheinberg C A, *Proposal Writing,* 1990, Newbury Sage Publications.
14. Sople, *Managing Intellectual Property: The Strategic Imperative*, Prentice Hall of India, New Delhi, 2012
15. Manna, Chakraborti, *Values and Ethics in Business Profession*, Prentice Hall of India, New Delhi, 2012.
16. Vesilind, *Engineering, Ethics and the Environment*, Cambridge University Press.
17. Wadehra, B.L. *Law relating to patents, trademarks, copyright designs and geographical indications*, Universal Law Publishing

Course plan			
Module	**Content**	**Hours**	**Semester Exam Marks (%)**
I	**Overview of Research Methodology** : Research concepts, meaning, objectives, motivation, types of research, research process, criteria for good research, problems encountered by Indian researchers, scientific method, research design process.	5	15
II	**Research Problem and Design** : Formulation of research task, literature review, methods, primary and secondary sources, web as a source, browsing tools, formulation of research problems, exploration, hypothesis generation, problem solving approaches, introduction to TRIZ (TIPS), experimental research, principles, laboratory experiment, experimental designs, ex post facto research, qualitative research.	5	15
First Internal Examination			
III	**Thesis Writing, Reporting and Presentation** : Interpretation and report writing, techniques of interpretation, precautions in interpretation, significance of report writing, principles of thesis writing, format of reporting, different steps in report writing, layout and mechanics of research report, references, tables, figures, conclusions, oral presentation, preparation, making presentation, use of visual aids, effective communication, preparation for presentation in seminars and conferences.	4	15
IV	**Research proposals, Publications, Ethics and IPR** : Research proposals, development and evaluation, research paper writing, layout of a research paper, journals in engineering, considerations in publishing, scientometry, impact factor, other indexing like h-index, citations, open access publication, ethical issues, plagiarism, software for plagiarism checking, intellectual property right (IPR), patenting case studies.	5	15
Second Internal Examination			
V	**Research Methods - Modeling and Simulation** : Modeling and simulation, concepts of modeling, mathematical modeling, composite modeling, modeling with ordinary differential equations, partial differential equations (PDE), graphs, heuristics and heuristic optimization, simulation modeling.	5	20
VI	**Research Methods - Measurement, Sampling and Data Acquisition** : Measurement design, errors, validity and reliability in measurement, scaling and scale construction, sample design, sample size determination, sampling errors, data collection procedures, sources of data, data collection methods, data preparation and data analysis.	4	20

Cluster Level End Semester Examination

Course No.	Course Name	L - T - P - Credits	Year of Introduction
10EC6409	**SEMINAR - 1**	**0 - 0 - 2 - 2**	**2015**

Course Prerequisites

(1) The habit of reading technical magazines, conference proceedings and journals;
(2) Basic knowledge in technical writing and communication skills earned through seminar at UG level.

Course Objectives

(1) To enhance the reading ability required for the literature review regarding the project work;
(2) To develop skills regarding professional communication and technical report writing.

Guidelines

The student shall prepare a paper and present a seminar on any current topic related to the branch of specialization under the guidance of a staff member. The student will undertake a detailed study based on current published papers, journals, books on the chosen subject and submit seminar report at the end of the semester. The student shall submit a printed copy of the paper to the Department. Grades will be awarded on the basis of the contents of the paper and the quality of presentation. A common format (in PDF format) shall be given for students for preparing the report. All such reports submitted by students shall be in this given format, for uniformity.

Expected Outcomes

The students are expected to :
(1) Be motivated in reading which enhances the literature review required for doing project work;
(2) Develop skills regarding professional communication and technical report writing.

References

1. M. Ashraf Rizvi, *Effective Technical Communication*, Tata McGraw Hill, New Delhi, 2005
2. Day R A, *How to Write and Publish a Scientific Paper*, Cambridge University Press, 1989
3. Coley S M and Scheinberg C A, *Proposal Writing*, 1990, Newbury Sage Publications.

Course plan

Item	Description	Time	
1	Abstract Submission	3 Weeks	
2	Allotment of Topic and Scheduling Seminars	2 Weeks	
3	Presentation Sessions	4 Weeks	
4	Report Submission	4 Weeks	
5	Publishing Grades	2 Weeks	

Course No.	Course Name	L - T - P - Credits	Year of Introduction
10EC6111	**DIGITAL SIGNAL PROCESSING LABORATORY**	**0 - 0 - 2 - 1**	**2015**

Course Prerequisites

(1) Knowledge in Digital Signal Processing at UG level;
(2) Programming ability in Octave/MATLAB and knowledge about DSP kits like TMS320C6X or AD.

Course Objectives

(1) To have a thorough understanding of Digital Signal Processing through software programming;
(2) To investigate Digital Signal Processing through DSP Kits like TMS320C6X or AD.

Experiments

1. Review of MATLAB Programming Practice
2. Low-pass FIR filter using Hamming Window
3. High-pass FIR filter using Hamming Window
4. Low-pass IIR filter using Butterworth Approximation
5. High-pass IIR filter using Butterworth Approximation
6. Convolution and Correlation of sequences
7. Laplace Transform and Z-Transform using MATLAB Symbolic Toolbox
8. Normal Density Estimation
9. Wiener Filter for 1-D Signals
10. Two Channel Quadrature Mirror Filter Bank
11. Wiener Filter for Images with Defocus Blur
12. Wiener Filter for Images with Motion Blur
13. Introduction to C-based embedded design using Code Composer Studio (CCS) and the TI6713 DSK
14. Familiarization of creating, building, and testing some simple projects in the CCS integrated development environment (IDE)
15. Implementation of DFT, FFT programs using CCS
16. Implementation of real-time FIR filtering on the TMS320C6713 with CCS using C
17. Implementation of real-time IIR filtering on the TMS320C6713 with CCS using C.
18. Interfacing of multimedia data to the 6713 DSK

Expected Outcomes

The students are expected to :
(1) Attain a thorough understanding of Digital Signal Processing through software programming;
(2) Develop skills for programming and doing real time DSP using kits like TMS320C6X or AD.

References

1. E. S. Gopi, *Algorithm Collections for Digital Signal Processing Applications using MATLAB*, Springer, 2007.
2. Vinay K. Ingle and John. G. Proakis, *Digital Signal Processing Using MATLAB*, PWS Publishing Company, 1997.
3. Gerard Blanchet and Maurice Charbit, *Digital Signal and Image Processing using MATLAB*, ISTE Ltd, 2006
4. Paul M. Embree, *C Algorithms for Real-time DSP*, Prentice Hall PTR, 1995.

Course plan

Item	Description	Time	
1	Octave/MATLAB based Experiments	4 Weeks	

2	CCS and TMS kits based Experiments	4 Weeks	
3	Preparation of Laboratory Record	2 Weeks	
4	Internal Examination	2 Weeks	
5	Publishing Grades	2 Weeks	

SECOND SEMESTER COURSES

Course No.	Course Name	L - T - P - Credits	Year of Introduction
10EC6102	**DIGITAL IMAGE PROCESSING**	**3 - 0 - 0 - 3**	**2015**

Course Prerequisites

(1) Basic knowledge in DSP and Linear Algebra at UG level.
(2) Basic knowledge in data compression at UG level.

Course Objectives

(1) To extend the knowledge on DSP to 2-D signal processing and hence to analyze digital images.
(2) To study the various aspects of image processing like restoration, enhancement, compression, etc.

Syllabus

Gray scale and colour Images, image sampling, quantization and reconstruction, Human visual perception, transforms: DFT, FFT, WHT, Haar transform, KLT, DCT, Filters in spatial and frequency domains, histogram-based processing, Edge detection - non parametric and model based approaches, LOG filters, Image Restoration - PSF, circulant and block-circulant matrices, deconvolution, restoration using inverse filtering, Wiener filtering and maximum entropy-based methods, Binary morphology, dilation, erosion, opening and closing, gray scale morphology, applications, thinning and shape decomposition, Image and video compression : Lossy and lossless compression, Transform based sub-band decomposition, Entropy Encoding, JPEG, JPEG2000, MPEG, Computer tomography - parallel beam projection, Radon transform, Back-projection, Fourier-slice theorem, CBP and FBP methods, Fan beam projection, Image texture analysis - co-occurrence matrix, statistical models, Hough Transform, boundary detection, chain coding, segmentation and thresholding methods.

Expected Outcomes

The students are expected to :
(1) Attain an ability to extend the one-dimensional DSP principles to two-dimension;
(2) Have good knowledge in various image processing methodologies.

References

1. A. K. Jain, *Fundamentals of digital image processing*, PHI, 1989.
2. Gonzalez and Woods, *Digital image processing* ,3/E Prentice Hall, 2008.
3. R.M. Haralick, and L.G. Shapiro, *Computer and Robot Vision*, Addison Wesley, 1992.
4. R. Jain, R. Kasturi and B.G. Schunck, *Machine Vision*, MGH International Edition, 1995.
5. W. K. Pratt, *Digital image processing*, Prentice Hall, 1989.
6. David Forsyth & Jean Ponce, *Computer Vision: A modern approach*, Pearson Edn., 2003
7. C . M. Bishop, *Pattern Recognition & Machine Learning*, Springer 2006

Course plan

Module	Content	Hours	Semester

			Exam Marks (%)
I	Image representation - Gray scale and colour Images, Representation of 2D signals, image sampling, quantization and reconstruction	4	15
	Two dimensional orthogonal transforms -Digital images, Human visual perception, transforms: DFT, FFT, WHT, Haar transform, KLT, DCT.	4	
II	Image enhancement - filters in spatial and frequency domains, histogram-based processing, homomorphic filtering.	4	15
	Edge detection - non parametric and model based approaches, LOG filters, localization problem.	4	
First Internal Examination			
III	Image Restoration - PSF, circulant and block-circulant matrices, deconvolution, restoration using inverse filtering, Wiener filtering and maximum entropy-based methods.	4	15
	Image texture analysis - co-occurrence matrix, measures of textures, statistical models for textures. Hough Transform, boundary detection, chain coding, segmentation and thresholding methods.	4	
IV	Mathematical morphology - binary morphology, dilation, erosion, opening and closing, duality relations, gray scale morphology, applications such as hit-and-miss transform, thinning and shape decomposition.	8	15
Second Internal Examination			
V	Image and Video Compression Standards: Lossy and lossless compression schemes: Transform Based, Sub-band Decomposition, Entropy Encoding, JPEG, JPEG2000, MPEG	6	20
VI	Computer tomography - parallel beam projection, Radon transform, and its inverse, Back-projection operator, Fourier-slice theorem, CBP and FBP methods, ART, Fan beam projection.	6	20
Cluster Level End Semester Examination			

Course No.	Course Name	L - T - P - Credits	Year of Introduction
10EC6402	**VLSI SIGNAL PROCESSING**	**3 - 0 - 0 - 3**	**2015**

Course Prerequisites

Basics of VLSI

Basics of Signal processing

Course Objectives

To have an advanced level knowledge on VLSI DSP Systems, Design and implementation

Syllabus

DSP Systems, Pipelining and Parallel Processing of FIR Filters, Retiming and Unfolding, Algorithmic Strength Reduction, Fast Convolution, Pipelining and Parallel Processing of IIR

Filters, Scaling, Round-off noise, Bit-level Arithmetic Architectures

Expected Outcomes

Through this paper, the students will have a thorough knowledge about the various VLSI structures for signal processing.

References

1. Keshab K. Parhi, *VLSI Digital Signal Processing Systems, Design and implementation*, Wiley, Interscience, 2007.
2. U. Meyer , Baese, *Digital Signal Processing with Field Programmable Gate Arrays*, Springer, Second Edition, 2004

Course plan

Module	Content	Hours	Semester Exam Marks (%)
I	**DSP Systems, Pipelining and Parallel Processing of FIR Filters:** Introduction to DSP systems, Typical DSP algorithms, Data flow and Dependence graphs, critical path, Loop bound, iteration bound, longest path matrix algorithm, Pipelining and Parallel processing of FIR filters, Pipelining and Parallel processing for low power.	8	15
II	**Retiming and Unfolding:** Retiming, definitions and properties, Unfolding, an algorithm for unfolding, properties of unfolding, sample period reduction and parallel processing application.	6	15
First Internal Examination			
III	**Algorithmic Strength Reduction** Algorithmic strength reduction in filters and transforms, 2-parallel FIR filter, 2-parallel fast FIR filter, DCT architecture, rank-order filters, Odd-Even merge-sort architecture, parallel rank order filters.	8	15
IV	**Fast Convolution :** Fast convolution, Cook-Toom algorithm, modified Cook-Toom algorithm	2	15
	Pipelining and Parallel Processing of IIR Filters: Pipelined and parallel recursive filters, Look-Ahead pipelining in first-order IIR filters, Look-Ahead pipelining with power-of-2 decomposition, Clustered look-ahead pipelining, Parallel processing of IIR filters, combined pipelining and parallel processing of IIR filters.	6	
Second Internal Examination			
V	**Scaling and Round-off noise:** Scaling and round-off noise, scaling operation, round-off noise, state variable description of digital filters, scaling and round-off noise computation, round-off noise in pipelined IIR filters.	7	20
VI	**Bit-level Arithmetic Architectures:** Bit-level arithmetic architectures, parallel multipliers with sign extension, parallel carry-ripple and carry-save multipliers, Design of Lyon's bit-serial multipliers using Horner's rule, bit-serial FIR filter, CSD representation, CSD multiplication using Horner's rule for precision improvement, Distributed Arithmetic fundamentals and FIR filters.	8	20
Cluster Level End Semester Examination			

Course No.	Course Name	L - T - P - Credits	Year of Introduction
10EC6404	**Adaptive Signal Processing**	3 - 0- 0 - 3	2015

Course Prerequisites

(1) Basic knowledge of Signal processing at UG/PG Level.
(2) Basic knowledge of different transform domains like Fouries, Laplace, Z transform etc.

Course Objectives

The course is designed to provide students a strong background in the concept of signal processing and apply it to the signals which can process adaptively.

Syllabus

Adaptive systems - definitions and characteristics - applications - properties- Correlation matrix and its properties- z transform- Searching performance surface- gradient estimation - performance penalty - LMS algorithm- sequential regression algorithm - adaptive recursive filters - Kalman filters- Applications- adaptive modeling and system identification-adaptive modeling for multipath communication channel, geophysical exploration, inverse adaptive modeling, equalization, and deconvolution-adaptive equalization of telephone channels

Expected Outcomes

The students are expected to :
(1) Understand basic concepts of adaptive signal processing
(2) Top-level understanding of the convergence issues, computational complexities and optimality of different filters

References

1.Bernard Widrow and Samuel D. stearns, "Adaptive Signal Processing", Person Education, 2005.
2.Simon Haykin, " Adaptive Filter Theory", Pearson Education, 2003.
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.

Course plan

Module	Content	Hours	Semester Exam Marks (%)
I	**Adaptive systems** - definitions and characteristics - applications - properties-examples - adaptive linear combiner-input signal and weight vectors, performance function, Gradient and minimum mean square error, Alternate expressions of gradient	6	15

II	**Theory of adaptation with stationary signals:** Correlation matrix and its properties, its physical significance.Eigen analysis of matrix, structure of matrix and relation with its eigen values and eigen vectors. Z Transforms in Adaptive signal processing and its applications	8	15
First Internal Examination			
III	**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 – misadjustments	8	15
IV	**LMS algorithm** - convergence of weight vector-LMS/Newton algorithm - properties - sequential regression algorithm - adaptive recursive filters - random-search algorithms	8	15
Second Internal Examination			
V	**Kalman filters** - recursive minimum mean square estimation for scalar random variables- statement of Kalman filtering problem-innovation process-estimation of the state-filtering-initial conditions-Kalman filter as the unifying basis for RLS filters	7	20
VI	**Applications** - adaptive modeling and system identification-adaptive modeling for multipath communication channel, geophysical exploration,inverse adaptive modeling, equalization, and deconvolution-adaptive equalization of telephone channels, Adaptive interference canceling: applications in Bio-signal processing	8	20
Cluster Level End Semester Examination			

Course No.	Course Name	L - T - P - Credits	Year of Introduction
10EC6414	**PRINCIPLES OF DIGITAL SYSTEM DESIGN**	**3 - 0 - 0 - 3**	**2015**

Course Prerequisites

(1) Basic knowledge in Digital system level at UG level

Course Objectives

(1) To have an advanced level knowledge on circuit theory and logic design

(2)To Design the digital circuits with Programmable Logic Devices.

Syllabus

MSI and LSI circuits and their applications, Sequential Circuit Design ,Asynchronous sequential circuits, Analysis Designing with SM charts, Designing with Programmable Logic Devices, Other Sequential PLDs, Advanced Topics in Boolean algebra

Expected Outcomes

The students are expected to :

(1) Have an advanced level knowledge on Digital system design

(2) Know how the theory of Boolean algebra and logic circuits could be applied in specific domains, like sequential circuit and higher logic designs.

REFERENCES

1. Fundamentals of Digital Design, Charles H. Roth, Jr., PWS Pub.Co. 1998.
2. Digital Design Fundamentals, Kenneth J Breeding, Prentice Hall, Englewood Cliffs, New Jersey,1989.
3. A Systematic Approach to Digital Design, William I. Fletcher, PHI, 1996.
4. Introduction to Digital Design, James E. Palmer, David E. Perlman, Tata McGraw Hill, 1996.
5. Logic Synthesis, S.Devadas, A.Ghosh and K.Keutzer, McGraw Hill, 1994.
6. Logic Design Theory, N.N Biswas, Prentice Hall of India, 1st Edn,1993.
7. Digital Design Principles and Practices, John F. Wakerly, Prentice Hall, 4th Edition, 2001

Course plan

Module	Content	Hours	Semester Exam Marks (%)
I	MSI and LSI circuits and their applications: Arithmetic circuits, comparators, Multiplexers, Code Converters, XOR & AOI Gates,	4	15
	Design of sequential systems with small number of standard modules, State register Counters and RAM with combinational networks Multimodule implementation of sequential systems	4	
II	Sequential Circuit Design: Clocked Synchronous State Machine Analysis, Mealy and Moore machines, Finite State Machine design procedure – derive state diagrams and state tables,	5	15
	State reduction methods, and state assignments. Incompletely specified state machines. Implementing the states of FSM.	5	
First Internal Examination			
III	Asynchronous sequential circuits: Analysis**,** Derivation of excitation table, Flow table reduction, state assignment, transition table , design of asynchronous Sequential circuits, Race conditions and cycles, Static and dynamic hazards, Methods for avoiding races and hazards, essential hazards Designing with SM charts – State machine charts, Derivation of SM charts, and Realization of Transform. SM charts.	8	15
IV	**Designing with Programmable Logic Devices:** Read – Only Memories, Programmable Array Logic PALs, Programmable Logic Arrays PLAs – PLA minimization and PLA folding,		15
Second Internal Examination			
V	Other Sequential PLDs, Design of combinational and sequential circuits using PLD's.	5	20
	Complex Programmable Logic Devices and Field Programmable Gate Arrays - Altera Series FPGAs and Xilinx Series FPGAs.	5	
VI	Advanced Topics in Boolean algebra: Shannon's Expansion Theorem, Consensus Theorem, Reed Muller Expansion,	4	20
	Design of Static Hazard free and dynamic hazard free logic circuits, Threshold logic, Symmetric functions	4	
Cluster Level End Semester Examination			

Course No.	Course Name	L - T - P - Credits	Year of Introduction
10EC6114	**BIOMEDICAL SIGNAL PROCESSING**	**3 - 0 - 0 - 3**	**2015**

Course Prerequisites

(1) Basic knowledge of bio-signals and random signals
(2) Basic knowledge of digital signal processing

Course Objectives

(1) To develop innovative techniques of signal processing for computational processing and analysis of biomedical signals.
(2) To extract useful information from biomedical signals by means of various signal processing techniques.

Syllabus

Tasks in Biomedical Signal Processing - Computer Aided Diagnosis. Properties and effects of noise in biomedical instruments - Filtering in biomedical instruments - Modeling of Biomedical signals - Detection of biomedical signals in noise Event detection - case studies with ECG & EEG - Independent component Analysis - Cardio vascular applications - ECG Signal Processing - Heart Rhythm representation - Spectral analysis of heart rate variability - interaction with other physiological signals. 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 – Nonlinear modeling of EEG - artifacts in EEG & their characteristics and processing.

Expected Outcomes

The students are expected to :

(1) Understands how basic concepts and tools of science and engineering can be used in understanding and utilizing biological processes.
(2) Hands-on approach to learn about signal processing and physiological signals through the application of digital signal processing methods to biomedical problems.

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, New Delhi, 2005

Course plan

Module	Content	Hours	Semester Exam Marks (%)
I	**Introduction to Biomedical Signals** - Examples of Biomedical signals - ECG, EEG, EMG etc - Tasks in Biomedical Signal Processing- Computer Aided Diagnosis. Origin of bio-potentials	4	15
	Review of linear systems – Fourier Transform and Time Frequency	4	

	Analysis - (Wavelet) of biomedical signals - Properties and effects of noise in biomedical instruments - Filtering in biomedical instruments		
II	**Concurrent, coupled and correlated processes** - illustration with case studies - Adaptive and optimal filtering - Modelling 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	6	15
	Independent component Analysis - Cocktail party problem applied to EEG signals - Classification of biomedical signals.	4	
First Internal Examination			
III	**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	7	15
IV	**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.	7	15
Second Internal Examination			
V	**Neurological Applications**: The electroencephalogram - EEG rhythms & waveform - categorization of EEG activity - recording techniques - EEG applications- Epilepsy, sleep disorders, brain computer interface. Modelling EEG- linear, stochastic models – Nonlinear modelling of EEG - artifacts in EEG & their characteristics and processing	7	20
VI	**Model based spectral analysis** - EEG segmentation - Joint Time-Frequency analysis - correlation analysis of EEG channels - coherence analysis of EEG channels.	6	20
Cluster Level End Semester Examination			

Course No.	Course Name	L - T - P - Credits	Year of Introduction
10EC6314	**OPTICAL SIGNAL PROCESSING**	**3 - 0 - 0 - 3**	**2015**

Course Prerequisites

Basic knowledge in signal processing and optical systems at UG level

Course Objectives

To have an advanced level knowledge on Optical Signal Processing and systems

Syllabus

Basic signal parameters, Spectral Analysis, Spatial Filtering and Filtering System, Acousto-Optic devices, Spectrum analysers, Optical radio

Expected Outcomes

The students are expected to have a thorough knowledge about:

1. Various operations in optical domain
2. Optical components and their working

References

1. Vanderlught, *Optical Signal Processing*, John Wiley & Sons, New York, 2005
2. Mahlke Gunther, Goessing Peter, *Fiber optic cables: Fundamentals*, *Cable Engineering*, System planning, John Wiley, 3rd Edition, 2001
3. Hiroshi Murata, *Handbook of Optical Fibers and Cables* Marcel Dekker Inc., New York, 1998.
4. P.K. Das, *Optical Signal Processing Fundamentals*, Narosa Publishing New Delhi,1991.
5. Bradley G. Boone, *Signal Processing Wing Optics*, Oxford University Press, 1998.

Course plan

Module	Content	Hours	Semester Exam Marks (%)
I	**Basic signal parameters:** Characterization- Sample function-geometrical optics- basic laws Refraction by prisms- lens formula-imaging condition- optical invariants- physical optics-Transforms: Fresnel- Fourier- Inverse Fourier and Extended Fourier.	8	15
II	**Spectral Analysis:** Spatial light modulation- spatial light modulators-detection process, system performance process- dynamic range- raster format- spectral analysis	7	15
First Internal Examination			
III	**Spatial Filtering and Filtering System**: Types of spatial filters-optical signal processing and filter generation- read out module-orientation and sequential search- applications of optical spatial filter	8	15
IV	**Acousto-Optic devices:** Acousto-optic cells- spatial light modulators-Raman, Nath and Bragg mode	6	15
Second Internal Examination			
V	**Spectrum analysers:** basic spectrum analyzer - aperture weighting dynamic range and SNR- photo detector- geometric considerations , radiometer, photo detector size, optimum photo detector size for 1D and 2D structure	8	20
VI	**Optical radio-** spatial and temporal frequencies- Distributed and local oscillator - Dynamic range comparison of heterodyne and power spectrum analyzers.	8	20
Cluster Level End Semester Examination			

Course No.	Course Name	L - T - P - Credits	Year of Introduction
1OEC6104	**ESTIMATION AND DETECTION THEORY**	**3 - 0 - 0 - 3**	**2015**

Course Prerequisites

(1) Basic knowledge in Probability Theory at UG level
(2) Basic knowledge in Signal Processing at UG level

Course Objectives

(1) To have a good knowledge on detecting and estimating different signal parameters in signal processing applications.
(2) To throw light into the applications of probability theory in filter theory and applications.

Syllabus

Review of Probability Theory, Bayes rule of probability ;Elementary hypothesis testing, Bayes detection (Bayes Risk), MAP detection, Maximum Likelihood detection, Minimum Probability of Error criterion,

Min-Max criterion, Neyman-Pearson criterion, Receiver Operating Characteristic Curves;Multiple Hypothesis Testing; Applications in communication
Composite hypothesis testing, LRT, GLRT, UMP; Concept of : Chernoff bound, asymptotic relative efficiency, sequential and distributed detection, sign test, rank test.;Applications;
Role of estimation in Signal Processing, Unbiased estimation, Consistency, Minimum Variance, Minimum Variance Unbiased Estimator [MVUE], Finding MVUE, Cramer-Rao Lower Bound[CRLB] , Transformation of parameters, Linear Models; Sufficient Statistics, Neyman-Fisher Factorization– Concept of RBLS Theorem;Applications;
Concept of Linear Estimator, Best Linear Unbiased Estimator (BLUE), Batch estimation and Sequential estimation, Least Squares, Weighted least squares, Recursive least square estimation, Likelihood and Maximum likelihood estimation[MLE], Invariance property - MLE of transformed parameter;Applications;
Random parameter estimation – Bayesian estimation, Selection of prior pdf, Minimum Mean Square Error Estimation (MMSE) , Maximum a Posteriori Estimation (MAP), Concept of method of moments.
Applications in: Bayesian Estimation of Fourier Analysis, MAP of exponential pdf, DC level in WGN – uniform prior PDF.

Expected Outcomes

The students are expected to :

(1) Have a good knowledge on how we can detect a particular signal in signal processing aplications;

(2) Know how to estimate the parameters of a signal that is detected in practical signal processing applications.

References

1. M D Srinath, P K Rajasekaran, R Viswanathan, Introduction to Statistical Signal Processing with Applications, “Pearson”.
2. Steven M. Kay, “Fundamentals of Statistical Signal Processing: Vol 1: Estimation Theory”, Prentice Hall Inc
3. Steven M. Kay, “Fundamentals of Statistical Signal Processing: , Vol 2: Detection Theory”, Prentice Hall Inc.
4. H.L. Van Trees, “Detection , Estimation and Modulation Theory, Part I”, Wiley.
5. H.V. Poor, “An introduction to Signal Detection and Estimation”, 2nd edition, Springer.

Course plan

Module	Content	Hours	Semester Exam Marks (%)
I	Review of Probability Theory, Bayes rule of probability ;Elementary hypothesis testing, Bayes detection (Bayes Risk), MAP detection, Maximum Likelihood detection.	5	15
	Minimum Probability of Error criterion, Min-Max criterion, Neyman-Pearson criterion.	4	
II	Receiver Operating Characteristic Curves, Detection Performance; Multiple Hypothesis Testing;	4	15
	Applications in communication: DC level in WGN using different detection methods, Multiple DC levels in WGN.	5	
First Internal Examination			
III	Composite hypothesis testing, LRT, GLRT, UMP; Deterministic signals and random signals, Detection of deterministic signals and random signals in Gaussian noise;	5	15

	Applications in: Matched Filter, Replica-Correlator, Minimum Distance Receiver, Sinusoidal Detection, Pattern Recognition. Concept of : Chernoff bound, asymptotic relative efficiency, sequential and distributed detection, sign test, rank test.;	4	
IV	Role of estimation in Signal Processing, Unbiased estimation, Consistency, Minimum Variance, Minimum Variance Unbiased Estimator [MVUE], Finding MVUE, Cramer-Rao Lower Bound[CRLB] , Transformation of parameters, Linear Models;	5	15
	Sufficient Statistics, Neyman-Fisher Factorization, Use of Sufficient statistics to find the MVUE – Concept of RBLS Theorem. Applications in : DC level in WGN, Phase estimation, Frequency estimation, Line fitting, Range estimation, Fourier Analysis.	4	
Second Internal Examination			
V	Concept of Linear Estimator, Best Linear Unbiased Estimator (BLUE), Batch estimation and Sequential estimation, Least Squares, Weighted least squares, Recursive least square estimation;	4	20
	Likelihood and Maximum likelihood estimation[MLE], Invariance property - MLE of transformed parameter; Applications in : DC level in WGN, Source Localization, MLE of DC level in WGN.	5	
VI	Random parameter estimation – Bayesian estimation, Selection of prior pdf, Minimum Mean Square Error Estimation (MMSE) , Maximum a Posteriori Estimation (MAP), Concept of method of moments.	4	20
	Applications in: Bayesian Estimation of Fourier Analysis, MAP of exponential pdf, DC level in WGN – uniform prior PDF.	5	
Cluster Level End Semester Examination			

Course No.	Course Name	L - T - P - Credits	Year of Introduction
10EC6316	**Multidimensional Signal Processing**	**3 - 0 - 0 - 3**	**2015**

Course Prerequisites

(1) Basic knowledge in signal processing at UG level
(2) Basic knowledge in Transform domain at UG level

Course Objectives

(1) To have an advanced level knowledge on Multidimensional Signal Processing
(2) To design multidimensional digital filters according to various applications.

Syllabus

Multidimensional Systems Fundamental operations on Multidimensional signals, Frequency responses of 2D LTI Systems- Impulse response- Multidimensional Fourier transforms **- Sampling continuous 2D signals - Multidimensional Discrete Fourier Transform -** Calculation of DFT- DFT for periodically sampled signals - Fast Fourier transform for periodically sampled signals- The Discrete Cosine Transform.**- Multidimensional Digital Filter Design -**Separable Filters- Linear phase filters- FIR Filters- Implementation of FIR filters - design of FIR filters using windows- Two dimensional window functions, IIR Filters

Expected Outcomes

The students are expected to :
(1) Have an advanced level knowledge on Multidimensional Signal Processing

(2) Know how to design a multidimensional digital filter.

References

1. Dudgeon Dan E. , Multidimensional Digital Signal Processing, Prentice Hall, Englewood Cliffs, New Jersey
2. P.P. Vaidyanathan. “Multirate systems and filter banks.” Prentice Hall. PTR. 1993.
3. Two- Dimensional Signal and Image Processing , JAE S. LIM - Prentice Hall Englewood Cliffs, New Jersey, 1990

Course plan

Module	Content	Hours	Semester Exam Marks (%)
I	Fundamental operations on Multidimensional signals, Linear Shift - Invariant systems-cascade and parallel connection of systems- separable systems, stable systems-.	4	15
	. Frequency responses of 2D LTI Systems- Impulse response- Multidimensional Fourier transforms- z transform, properties of the Fourier and z transform	4	
II	Periodic sampling with rectangular geometry- sampling density,	3	15
	Aliasing effects created by sampling - Periodic sampling with different sampling geometrics-hexagonal- Quincunx etc.- comparison	4	
First Internal Examination			
III	Multidimensional discrete Fourier transform- Properties of DFT, Circular convolution- Calculation of DFT- DFT for periodically sampled signals - Fast Fourier transform for periodically sampled signals- The Discrete Cosine Transform.	8	15
IV	Separable Filters- Linear phase filters- FIR Filters- Implementation of FIR filters - design of FIR filters using windows- Two dimensional window functions	7	
Second Internal Examination			
V	Design and implementation of two dimensional IIR filters: classical 2 D IIR filter implementations, Iterative implementation of 2 D IIR filters,	4	20
	Signal flow graphs- circuit elements and their realizations, state variable realizations,	3	
VI	dimensional Inverse problems: Constrained iterative signal restoration; iterative techniques for constrained deconvolution and signal extrapolation, reconstructions from phase or magnitude, ,	4	20
	Reconstruction of signals from their projections: Projection slice theorem Projection slice theorem, Discretization of the Reconstruction problem, Fourier domain reconstruction	4	

	algorithms		
Cluster Level End Semester Examination			

Course No.	Course Name	L - T - P - Credits	Year of Introduction
10EC6302	**WAVELET THEORY**	**3 - 0 - 0 - 3**	**2015**

Course Prerequisites

(1) Basic knowledge in DSP and Linear Algebra at UG level;
(2) Basic knowledge in Geometry and Transforms at UG level.

Course Objectives

(1) To understand the shortcomings of Fourier Transform and the need of Wavelets;
(2) To investigate the construction of Wavelets and to attain a good knowledge in Wavelet Theory.

Syllabus

Generalized Fourier theory, Fourier transform, Short-time Fourier transform, Time-frequency analysis, Theory of Frames : Bases, Resolution of unity, Definition of frames, Geometrical considerations, Frame projector, Wavelets : The basic functions, Admissibility conditions, CWT & DWT; MRA : Axioms, Construction of an MRA from scaling functions - The dilation equation, Compactly supported orthonormal wavelet bases - Necessary and sufficient conditions for orthonormality, Wavelet transform: Wavelet decomposition and reconstruction of functions in $L^2(R)$. Fast wavelet transform algorithms - Relation to filter banks, Wavelet packets – Representation of functions, Selection of basis, Regularity and selection of wavelets : Smoothness and approximation order - Analysis in Soboleve space, Criteria for wavelet selection with examples, Construction of wavelets : Splines, Sub-band filtering schemes, Bi-orthogonal basis, Bi-orthogonal system of wavelets - construction, The Lifting scheme.

Expected Outcomes

The students are expected to :
(1) Understand the shortcomings of Fourier Transform and the need of Wavelets;
(2) Understand the construction of Wavelets and attain a good knowledge in Wavelet Theory.

References

1. Stephen G. Mallat, "A wavelet tour of signal processing" 2nd Edition Academic Press, 2000.
2. M. Vetterli, J. Kovacevic, "Wavelets and subband coding" Prentice Hall Inc, 1995
3. Gilbert Strang and Truong Q. Nguyen, "Wavelets and filter banks" Cambridge Press, 1998.
4. Gerald Kaiser, "A friendly guide to wavelets" Birkhauser/Springer 1994, Indian reprint 2005.
5. Prasad and S. Iyengar, "Wavelet analysis with applications to image processing" CRC Press, 1997.
6. J. C. Goswami and A. K. Chan, "Fundamentals of wavelets: Theory, Algorithms and Applications" Wiley-Interscience Publication, John Wiley & Sons Inc., 1999.
7. Mark A. Pinsky, "Introduction to Fourier Analysis and Wavelets" Brooks/Cole Series,

2002.
8. R. M. Rao and A. Bopardikar, "Wavelet transforms: Introduction to theory and applications" Addison-Wesley, 1998.
9. H. L. Resnikoff and R. O. Wells, Jr., "Wavelet analysis: The scalable structure of information" Springer, 1998.
10. P. P. Vaidyanathan, "Multirate systems and filter banks" Prentice Hall P T R, 1993.
11. Michael W. Frazier, "An introduction to wavelets through linear algebra" Springer-Verlag, 1999.

Course plan

Module	Content	Hours	Semester Exam Marks (%)
I	Fourier and Sampling Theory : Generalized Fourier theory, Fourier transform, Short-time Fourier transform, Time-frequency analysis, Fundamental notions of the theory of sampling.	4	15
	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.	4	
II	Wavelets: The basic functions, Specifications, Admissibility conditions, Continuous wavelet transform (CWT), Discrete wavelet transform (DWT).	8	15
First Internal Examination			
III	Wavelet transform: Wavelet decomposition and reconstruction of functions in $L^2(R)$. Fast wavelet transform algorithms - Relation to filter banks, Wavelet packets – Representation of functions, Selection of basis.	7	15
IV	Multi-resolution analysis (MRA) of $L^2(R)$: The 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.	8	15
Second Internal Examination			
V	Regularity and selection of wavelets: Smoothness and approximation order - Analysis in Soboleve space, Criteria for wavelet selection with examples.	6	20
VI	Construction of wavelets : Splines, Cardinal B-spline MRA, Sub-band filtering schemes, Compactly supported orthonormal wavelet bases, Bi-orthogonality and bi-orthogonal basis, Bi-orthogonal system of wavelets - construction, The Lifting scheme.	8	20
Cluster Level End Semester Examination			

Course No.	Course Name	L - T - P - Credits	Year of Introduction
10EC6118	**STATISTICAL SIGNAL PROCESSING**	**3 - 0 - 0 - 3**	**2015**

Course Prerequisites

(1) Knowledge in Digital Signal Processing at UG level
(2) Knowledge in Probability and Matrices at UG level

Course Objectives

(1) To extend the knowledge on DSP to statistical signal processing;
(2) To have a good foundation in the design of various types of adaptive filters.

Syllabus

Review of fundamentals: Correlation matrix - Eigen analysis of matrix, Spectral decomposition of corr. matrix, positive definite matrices - Complex Gaussian processes, MA, AR, ARMA processes and their properties, method of Lagrange multipliers, LMMSE Filters : problem formulation, MMSE predictors, LMMSE predictor, orthogonality theorem, Yule-walker equation, Wiener Solution, Iterative solution of Wiener-Hopf's equation, Levinson Durbin Algorithm (LDA), Kalman Filter (KF), Adaptive filters: Filters with recursions - the steepest descent - Newton's method, LMS filter, the MSE of LMS and misadjusment, Criteria for convergence and LMS versions : normalized LMS, leaky, sign, variable step-size, Sub-band LMS adaptive filters: multi-rate concepts, decimation, interpolation, perfect reconstruction, Block LMS algorithm (BLMS): Frequency domain BLMS, IIR adaptive filters- output error method, equation error method, Recursive Least Square (RLS) method, Tracking performance of the time varying filters: Tracking performance of LMS and RLS filters. Applications : Spectral Estimation, System identification, channel equalization, noise and echo cancellation.

Expected Outcomes

The students are expected to :
(1) Have an ability to extend the knowledge on DSP to statistical signal processing;
(2) Have a good foundation in the design of various types of adaptive filters

References

1. B. Farhang-Boroujeny, Adaptive filters: Theory and Applications, John-Wiley, 1998.
2. S. Haykin. (1986). *Adaptive Filters Theory*. Prentice-Hall.
3. Dimitris G. Manolakis, Vinay K. Ingle, Stephan M Krgon, *Statistical and Adaptive Signal Processing*, McGraw Hill (2000).
4. Jones D. *Adaptive Filters* [Connexions Web site]. May 12, 2005. Available at: http://cnx.rice.edu/content/col10280/1.1/

Course plan

Module	Content	Hours	Semester Exam Marks (%)
I	Review of fundamentals : Correlation matrix - properties - physical significance. Eigen analysis of matrix, structure of matrix and relation with its Eigen values & Eigen vectors. Spectral decomposition of corr. matrix, positive definite matrices - properties - physical significance. Complex Gaussian processes, MA, AR, ARMA processes and their properties, method of Lagrange multipliers.	8	15

II	LMMSE Filters: Goal of adaptive signal processing, some application scenarios, problem formulation, MMSE predictors, LMMSE predictor, orthogonality theorem (concept of innovation processes), Yule-walker equation, Wiener Solution, Iterative solution of Wiener-Hopf's equation, Levinson Durbin Algorithm (LDA), inverse LDA, Method of steepest descent and its convergence criteria. Kalman Filter (KF), recursions, Extended KF, comparison of KF and Weiner filter.	8	15
First Internal Examination			
III	Adaptive filters: Filters with recursions - the steepest descent - Newton's method, criteria for the convergence, rate of convergence. LMS filter, mean and variance of LMS, the MSE of LMS and misadjusment, Criteria for convergence and LMS versions: normalized LMS, leaky, sign, variable step-size, filtered input LMS and complex LMS algorithms. Transform domain LMS algorithm using DFT and DCT, its performance improvement over LMS and Newton's LMS algorithm.	8	15
IV	Sub-band LMS adaptive filters: multi-rate concepts, decimation, interpolation, perfect reconstruction, oversampled filter bank design and delay-less sub-band adaptive filter. Block LMS algorithm(BLMS): Frequency domain BLMS(FBLMS), constrained FBLMS, partitioned FBLMS, delay-less FBLMS, iterated FBLMS.	7	15
Second Internal Examination			
V	IIR adaptive filters- output error method, equation error method, their problems and solutions. Recursive Least Square (RLS) method, fast transversal, fast lattice RLS and affine projection algorithms. Tracking performance of the time varying filters: Tracking performance of LMS and RLS filters.	7	20
VI	Applications : Spectral Estimation, System identification, channel equalization, noise and echo cancellation.	6	20
Cluster Level End Semester Examination			

10EC6106	CODING THEORY	3-0-0-3	2015

Course Prerequisites

Undergraduate level courses in probability and random processes, digital communications

Course Objectives

To provide an introduction to traditional and modern coding theory

Syllabus

Introduction to algebra: Groups, Fields, Arithmetic of Galois Field, Vector spaces. Block Codes, Convolutional Codes, Trellis Coded Modulation, Modern iterative coding, Low-density Parity-check Codes

Expected Outcomes

The students are expected to develop understanding about theory of coding and its application

References

1. Todd K. Moon, Error Control Coding, Mathematical Methods and Algorithms, Wiley
2. P. V. Kumar, M. Win, H-F.Lu, C. Georghiades, Error Control Coding and Techniques and Applications, {chapter in the handbook, Optical Fiber Telecommunications IV};edited by Ivan P. Kaminow and Tingye Li, 2002
3. W.Cary Huffman and Vera Pless, Fundamentals of Error Correcting Codes, Cambridge University Press, 2003
4. L. H. Charles Lee, Convolutional Coding: Fundamentals and Applications, Artech House, Boston
5. Shu Lin and Daniel Costello, Error Control Coding (2nd edition), Pearson, Prentice- Hall, 2004.
6. RudigerUrbanke and Thomas Richardson, Modern coding theory, Cambridge University Press.
7. R. W. Yeung., Information Theory and Network Coding, Springer, 2008.
8. T. M. Cover and J. A. Thomas, Elements of Information Theory, 2/E, Wiley Interscience, 2006
9. D. Tse and P Viswanath, *Fundamental of Wireless Communication*, Cambridge University Press , 2005.

Module	Content	Hours	Semester Exam Marks (%)
I	Mathematical Preliminaries: Introduction to algebra: Groups, Ring, Fields, Arithmetic of Galois Field, Vector spaces, the generalized distributive law	5	15

II	Block Codes,Cyclic Codes including Reed Solomon and BCH codes; List decoding of Reed Solomon Codes.	6	15
First Internal Examination			
III	Convolutional Codes: Structures of convolution codes, Suboptimal and optimal decoding of Convolutional codes- Viterbi Algorithm, BCJR algorithm, FanoMetric, Stack Algorithm, Fano Algorithm decoding, Error Analysis of convolution codes, Puctured Convolution codes	6	15
IV	Advanced coding techniques: Trellis Coded Modulation- Encoding and Decoding	6	15
Second Internal Examination			
V	Modern iterative coding,Turbo codes-Encoders, interleavers, turbo decoder.	5	20
VI	Low-density Parity-check Codes: Construction, Decoding LDPC Codes-Hard and Soft decoders, Message-passing decoders, Threshold phenomenon and density evolution.	6	20
Cluster Level End Semester Examination			

Course No.	Course Name	L - T - P - Credits	Year of Introduction
10EC6408	**MINI PROJECT**	**0 - 0 - 4 - 2**	**2015**

Course Prerequisites

(1) The habit of reading technical magazines, conference proceedings and journals;

(2) Skills in hardware/software implementation techniques earned through UG studies;

(3) The course Seminar-1 in the first semester.

Course Objectives

(1) To support the problem based learning approach and to enhance the reading habit among students;

(2) To enhance the skills regarding the implementation aspects of small hardware/software projects.

Guidelines

Each student has to do a mini project related to the branch of specialization under the guidance of a faculty member. It has to be approved by a committee constituted by the institute concerned. It is recommended that the same faculty member may serve as his/her Project Supervisor during 3rd& 4th semesters. The mini project is conceptualized in such a way that, some the outcomes of the work can be utilized in the selection of the thesis. Hence on completion of mini project the student can suggest possible list of their thesis topic in the second semester itself. The implementation of the mini project can be software and/or hardware based one. Mini project is envisaged as a way for implementing *problem based learning*. Problems of socially relevance and/or problems identified by the institute/ research organizations/ industry/ state should be given high priority. In such interdisciplinary and inter institutional projects, a student can have co-guide(s) from other department/ institute/ research organizations/ industry. The university encourages *interdisciplinary projects* and *problem based learning strategy*. The references cited for the mini project shall be *authentic*.

Expected Outcomes

The students are expected to :

(1) Develop skills regarding enumerating and selecting problems, subsequent analysis, and effective implementation of the solution;

(2) Be motivated and successful in the selection of the topic for the main project.

References

1. J.W. Bames, *Statistical Analysis for Engineers and Scientists*, McGraw Hill, New York.
2. Schank Fr., *Theories of Engineering Experiments*, Tata McGraw Hill Publication.
3. Douglas C Montgomery, *Design and analysis of experiments,* Wiley International
4. Leedy P D, *Practical Research : Planning and Design,* 4th Edition, N W MacMillan Publishing Co

Course plan

Item	Description	Time	
1	Abstract Submission	2 Weeks	
2	Allotment of Topic	1 Week	
3	Preliminary Presentation Sessions	1 Week	
4	Implementation Phase	9 Weeks	
5	Final Presentation-cum Demonstration	1 Week	

10EC6412	**IMAGE PROCESSING LABORATORY**	**0 - 0 - 2 -1**	**2015**

Course Prerequisites

(1) Knowledge in Digital Image Processing at UG level;

(2) Programming ability in MATLAB.

Course Objectives

(1) Explore the algorithms and techniques involved in Digital Image Processing using computational tools.

(2) The comprehensive understanding of digital imagery and digital image processing through the usage of computer algorithms to perform image processing on digital images.

Experiments

1. Basic Image Processing: Image resizing, rotation and quantization.
2. Mirror image generation, negative of an image, shrinking of an image, zooming of an image, image cropping.

3. Display Image in Gray scale, Red, Green and Blue.
4. Histogram algorithms: study of histogram, histogram normalization and histogram equalization.
5. Image filtering in spatial and in frequency domains.
6. Illustrate the effect of Laplacian Derivative on an image.
7. Illustrate the effect of Unsharp Mask and High boost filtering.
8. Illustrate the difference between arithmetic mean filter and Geometric mean filter in removing Gaussian noise.
9. Illustrate the effect of Square Averaging filter of different masks on an image.
10. The effect of order-statistics filter like Median Filter on an image corrupted by salt & pepper noise.
11. Slicing: Gray level (Intensity) slicing and bit plane slicing.
12. Image morphology: erosion, dilation, opening, closing, open-close, and close-open, demonstrate boundary extraction, interior filling etc.
13. Image Restoration.
14. Image Scanning.
15. Image Segmentation.
16. Image Enhancement.
17. Edge detection.
18. Image compression.
19. Color image processing: conversion between color spaces, Color Approximation, Quantization and Color Mapping.
20. 2-D DFT and DCT.

Expected Outcomes

The students should :

(1) Have an appreciation of the fundamentals of Digital image processing, image analysis and compression.

(2) Be able to implement basic image processing algorithms in MATLAB.

THIRD SEMESTER COURSES

Course No.	Course Name	L - T - P - Credits	Year of Introduction
10EC7105	AUDIO PROCESSING	3 - 0 - 0 - 3	2015

Course Prerequisites

(1) Basic knowledge in data compression and multimedia at UG level;

(2) Knowledge in Digital Signal Processing at PG level.

Course Objectives

(1) To apply the theoretical knowledge in DSP to audio processing;

(2) To have a good foundation in speech modeling, coding and compression.

Syllabus

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, Spectral analysis of speech - Short Time Fourier analysis - filter bank design. Auditory Perception : Psychoacoustics- Speech coding - sub-band coding of speech - transform coding - channel vocoder - formant vocoder - cepstralvocoder - homomorphic speech processing - homomorphic systems for convolution - complex cepstrums - Speech Transformations - Time Scale Modification - Voice Morphing. Automatic speech recognition systems - isolated word recognition - connected word recognition -large vocabulary word recognition systems - pattern classification - Audio Processing : Non speech and Music Signals - Modeling -Differential, transform and subband coding of audio signals & standards - Audio Data bases and applications - Content based retrieval.

Expected Outcomes

The students are expected to :

(1) Have the ability to apply the theoretical knowledge in DSP to audio processing;

(2) To have a good foundation in speech modeling, coding and compression.

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" PH.
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. Saito S. & Nakata K., "Fundamentals of Speech Signal Processing", Academic Press, Inc.
7. Papamichalis P.E., "Practical Approaches to Speech Coding", Texas Instruments, Prentice Hall
8. Jayant, N. S. and P. Noll. "Digital Coding of Waveforms: Principles and Applications to Speech and Video. Signal Processing Series", Englewood Cliffs: Prentice-Hall.

Course plan

Module	Content	Hours	Semester Exam Marks (%)
I	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 -	8	15

	PARCOR coefficients		
II	Spectral analysis of speech - Short Time Fourier analysis - filter bank design. Auditory Perception : Psychoacoustics- Frequency Analysis and Critical Bands - Masking properties of human ear.	6	15
First Internal Examination			
III	Speech coding -subband coding of speech - transform coding - channel vocoder - formant vocoder - cepstralvocoder - vector quantizer coder- Linear predictive Coder. Speech synthesis - pitch extraction algorithms - gold Rabiner pitch trackers - autocorrelation pitch trackers - voice/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.	8	15
IV	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.	8	15
Second Internal Examination			
V	Audio Processing : Non speech and Music Signals - Modeling - Differential, transform and subband coding of audio signals & standards - High Quality Audio coding using Psychoacoustic models - MPEG Audio coding standard.	6	20
VI	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.	6	20
Cluster Level End Semester Examination			

Course No.	Course Name	L - T - P - Credits	Year of Introduction
10EC7405	**SPECTRAL ESTIMATION**	**3 - 0 - 0 - 3**	**2015**

Course Prerequisites

(1) Linear algebra
(2) Random Process

Course Objectives

(1) To have an advanced level knowledge on Estimation theory.

Syllabus

Fundamentals of Discrete Time Signal Processing-Mathematical representation of Signals, Transform Domain representation of Continuous and Discrete signals, Discrete Time systems, Minimum phase and system invertibility, all pass systems. Review of Random variables and Random vectors, Whitening and innovations representations, Linear non parametric signal models, parametric pole zero signal models, Spectral analysis of deterministic signals. Parametric model based spectral analysis.

Expected Outcomes

The students are expected to :

(1) Have an advanced level knowledge on Spectral estimation theory

References

1. Statistical and Adaptive signal processing- Manalokis, Ingle and Kogon, Artech House INC., 2005.
2. Digital Signal Processing, A Computer Based approach- Sanjit K Mitra, Tata McGraw-Hill
3. Introduction to spectral analysis, Stoica, R L Moses, Prentice Hall
4. Modern Spectral Estimation Theory and Applications, Kay S M, Prentice Hall

Course plan

Module	Content	Hours	Semester Exam Marks (%)
I	**Fundamentals of Discrete Time Signal Processing:** Mathematical representation of Signals, Transform Domain representation of Continuous and Discrete signals, Fourier Series and Fourier Transforms, Sampling, DFT, Z Transform, Representing narrow band signals, Discrete Time systems, Analysis of LTI Systems, Response to Periodic inputs, Correlation analysis and spectral density.	9	20
II	Minimum phase and system invertibility, All pass systems, Minimum phase and all pass decomposition, Spectral factorization.	6	15
First Internal Examination			
III	**Random variables, vectors and sequences:** Review of Random variables and Random vectors, Discrete time stochastic processes, Linear systems with stationary random inputs, Whitening and innovations representations- Transformations using eigen and triangular decomposition, Discrete Karhunen Loeve transform, Principles of estimation theory.	9	20
IV	**Linear signal models**: Linear non parametric signal models, parametric pole zero signal models, Mixed Processes and the Wold decomposition, all-pole models, Linear Prediction, Autoregressive models, all zero models, Moving average models, pole-zero models, Auto regressive Moving Average Models.	10	15
Second Internal Examination			
V	**Non Parametric spectral estimation:** Spectral analysis of deterministic signals, Estimating auto correlation of stationary random signals, estimating power spectrum of stationary random signalsperiodogram, Blackmann Tukey method, Welch Bartlett method.	10	15

VI	**Parametric Model Based spectral analysis:** Spectral analysis based on AR, MA or ARMA, relation between model parameters and the auto correlation sequence, Power spectrum estimation using AR model- the Yule walker method	10	15
Cluster Level End Semester Examination			

Course No.	Course Name	L - T - P - Credits	Year of Introduction
10EC7109	**ARRAY SIGNAL PROCESSING**	**3 - 0 - 0 - 3**	**2015**

Course Prerequisites

(1) Basic knowledge in probability and random processes at UG level;
(2) Basic knowledge in digital communications at UG level.

Course Objectives

(1) To enable the students to understand the one to one correspondence of spatial signals with time domain signals and hence equip them to apply the time domain signal processing techniques in spatial domain.

Syllabus

Spatial Signals, Sensor Arrays, Spatial Frequency, Direction of Arrival Estimation, Wavenumber Frequency Space Spatial Sampling.

Expected Outcomes

The students are expected to :
(1) Develop understanding about theory of array signal processing.

References

1. Dan E. Dugeon and Don H. Johnson, Array Signal Processing: Conceptsand Techniques, Prentice Hall, 1993.
2. PetreStoica and Randolph L. Moses, Spectral Analysis of Signals, Prentice Hall, 2005, 1997.
3. Bass J, McPheeters C, Finnigan J, Rodriguez E. Array Signal Processing[Connexions Web site]. February 8, 2005. Available at:http://cnx.rice.edu/content/col10255/1.3/
4. Harry L. Van Trees; Optimum Array Processing; Wiley-Interscience.
5. Sophocles J Orfandis ; Electromagnetic Waves and Antennas.

Course plan

Module	Content	Hours	Semester Exam Marks (%)
I	Introduction to array signal processing: Signals in space and time, Spatial frequency, Direction vs. frequency, Wave fields, Far field and Near field signals.	7	15
II	Review of Co-ordinate Systems, Maxwell's Equation, Wave Equation. Solution to Wave equation in Cartesian Co-ordinate system - Wavenumber vector, Slowness vector.	7	15
First Internal Examination			
III	Spatial sampling, Nyquist criterion, Sensor arrays, Uniform linear arrays, planar and random arrays, Array transfer (steering) vector, Array steering vector for ULA, Broadband arrays.	7	15

IV	Aliasing in spatial frequency domain, Spatial Frequency Transform, Spatial spectrum, Spatial Domain Filtering, Beam Forming, Spatially white signal.	7	15
Second Internal Examination			
V	Non parametric methods, Beam forming and Capon methods, Resolution of Beam forming method, Subspace methods – MUSIC, Minimum Norm and ESPRIT techniques, Spatial Smoothing.	7	20
VI	Application of array signal processing in signal analysis.	7	20
Cluster Level End Semester Examination			

Course No.	Course Name	L - T - P - Credits	Year of Introduction
10EC7305	**COMPUTER VISION**	**3 - 0 - 0 - 3**	**2015**

Course Prerequisites

(1) Basic knowledge in optics at UG level;
(2) Basic knowledge in digital image processing at UG level.

Course Objectives

(1) To investigate the issues in machine vision;
(2) To have a good foundation in stereo vision, depth analysis and image understanding.

Syllabus

Imaging model and geometry: scene radiance and image irradiance, reflectance model of a surface, Lambertian and specular reflectance, photometric stereo, Ill-posedness of vision problems: regularization theory.; Shape from shading, structured light and texture. Optical flow, structure from motion and recursive motion analysis, Stereo vision and correspondence problem.; Depth analysis using real-aperture camera: depth from defocused images, MRF approach to early vision problems: (shape from shading, matching, stereo and motion), Image texture analysis, Introduction to image understanding, Integrated vision, sensor fusion, Affine structure from motion - Elements of affine geometry - Affine structure from two images.

Expected Outcomes

The students are expected to :
(1) Have the ability to estimate depth using computer vision techniques;
(2) Acquire a good knowledge in image understanding.

References

1. B. K. P. Horn, Robot Vision, MIT Press, 1986.
2. D. Marr, Vision, Freeman and Co., San Francisco, 1982.
3. S. Chaudhuri and A. N. Rajagopalan, Depth from Defocused Images, Springer Verlag, NY, 1999, Selected Papers.
4. David A. Forsyth, Jean Ponc, Computer Vision, A Modern Approach, Prentice Hall, 2002

Course plan

Module	Content	Hours	Semester

			Exam Marks (%)
I	Imaging model and geometry: scene radiance and image irradiance, reflectance model of a surface, Lambertian and specular reflectance, photometric stereo.	8	15
II	Ill-posedness of vision problems: regularization theory.; Shape from shading, structured light and texture. Optical flow, structure from motion and recursive motion analysis.	8	15
First Internal Examination			
III	Stereo vision and correspondence problem.; Depth analysis using real-aperture camera: depth from defocused images.	6	15
IV	MRF approach to early vision problems: (shape from shading, matching, stereo and motion), Image texture analysis.	6	15
Second Internal Examination			
V	Introduction to image understanding, Integrated vision, sensor fusion.	6	20
VI	Affine structure from motion - Elements of Affine Geometry - Affine Structure from Two Images - Singular Value Decomposition Technique - Factorization Approach to Affine Motion Analysis	8	20
Cluster Level End Semester Examination			

Course No.	Course Name	L-T-P-Credits	Year of Introduction
10EI7107	**DIGITAL CONTROL SYSTEMS DESIGN**	**3-0-0- 3**	**2015**

Course Prerequisites

Basic knowledge of Control system theory at UG Level.

Course Objectives

The course is designed to provide students a strong background in the concept and analysis of control system theory in discrete domain.

Syllabus

Introduction to discrete domain, State space representation and analysis in discrete domain, State observation, State control, State feedback. Full order and lower order observers, Pole placement, Ideal tracking system design.

Expected Outcomes

The students areable to

- Apply the general concepts of control systems in discrete domain
- Understand the concept of state space representation of systems
- Familiarize the concept of state observability and controllability
- Design state feedback controllers
- Design Ideal model tracking systems
- Analyze system stability and design controlled systems.

References

1. Gene H. Hostetter, Digital Control System, Second Edition Holt,Rinehart and Winston, Inc.U.S, 1997
2. Ogata K, Discrete Time Control Systems, Pearson Education, 2001.
3. Gopal M, Digital Control and State variable Methods, Second Edition, Tata McGrawHill, New Delhi, 2003.

Module	Content	Hours	Semester Exam Marks (%)
I	**Introduction to discrete domain:** Discrete time signals, Discrete time systems, Sampling and reconstruction, digitizing analogcontrollers.	8	15
II	**State space representation and analysis in discrete domain:**Discrete time state equations, discrete time system response, the characteristic value problem,Uncoupling state equations, Observability and controllability.	6	15
	First Internal Examination		
III	**State observation:** Observability and state observation, Estimation and identification.	4	15
	State Control: Controllability and state control,State feedback, Output feedback.	4	
IV	**State feedback control design:** Full order state observer, Observer design, Lower-order observers, Eigenvalue placement with observer feedback.	6	15
	Second Internal Examination		
V	**Ideal tracking system design:** Ideal tracking system design, Response model tracking system design, Reference model trackingsystem design.	6	20
VI	**Pole Placement design:** Introduction, Basic concepts, State regulator design **Lyapunov stability Analysis:**Basic concepts, Asymptotic stability, Conditions of stability, Stability analysis.	8	20
	Cluster Level End Semester Examination		

Course No.	Course Name	L - T - P - Credits	Year of Introduction
10EC7113	**PATTERN RECOGNITION**	**3 - 0 - 0 - 3**	**2015**

Course Prerequisites

(1) Basic knowledge in probability and linear algebra at UG level;

(2) Basic knowledge in digital signal processing at UG level.

Course Objectives

(1) To apply the theoretical knowledge in probability, linear algebra and DSP to pattern recognition;
(2) To have a good foundation in methods for feature selection, classification and clustering.

Syllabus

Features, feature vectors and classifiers, Supervised versus unsupervised pattern recognition, Classifiers based on Bayes Decision theory- Linear classifiers,- Linear discriminant functions and decision hyper planes, The perceptron algorithm, MSE estimation, Support Vector Machines (SVM), Non-Linear classifiers - Two layer and three layer perceptrons, Back propagation algorithm, Radial Basis function networks, Decision trees, combining classifiers, Receiver Operating Characteristics (ROC) curve, Class separability measures, Feature Generation - Linear transforms - KLT, SVD, ICA, DFT, DCT, DST, Hadamard Transform, Wavelet Transform, Regional features, features for shape and characterization, Fractals, Context dependent classification, HMM, Viterbi Algorithm. System evaluation, Cluster analysis, Proximity measures, Clustering Algorithms - Sequential algorithms, Neural Network implementation., Agglomerative algorithms, Divisive algorithms, Fuzzy clustering algorithms, Probabilistic clustering, K-means algorithm, Clustering algorithms based on graph theory, Binary Morphology Clustering Algorithms, Boundary detection methods.

Expected Outcomes

The students are expected to :
(1) Apply the theoretical knowledge in probability, linear algebra and DSP to pattern recognition;
(2) To have a good foundation in methods for feature selection, classification and clustering.

References

1. Sergios Theodoridis, Konstantinos Koutroumbas, *Pattern Recognition*, Academic Press, 2006.
2. Duda and Hart P.E, *Pattern classification and scene analysis*, John Wiley and sons, NY, 1973.
3. E. Gose, R. Johnsonbaugh, and S. Jost, *Pattern Recognition and Image Analysis*, PHI, 1999.
4. Fu K.S., Syntactic *Pattern recognition and applications*, Prentice Hall, Eaglewood cliffs, N.J., 1982.
5. R. O. Duda, P. E. Hart and D. G. Stork, *Pattern classification*, John Wiley & Sons Inc., 2001.
6. Andrew R. Webb, *Statistical Pattern Recognition*, John Wiley & Sons, 2002.
7. D. Maltoni, D Maio, AK Jain, S Prabhakar, Handbook of Fingerprint Verification, Springer Verlag, 2003.
8. S. Â Kung, M. Â Mak, S.Â Lin, Biometric Authentication: A Machine Learning Approach, PH PTR, 2004.
9. Paul Reid, *Introduction to Biometrics and Network Security*, Prentice Hall PTR, 2004.

Course plan

Module	Content	Hours	Semester Exam Marks (%)
I	Features, feature vectors and classifiers, Supervised versus unsupervised pattern recognition. Classifiers based on Bayes Decision theory- introduction, discriminant functions and decision surfaces, Bayesian classification for normal distributions, Estimation of unknown probability density functions, the nearest neighbour rule.	8	15
II	Linear classifiers,- Linear discriminant functions and decision hyper planes, The perceptron algorithm, MSE estimation, Logistic determination, Support Vector Machines (SVM).	6	15
First Internal Examination			

III	Non-Linear classifiers - Two layer and three layer perceptrons, Back propagation algorithm, Networks with Weight sharing, Polynomial classifiers, Radial Basis function networks, Support Vector machines-nonlinear case, Decision trees, combining classifiers, Feature selection, Receiver Operating Characteristics (ROC) curve, Class separability measures, Optimal feature generation, The Bayesian information criterion.	8	15
IV	Feature Generation - Linear transforms - KLT, SVD, ICA, DFT, DCT, DST, Hadamard Transform, Wavelet Transform, Wavelet Packets - 2-D generalizations - Applications. Regional features, features for shape and characterization, Fractals, typical features for speech and audio classification, Template Matching, Context dependent classification - Bayes classification, Markov chain models, HMM, Viterbi Algorithm. System evaluation - Error counting approach, Exploiting the finite size of the data.	8	15
Second Internal Examination			
V	Cluster analysis, Proximity measures, Clustering Algorithms - Sequential algorithms, Neural Network implementation. Hierarchical algorithms - Agglomerative algorithms, Divisive algorithms. Schemes based on function optimization - Fuzzy clustering algorithms, Probabilistic clustering, K-means algorithm.	8	20
VI	Clustering algorithms based on graph theory, Competitive learning algorithms, Binary Morphology Clustering Algorithms, Boundary detection methods, Valley seeking clustering, Kernel clustering methods. Clustering validity.	6	20
Cluster Level End Semester Examination			

Course No.	Course Name	L - T - P - Credits	Year of Introduction
10EC7307	**MULTIMEDIA SYSTEMS**	**3 - 0 - 0 - 3**	**2015**

Course Prerequisites

(1) Basic knowledge in digital image processing at UG level;

(2) Basic knowledge in data compression at UG level.

Course Objectives

(1) To study the various types of representation of multimedia;

(2) To have a good foundation in the methods for compression for audio, image and video.

Syllabus

Multimedia Data Representations- audio, images, video, colour, Basics of audio - Digitization of sound, Typical Audio Formats (.au, .wav) Introduction to MIDI, Graphic/Image File Formats - Graphic/Image Data Structures. Standard System Independent Formats (GIF, JPEG, TIFF, PNG, PS, EPS), Color in Image and Video - Basics of Color, Human visual system, Rods and Cones. Color Models in Images and Video, Basics of Video - Types of Color Video Signals, Basics of Signal Compression: Lossless Compression Algorithms - Basics of Information Theory. Huffman Coding, Lempel-Ziv-Welch Algorithm, Lossy Image Compression – Overview of JPEG. JPEG 2000, Audio Compression: Simple Audio Compression Methods. Psychoacoustics, Overview of Audio Standards - MPEG, AAC, AC3, Video Compression: Fundamentals of Lossy Video Compression - Intra Frame and Inter Frame redundancy, Motion estimation techniques, Motion compensation, Intra Frame Prediction, Overview of Video Standards – MPEG video standards, Video Teleconferencing Standards.

Expected Outcomes

The students are expected to :

(1) Have good knowledge in various types of representation of multimedia;

(2) To have a good foundation in the methods for compression for audio, image and video.

References

1. V. Bhaskaran and K. Konstantinides, "Image and Video Compression Standards: Algorithms and Architectures", 2nd ed., *Kluwer Academic Publishers*, 1997.
2. Steinmetz, Ralf; Nahrstedt, Klara, "Multimedia Fundamentals, Volume 1: Media Coding And Content Processing", Pearson Education India, 2002.
3. Keith Jack, "Video Demystified: A Handbook for the Digital Engineer", 4th ed, Newnes, 2004.
4. Symes, Peter D, "Video Compression Demystified", McGraw-Hill, 2001.
5. K. R. Rao, Zoran S. Bojkovic, Dragorad A Milovanovic – *Multimedia Communication Systems: Techniques, Standards and Networks*- Prentice Hall.

Course plan

Module	Content	Hours	Semester Exam Marks (%)
I	Audio and speech - Introduction, speech generation, phonemes, mechanism of hearing, HAS, digitization of audio, basics of digital audio - Typical Audio Formats (.au, .wav), Introduction to MIDI.	6	15
II	Representation of images, types of images, Graphic/Image File Formats - Graphic/Image Data Structures, Standard System Independent Formats (GIF, JPEG, TIFF, PNG, PS, EPS), System Dependent Formats (XBM, BMP).	8	15
First Internal Examination			
III	Color in Image and Video - Basics of Color, Human visual system, Rods and Cones, Color Models in Images (RGB, CMY), Color Models in Video (RGB, YUV, YCrCb), Basics of Video - Types of Color Video Signals, Analog Video, Digital Video.	8	15
IV	Basics of Signal Compression : Lossless Compression Algorithms - Basics of Information Theory, Huffman Coding. Adaptive Huffman Coding, Lempel-Ziv-Welch Algorithm, Lossy Image Compression – Overview of JPEG. JPEG 2000.	6	15
Second Internal Examination			
V	Audio Compression: Simple Audio Compression Methods, Psychoacoustics, Overview of Audio Standards - MPEG, AAC, AC3.	6	20
VI	Video Compression: Fundamentals of Lossy Video Compression - Intra Frame and Inter Frame redundancy. Motion estimation techniques. Motion compensation. Intra Frame Prediction. Faster algorithms for motion estimation. De-blocking. Rate Control. Overview of Video Standards – MPEG video standards, Video Teleconferencing Standards.	8	20
Cluster Level End Semester Examination			

Course No.	Course Name	L - T - P - Credits	Year of Introduction

10EC7117	INFORMATION HIDING AND DATA ENCRYPTION	3 - 0 - 0 - 3	2015

Course Prerequisites

Basic knowledge of data encryption at UG Level.

Course Objectives

To develop understanding about information hiding and data encryption.

Syllabus

Basics of Linear Algebra, Information Hiding, Hiding in 1D signals,2D signals and videos,Steganalysis and Quality evaluation.

Expected Outcomes

The students are expected to understand the importance of information hiding and to explore techniques of hiding data using steganography.

References

1Neal Koblitz, A Course in Number Theory and Cryptography, 2nd Edition, Springer
2. Stefan Katzenbeisser, Fabien A. P. Petitcolas, Information Hiding Techniques for Steganography and Digital Watermarking, Artech House Publishers, 2000.
3. Neil F Johnson et al Kluwer, Information hiding: steganography and watermarking attacks and countermeasures Academic Publishers London.
4. Ingmar J Cox eta al, Digital Watermarking, Morgan Kaufman Series, Multimedia information and system.
5.Ira S Moskowits, Proceedings, 4th international workshop, IH 2001, Pitts burg, USA April 2001 Eds
6.AVISPA package homepage ,http:/ www.avispaproject.org/
7.AJ Menezesetc al, Handbook of Applied Cryptography,CRC Press

Course plan

Module	Content	Hours	Semester Exam Marks (%)
I	**Basics of Linear Algebra**:Introduction to Complexity theory, Elementary Number theory, Algebraic Structures-Groups, Rings and Finite Fields, Polynomials over Finite Fields (Fq).	5	20
	Classical Cryptography, Stream Ciphers, Public Key Cryptography: based on Knapsack problem, AES. Digital Signature, Zero Knowledge Proofs.	4	
II	**Information Hiding**: Watermarking, Steganography. Objectives, difference,requirements, types (Fragile and robust). Parameters and metrics (BER, PSNR, WPSNR,Correlation coefficient, MSE, Bit per pixel). LSB, additive, spread spectrum methods.	6	20
	Applications: Authentication, annotation, tamper detection and Digital rights management. Hiding text and image data, mathematical formulations, Adaptive steganography, Costa’s approach, hiding in noisy channels, Information theoretic approach for capacity evaluation.	6	
First Internal Examination			

III	**Hiding in 1D signals**: Time and transform techniques-hiding in Audio, biomedical signals, HAS Adaptive techniques.	5	10
IV	**Hiding in 2D signals:** Spatial and transform techniques-hiding in images, ROI images,HVS Adaptive techniques**.** **Hiding in video:** Temporal and transform domain techniques, Bandwidth requirements	7	20
Second Internal Examination			
V	**Steganalysis**: Statistical Methods, HVS based methods, SVM method, Detection theoretic approach.	6	15
VI	**Quality evaluation**: Benchmarks, Stirmark, Certimark, Checkmark, standard graphs for evaluation.	6	15

Course No.	Course Name	L - T - P - Credits	Year of Introduction
10EC7213	**INTRODUCTION TO NANOELECTRONICS**	**3 - 0 - 0 - 3**	**2015**

Course Prerequisites

Basic knowledge in Solid State Devices at UG level.

Course Objectives

To have in-depth knowledge in usage and working of nano-meter scale devices.

Syllabus

Challenges going to sub-100 nm MOSFETs: Oxide layer thickness, tunneling, power density, High-K gate dielectrics, effects of high-K gate dielectrics on MOSFET performance, Novel MOS-based devices: Multiple gate MOSFETs, Hetero structure based devices: Type I, II and III Heterojunction, Si-Geheterostructure, Carbon nanotubes based devices: CNFET, characteristics, Spin-based devices – spin FET, characteristics, Quantum structures: Quantum wells, quantum wires and quantum dots, Single electron devices, Bloch oscillations.

Expected Outcomes

- Explains the fundamental science and quantum mechanics behind nanoelectronics.
- Explains the concepts of a quantum well, quantum transport and tunnelling effects.
- Describes the spin-dependant electron transport in magnetic devices.
- Calculate the energy levels of periodic structures and nanostructures.

References

1. Mircea Dragoman and Daniela Dragoman, Nanoelectronics – Principles & devices, Artech House Publishers, 2005.
2. Karl Goser, Nanoelectronics and Nanosystems: From Transistors to Molecular and Quantum Devices, Springer 2005.
3. Mark Lundstrom and Jing Guo, Nanoscale Transistors: Device Physics, Modeling and Simulation, Springer, 2005.
4. George W.Hanson,Fundamentals of nano electronics,Pearson

Cluster Level End Semester Examination

Course plan			
Module	**Content**	**Hours**	**Semester Exam Marks (%)**
I	**Challenges going to sub-100 nm MOSFETs**: Oxide layer thickness, tunneling, power density, non-uniform dopant concentration, threshold voltage scaling, lithography, hot electron effects, sub-threshold current, velocity saturation, interconnect issues, fundamental limits for MOS operation.	5	15
	High-K gate dielectrics, effects of high-K gate dielectrics on MOSFET performance.	3	
II	**Novel MOS-based devices**: Multiple gate MOSFETs, Silicon-on-nothing, Silicon-on-insulator devices, FD SOI, PD SOI, FinFETs, vertical MOSFETs, strained Si devices.	10	15
First Internal Examination			
III	**Hetero structure based devices**: Type I, II and III Heterojunction, Si-Geheterostructure, hetero structures of III-V and II-VI compounds - resonant tunneling devices, MODFET/HEMT	6	15
IV	**Tunnel junctions and applications of tunnelling**: Tunneling through a potential barrier, Potential energy profiles for material interfaces, Applications of tunnelling.	5	15
Second Internal Examination			
V	**Carbon nanotubes based devices**: CNFET, characteristics, Spin-based devices – spin FET, characteristics	6	20
VI	**Quantum structures:** Quantum wells, quantum wires and quantum dots, Single electron devices – charge quantization, energy quantization, Coulomb blockade, Coulomb staircase, Bloch oscillations	7	20
Cluster Level End Semester Examination			

Course No.	**Course Name**	**L - T - P - Credits**	**Year of Introduction**
10EC7401	**SEMINAR - 2**	**0 - 0 - 2 - 2**	**2015**

Course Prerequisites

(1) The habit of reading technical magazines, conference proceedings, journals etc.;

(2) Knowledge in technical writing and communication skills earned through seminar at UG level

and in first semester;
(3) The course Seminar-1 in the first semester.

Course Objectives

(1) To enhance the reading ability required for identification of the thesis area and its literature review;
(2) To develop skills regarding professional communication and technical report writing;
(3) To establish the fact that student is not a mere recipient of ideas, but a participant in discovery and inquiry;
(4) To arrive at a conclusion for doing Project Phase 1;
(5) To learn how to prepare and publish technical papers.

Guidelines

Students have to present a second seminar in 3rd semester. It is highly recommended that seminar-2 may report the literature survey being conducted as a requirement for doing the main project. Since the topic for the main project topic is to be finalized at the end of the second semester/ in the beginning of the 3rd semester, one can perform the literature search and present it as a seminar towards the middle of the semester. The Progress Evaluation Committee (PEC) formed in the second semester itself, may be the panel of evaluators for Seminar-2 also. The presentation of seminar-2 shall be of 20 minutes duration with another 5 minutes allocated for a discussion session. The committee shall evaluate the seminar based on the style of presentation, technical context, coverage of the topic, adequacy of references, depth of knowledge and the overall quality. Moreover, each student has to submit a seminar report in the prescribed format given by the Institution. It is recommended that the report for seminar-2 may be in the form of a technical paper which is suitable for publishing in Conferences / Journals as a review paper. This makes a student learn how to publish a paper and consequently develops a publishing culture among the PG student community. The references cited in the report shall be *authentic*.

Expected Outcomes

The students are expected to :
(1) Be motivated in reading which equip them in identification of thesis area and its literature review;
(2) Develop the capacity to observe intelligently and propose and defend opinions and ideas with tact and conviction;
(3) Develop skills regarding professional communication and technical report writing;
(4) Arrive at a conclusion for doing Project Phase 1;
(5) Learn the methodology of publishing technical papers.

References

4. M. Ashraf Rizvi, *Effective Technical Communication*, Tata McGraw Hill, New Delhi, 2005
5. Day R A, *How to Write and Publish a Scientific Paper*, Cambridge University Press, 1989
6. Coley S M and Scheinberg C A, *Proposal Writing*, 1990, Newbury Sage Publications.

Course plan

Item	Description	Time	
1	Abstract Submission	3 Weeks	
2	Allotment of Topic and Scheduling Seminars	1 Week	
3	Literature Review and Presentation Sessions	6 Weeks	
4	Report Submission	3 Weeks	
5	Publishing Grades	1 Week	

Course No.	Course Name	L - T - P - Credits	Year of Introduction
10EC7403	**PROJECT - PHASE 1**	**0 - 0 - 12 - 6**	**2015**

Course Prerequisites

(1) The habit of reading technical magazines, conference proceedings and journals;
(2) Interest solving in socially relevant or research problems;
(3) Skills in hardware/software implementation techniques earned from UG studies and the mini project done in second semester;
(4) The courses Research Methodology, Mini Project, and Seminar-2 done in previous semesters.

Course Objectives

(1) To start experimentation based on the background knowledge acquired through the literature survey performed for seminar-2;
(2) To work on the topic, familiarize with the design and analysis tools required for the project work and plan the experimental platform, if any, required for project work;
(3) To develop the skill of identifying research problems/ socially relevant projects;
(4) To enhance the skills regarding the implementation aspects of hardware/ software projects.

Guidelines

Each student has to identify a topic related to the branch of specialization for his/her main project under the guidance of a faculty member and the related experimentations namely project - phase 1, should be started in the 3rd semester. The project topic has to be approved by a committee constituted by the department. This committee, namely Progress Evaluation Committee (PEC), should study the feasibility of each project work before giving consent. It is recommended that students should execute the project work using the facilities of the institute itself. However, external projects can be taken up in the 4th semester, if that work solves a technical problem of the external firm. Prior sanction should be obtained from the Head of Institution before taking up external project work.

Project work is to be carried out in the 3rd and 4th semesters and also to be evaluated in both semesters. It is recommended that the same faculty member may serve as his/her Project Supervisor during 4th semester also. This project phase is conceptualized in such a way that, the outcomes of the work may be continued for the project - phase 2. Hence on completion of this project phase, the student will make a presentation based on the work and suggest future plan for his project - phase 2. The implementation of the project - phase 1 can be software and/or hardware based one. This project phase is also envisaged as a way for implementing *problem based learning*. Problems of socially relevance and/or problems identified by the institute/ research organizations/ industry/ state should be given high priority. In such interdisciplinary and inter institutional projects, a student can have co-guide(s) from other department/ institute/ research organizations/ industry. The university encourages *interdisciplinary projects* and *problem based learning strategy*. The following guidelines also have to be followed.

1. The student will submit a detailed *project report* for project -phase 1;
2. The student will present *at least* two seminars;
3. The *first one* in the beginning of the semester will highlight the topic, objectives and methodology;
4. A *progress seminar* can be conducted in the middle of the semester (optional);
5. The *third seminar* will be an end-semester presentation of the work they have completed till the end of the 3rd semester and the scope of the work which is to be accomplished in the 4th semester, mentioning the expected results.

All such presentations are to be evaluated internally by the progress evaluation committee (PEC). All the references cited in the report for project - phase 1 shall be *authentic*.

Expected Outcomes

The students are expected to :

(1) Develop the skill of identifying industrial/ research problems/ socially relevant projects;
(2) Develop skills regarding enumerating and selecting problems, subsequent analysis, and effective implementation of the solution;
(3) Have hands on experience in design and analysis tools required for the project work;
(4) Plan the experimental platform, if any, required for project work, which will be helpful in actual real life project planning;
(5) Enhance the skills regarding the implementation aspects of hardware/ software projects;
(6) Acquire documentation and problem solving skills;
(7) Develop professionalism;
(8) Effectively communicate technical information by means of written and oral reports.

References

1. J.W. Bames, *Statistical Analysis for Engineers and Scientists*, McGraw Hill, New York.
2. Schank Fr., *Theories of Engineering Experiments*, Tata McGraw Hill Publication.
3. Douglas C Montgomery, *Design and analysis of experiments*, Wiley International
4. Leedy P D, *Practical Research : Planning and Design*, 4th Edition, N W MacMillan Publishing Co.

Course plan

Item	Description	Time	
1	Abstract Submission	2 Week	
2	Allotment of Topic	1 Week	
3	Preliminary Presentation Sessions	1 Week	
4	Implementation Phase	9 Weeks	
5	Final Presentation-cum Demonstration	1 Week	

FOURTH SEMESTER COURSE

Course No.	Course Name	L - T - P - Credits	Year of Introduction
10EC7404	**PROJECT - PHASE 2**	**0 - 0 - 24-12**	**2015**

Course Prerequisites

(1) The habit of reading technical magazines, conference proceedings and journals;
(2) Interest in solving socially relevant or research problems;
(3) Skills in hardware/ software implementation techniques earned from UG studies and mini project in the second semester;
(4) The courses Research Methodology, Seminar-2 and Project - Phase 1 done in previous semesters.

Course Objectives

(1) To implement and complete the M. Tech. thesis work, which is normally based on Project - Phase 1;
(2) To have a continuous work on the topic, and get improved results;
(3) To develop the skill of achieving specific research target in a limited time;
(4) To develop skills regarding professional communication and technical report writing.

Guidelines

Each student has to complete the project - phase 2 under the guidance of a faculty member, as specified in phase 1, since this phase is generally an extension of the previous phase. It is recommended that students should execute the project work using the facilities of the institute itself. However, external projects can be taken up in this semester, if that work solves a technical problem of the external firm. Prior sanction should be obtained from the Head of Institution before taking up external project work. This project phase is also envisaged as a way for implementing *problem based learning*. Problems of socially relevance and/or problems identified by the institute/ research organizations/ industry/ state should be given high priority. In such interdisciplinary and inter institutional projects, a student can have co-guide(s) from other department/ institute/ research organizations/ industry. The university encourages *interdisciplinary projects* and *problem based learning strategy*. The following guidelines also have to be followed.

1. The student will submit a detailed report for project - phase 2;
2. The student will present at least *three* seminars
3. The *first seminar* in the beginning of the semester will highlight the topic, objectives, methodology and the background knowledge and preliminary results carried over from the phase 1;
4. A *progress seminar* can be conducted in the middle of the semester;
5. The *third seminar*, could be a *pre-submission seminar*, will be a presentation of the work they have completed till the end of 4th semester and the scope for future work. The pre-submission seminar has to be presented before the Progress evaluation committee (PEC) for being assessed for the quality and quantum of the work. This would be the qualifying exercise for the students for getting approval from the Department Committee for the submission of the Thesis.
6. Incorporating the suggestions by the PEC, each student has to convert the project - phase 2 report to a Thesis and to submit to the University (Cluster) for external evaluation. At least one technical paper is to be published in Journals / Conferences so as to meet the requirements for final external submission.
7. The University will appoint an External Expert to evaluate the Thesis through a final presentation by the student.

The comments of the examiners during this presentation should be incorporated in the work and the approved Thesis is to be submitted to the Institution as hard bound copies, before the program exit by the student. All the references cited in the Thesis shall be *authentic*.

Expected Outcomes

The students are expected to :

(1) Develop the skill of identifying industrial/ research problems/ socially relevant projects;
(2) Develop skills regarding enumerating and selecting problems, subsequent analysis, and effective implementation of the solution;
(3) Have hands on experience in design and analysis tools required for the project work ;
(4) Plan the experimental platform, if any, required for project work, which will be helpful in actual real life project planning;
(5) Enhance the skills regarding the implementation aspects of hardware/ software projects;
(6) Acquire documentation and problem solving skills;
(7) Develop professionalism;
(8) Effectively communicate technical information by means of written and oral reports.

References

1. J.W. Bames, *Statistical Analysis for Engineers and Scientists,* McGraw Hill, New York.
2. Schank Fr., *Theories of Engineering Experiments*, Tata McGraw Hill Publication.
3. Douglas C Montgomery, *Design and analysis of experiments,* Wiley International
4. Leedy P D, *Practical Research : Planning and Design,* 4th Edition, N W MacMillan Publishing Co

Course plan

Item	Description	Time	
1	Implementation Phase	10 Weeks	
2	Thesis Preparation	3 Weeks	

3	Pre-submission seminar-cum Demonstration	1 Week	
4	Evaluation by the External expert	4 Weeks	

ASSESSMENT CRITERIA

A. Evaluation of Theory Courses

The university follows a continuous academic evaluation procedure. This includes two internal examinations and one end semester cluster level University examination. Besides, students should be given proper assignments / course seminars which are essential aspects of a student-centric teaching approach. The continuous assessment procedure and corresponding weights for awarding 100 marks for a theory subject are as follows.

1. Two internal tests, each having 15 marks each summing to a total of 30 marks
2. Tutorials / Assignments / Course Seminars summing to a total of 10 marks, and
3. Cluster level end-semester examination having 60 marks

B. Evaluation of Research Methodology

The course Research Methodology should be a common one for all specializations, which is envisaged to provide a research orientation for PG students. The teaching - learning process for this course should be a student-centric one in which the faculty-in-charge would take the role of a facilitator in the system. Students should be given proper guidelines for practicing the various methodologies which aims at the overall improvement of their skills required for pursuing research. The continuous assessment procedure and corresponding weights for awarding 100 marks (fully internal) for Research Methodology are as follows.

1. Two internal tests, each having 30 marks summing to a total of 60 marks
2. Tutorials / Assignments / Course Seminars summing to a total of 40 marks

C. Evaluation of Practical Courses

The continuous assessment procedure and corresponding weights for awarding 100 marks for a practical subject are as follows.

1. Practical Records / Results summing to a total of 40 Marks
2. Regular Class Viva-Voce summing to a total of 20 Marks

3. Final Test (Internal & Objective Type) having 40 Marks

D. Evaluation of Seminar-1

The weights for awarding 100 marks (totally internal) for the seminar-1 is as follows.

1. Presentation (Verbal & Nonverbal Communication skills) : 20 Marks
2. Breadth of the topic (Coverage : Content of the slides and speech) : 20 Marks
3. Depth of knowledge (Ability to answer questions) : 30 Marks
4. Seminar Report in the prescribed format given by the Institution : 30 marks

E. Evaluation of the Mini Project

The weights for awarding 100 marks (totally internal) is as follows.

1. Preliminary Presentation evaluated by the Progress Evaluation Committee (PEC) : 20 Marks

2. Progress Evaluation (Guide and/or Co-guide) : 30 Marks

3. Final Presentation-cum-demonstration evaluated by the PEC : 30 Marks

4. Report (Mandatory) : 20 Marks

F. Evaluation of Seminar-2

The weights for awarding 100 marks (totally internal) for the seminar-2 is as follows.

1. Presentation (Verbal & Nonverbal Communication skills) : 20 Marks
2. Breadth of the literature review (Coverage : Content of the slides and speech) : 20 Marks
3. Depth of knowledge (Ability to answer questions) : 30 Marks
4. Seminar Report / Paper in the prescribed format given by the Institution : 30 marks

G. Evaluation of the Project Work

The weights for awarding 150 marks for Project shall be as follows.

A. 3rd Semester - Marks : 50 for Project Progress Evaluation

1. Preliminary presentation, evaluated by the PEC : 15 Marks

2. Progress evaluation by the Project Supervisor/s : 20 Marks

3. End-semester presentation, evaluated by the PEC : 15 Marks

B. 4th Semester - Marks : 100 for Final Evaluation

1. Preliminary presentation, evaluated by the PEC : 20 Marks
2. Project evaluation by the supervisor/s : 30 Marks
3. Pre-submission seminar evaluated by the PEC : 20 Marks
4. Evaluation of the thesis presentation by an External Expert : 30 Marks