Paper – II

Ph. D. (Electronics & Telecommunication)

ADVANCES IN E&TC ENGINEERING

Teaching Scheme: **Examination Scheme:**

Theory: 4 Hrs/week **Theory Examination: 100 marks**

Unit 1: Matrix Computations

Basic iterative methods for solutions of linear systems and their rates of convergence. Generalized conjugate gradient, Krylov space and Lanczos methods. Iterative methods for symmetric, non-symmetric and generalized eigenvalue problems. Singular value decompositions. Fast computations for structured matrices. Polynomial matrix computations. Perturbation bounds for eigenvalues. **[10]**

Unit 2: Advances in Signal Processing

Various transform techniques, Filter design technique (digital and analog filters), LMS algorithm ,filter bank design technique, Adaptive filter design, DSP processors, Application of DSP for image processing Image representation format, noise , processing technique, pattern classification and recognition technique and biometric, speech recognition and synthesis technique. **[12]**

Unit 3: Coding, modulation and communication techniques

Source coding, channel coding and error control coding technique, performance measure of communication systems, RF and microwave design: MW amplifier, Oscillator, Mixer, MMIC technique, IEEE/ITV/ETSI communication standard and specifications, 3G and 4G mobile cellular Techniques, Internet Telephony and Voice over IP (VOIP), RTP and RTCP, IP switching and MPLS IP over ATM and Its evaluation to IP switching to IP switching. **[12]**

Unit 4: Advances in Embedded and VLSI system

Overview of PIC microcontroller, AVR microcontroller and tools ARM processor. CMOS design issues and tools circuit's fabrication methods for CMOS, level of abstraction, Digital CMOS IC design. **[9]**

Reference books

Unit 1:

1. Owe Axelsson, Iterative solution methods. Cambridge.1994.
2. G. Meurant: Computer solution of large linear systems. North Holland, 1999.
3. Golub and C. Van Loan: Matrix computations. John Hopkins Press 1996.
4. G. W. Stewart and J. Sun: Matrix perturbation theory. Academic press,1990.

Unit 2:

1. Prokis J. G. "Digital Image Processing" PHI publication.
2. Gold B. "Speech and Audio Signal processing", john wiley publication.
3. M. J.Roberts "Signals and systems" , Tata MCgraw hill
4. R.C.Gonzalez & R.E. Woods, "Digital Image Processing", Pearson publication.

Unit 3:

1. T.S.Rappaport "Wireless communication principle and practices" Pearson education.
2. David and Pozar "Microwave Engineering "
3. Rein hold Ludwig, Pavel Bretchko, "RF circuit design theory and applications"
4. Hsiao _HWA chen and Mohsen Guizani, "Next generation wireless system and networks" john wiley and sons Ltd 2006
5. Lin "Introduction to error correcting code" Phi publications.
6. K Sam-Shanguman, "Digital and Analog Communication", john wiley publication.

Unit 4:

1. N.H.E. weste and K. Eshghian , "Principles of CMOS VLSI design".Newyork, Addison- Wesley,-1993
2. Christopher Saint and Judy Saint, "IC layout Basic " MCgraw hill
3. Weste and Harris, CMOS VLSI design a circuit and system perspective (3rd edition)
4. PIC microcontroller: An Introduction to Microelectronics, Martin P. Bates, Elsevier.
5. Embedded Design with PIC18F452, John B. Peatman.

PAPER III

Ph. D. (Electronics & Telecommunication)

REAL TIME EMBEDDED SYSTEMS

Teaching Scheme	Examination Scheme
Lect. 3 hrs./week	Theory Paper : 80 Marks,
Practical/Tutorial 1 hr. /week	Term work: 20 marks

Unit 1:

Fundamentals of Real-Time Theory : Real-time, embedded multitasking systems challenges, Best effort, Hard real-time, Soft real-time, Best Effort scheduling (Round-Robin Time slice Scheme - Review), Introduction to Fixed priority preemptive scheduling, Introduction to Dynamic priority scheduling, Utility Curves Real-Time Services : Service Release Timeline, The CPU, I/O, Memory Resource Space (Characterizing RT Applications), Introduction to Timing diagrams (interference), Introduction to Hard real-time safe resource utilization bounds, The hard real-time requirements and performance (9)

Unit 2:

Synchronization and Resource Issues : Problems with Blocking (resources other than CPU, e.g. I/O), Break up into more threads (better scheduling control), Interrupt driven I/O - e.g. Programmable FIFOs, Model Blocking Time, Priority inversion (general concept), Unbounded priority inversion problem (mutex C.S.), Priority inheritence, Priority ceiling Device interfaces- introduction to drivers: Top half (driver entry point interface to tasks), bottom half (interface to devices), ring buffers, blocking/non-blocking, ioctl, ISRs and signals/semaphores, scheduled I/O (handle buffering and processing in task), (8)

Unit 3:

Device Drivers and Characterization of Embedded I/O : I/O interfaces, Digital, Analog (ADC, DAC interfaces), Microprocessor interface types (word or block), Register-based control, status, data, Higher rate FIFO I/O, Block-oriented 1st/3rd party DMA tx/rx between I/O interfaces and memory, Bus burst transfers and block transfers, system memory map for MMIO devices - DRAM/SDRAM/DDR, BOOTROM, Flash, External interface types, CPU local bus IO/MMIO E.g. PCI 2.x, GPIO, DRAM, Flash, Point-to-point or switched devices E.g. RS-232, RS-422, PCI-Express, Network multi-access devices E.g. Ethernet (9)

Unit 4:

Estimating/Measuring Performance Based on CPU Architecture: Measuring / Controlling CPU Efficiency, Trace Ports (e.g. IBM PowerPC 4xx series, Strong Arm), Built-in PMU (Performance Monitoring Units) (e.g. Intel Pentium, Xscale), External Methods, Logic Analyzer Memory Traces (Cache Misses, DMA, Un-cached access), Memory Port Markers (Writes to Un-cached Memory), Profiling Code by Function or Block, Software in Circuit Methods (e.g. CodeTest Trace SW In-Circuit, gprof), Hardware Supported Profiling (e.g. Intel Vtune, CodeTest HW In-Circuit), Cycle-based profiling, Event-based profiling, Cache Coherency, Harvard I-Cache, D-cache Architecture, Cache Invalidate, Flush, Lock, Pre-fetch, Measuring/Controlling I/O Efficiency, Bus Analyzers - e.g. PCI Event Traces, Logic Analyzer with Support Package (8)

Reference Books:

1. Real-Time Embedded Systems and Components: Sam Siewert, ISBN 1584504684 Books, Barnes &
   Noble
2. PCI System Architecture (Paperback) Mindshare Inc Tom Shanleyr), Don Anderson

PAPER III

Ph. D. (Electronics & Telecommunication)

CRYPTOGRAPHY & NETWORK SECURITY

Teaching Scheme	Examination Scheme
Lect. 3 hrs./week	Theory Paper : 80 Marks,
Practical/Tutorial 1 hr. /week	Term work: 20 marks

Unit 1:

Block Ciphers and the Data Encryption Standard: Simplied DES, Block Cipher Principles, The Data Encryption Standard, The Strength of DES, Differential Linear Cryptanalysis, Block Cipher Design Principles, Block Cipher Modes of Operation, Contemporary symmetric Ciphers: Triple DES, Blowfish, RC5, Characteristics of Advanced Symmetric Block Ciphers, Confidentially using symmetric Encryption: Placement of Encryption Function, Traffic Confidentiality, Key Distribution, Random Number Generation. (9)

Unit 2

Public Key Cryptography and RSA: Principles of Public Key cryptosystems, The RSA Algorithm, Key Management, other Public Key Cryptosystems key Management, Diffle-Hellman Key exchange. Message Authentication and hash functions: Authentication Requirements, Authentication Function, Message Authentication Codes, Hash Functions, Security of Hash Functions and MACs. (9)

Unit 3:

Hash Algorithms: MD5 Message Digest Algorithm, Secure Hash Algorithm. Authentification Applications: Kerberos, X. 509 Authentication Service. (8)

Unit 4:

Electronic Mail Security: Pretty Good Privacy, S/MIME, IP Security Overview, IP Security Architecture, Authentifications, Header, Encapsulating Security Payload, Combining Security Associations, Key Management. Web Security: Web Security Considerations, System Security: Intruders, Malicious Software, Viruses, Viruses and Related Threats, Firewalls: Firewall Design Principles (8)

Reference Books

1. Willam Stallings, Cryptography and Network Security, Third Edition, Pearson Education
2. Cbarlie Kaufman, Radia Perlman, Mike Speciner, Network Security, Provate Communication in a public world, Second Edition, Pearson Education Asia, 2002.
3. Atul Kahate, Cryptography and Network Security, Tata McGrawhill, 2003.

PAPER III
Ph. D. (Electronics & Telecommunication)
SPEECH & AUDIO PROCESSING

Teaching Scheme	Examination Scheme
Lect. 3 hrs./week	Theory Paper : 80 Marks,
Practical/Tutorial 1 hr. /week	Term work: 20 marks

Unit 1:
Digital models for the speech signal: Process of speech production, Acoustic theory of speech production, Lossless tube models, and Digital models for speech signals. Time domain models for speech processing: Time dependent processing of speech, Short time energy and average magnitude, Short time average zero crossing rate, Speech vs silence discrimination using energy & zero crossings, Pitch period estimation, Short time autocorrelation function, Short time average magnitude difference function, Pitch period estimation using autocorrelation function, Median smoothing. (9)

Unit 2:
Homomorphic speech processing: Homomorphic systems for convolution, Complex cepstrum, Pitch detection, Formant estimation, Homomorphic vocoder. Linear predictive coding of speech: Basic principles of linear predictive analysis, Solution of LPC equations, Prediction error signal, Frequency domain interpretation, Relation between the various speech parameters, Synthesis of speech from linear predictive parameters, Applications. (8)

Unit 3:
Speech Enhancement: Spectral subtraction & filtering, Harmonic filtering, parametric re-synthesis, Adaptive noise cancellation. speech Synthesis: Principles of speech synthesis, Synthesizer methods, Synthesis of intonation, Speech synthesis for different speakers, Speech synthesis in other languages, Evaluation, Practical speech synthesis. (8)

Unit 4:
Automatic Speech Recognition: Introduction, Speech recognition vs. Speaker recognition, Signal processing and analysis methods, Pattern comparison techniques, Hidden Markov Models, Artificial Neural Networks. Audio Processing: Auditory perception and psychoacoustics - Masking, frequency and loudness perception, spatial perception, Digital Audio, Audio Coding - High quality, low-
bit-rate audio coding standards, MPEG, AC-3, Multichannel audio - Stereo, 3D binaural and Multichannel surround sound. (9)

Text Books:

1. L. R. Rabiner and R. W. Schafer, “Digital Processing of Speech Signals," Pearson Education (Asia) Pte. Ltd., 2004.
2. D. O’Shaughnessy, “Speech Communications: Human and Machine,” Universities Press, 2001.
3. L. R. Rabiner and B. Juang, “Fundamentals of Speech Recognition,” Pearson Education (Asia) Pte. Ltd., 2004.
4. Z. Li and M.S. Drew, “Fundamentals of Multimedia,” Pearson Education (Asia) Pvt. Ltd., 2004.

Reference Books:

1. C Becchetti & L P Ricotti, “Speech Recognition Theory & C++ Implementation” John Wiley & Sons

2. D. O'Shaughnessy, "Speech Communication Human & Machine", Universities Press.
3. B. Gold & N. Morgan "Speech & Audio Signal Processing", John Wiley & Sons

PAPER III
Ph. D. (Electronics & Telecommunication)
MOBILE COMPUTING

Teaching Scheme	Examination Scheme
Lect. 3 hrs./week	Theory Paper : 80 Marks,
Practical/Tutorial 1 hr. /week	Term work: 20 marks

Unit 1:
Wireless network technology: Global System for Mobile Communication (GSM) , Wireless media access control protocols; Wireless LAN, TDMA, PRMA, CDMA, etc.
Routing in wireless networks: Unicast routing protocol, Dynamic source routing, DSR optimization, route caching , Relative distance micro discovery routing, On-demand distance vector routing, power aware routing, Hybrid protocols (9)

Unit 2:
Location management: Location management in internet, Location management in cellular phone network and PCN, performance issues, future research directions
Transport protocols in mobile environments: I-TCP, snooping protocols, Multicast transport services (8)

Unit 3:
Services in wireless networks : Quality of service, Delays, error and packet loss, Error control schemes Mobile distributed application support :Operating system support, Mobile middleware and object architecture, Mobile transaction, Remote execution and mobile RPC, Cache strategies for wireless networks (9)

Unit 4:
Security issues in mobile computing: security technique s and algorithms, security protocol, public key infrastructure, trust, security model, security frame work.
Wireless devises with symbian OS: Symbian OS architecture, control and compound control, active objects, Localization, security on the symbian OS (9)

Reference books :

1. Mobile Computing, edited by T. Imielinski and H.F. Korth, Kluwer Academic
2. Mobile computing by Asok Talukdar, Roopa Yawagal, TMH

PAPER III

Ph. D. (Electronics & Telecommunication)

STOCHASTIC MODELS & QUEUING THEORY

Teaching Scheme	Examination Scheme
Lect. 3 hrs./week	Theory Paper : 80 Marks,
Practical/Tutorial 1 hr. /week	Term work: 20 marks

Unit 1:

Renewal Theory And Regenerative Processes : Definition of a Stochastic Process, Realizations, Renewal Processes, Reward and cost models, Cumulative processes, Equilibrium distribution and the inspections paradox, The Batch Effects, The Poisson Process, Stopping Time, The connection Between the time averages and the point wise limits, Point Distribution Process, Defective Renewal Processes, Regenerative Processes, Time Average and The mean of a Limiting distribution, Wald's Equation, The Expected-Value Version of the elementary Renewal Theorem, Renewal equation, Transient Behavior & the Renewal Equation for General Renewal Processes, Stationary Regenerative Processes, Transient Expressions, Lattice Distributions, Blackwell's Theorem, Key Renewal Theorem and point wise Limits, Asymptotic Normality and the regenerative method. (9)

Unit 2:

Discrete Markov Chains : Discrete Markov Chains, Transition Probabilities, Connections with Renewal Theory, Communication Classes and Class Properties, Irreducible Chains-Positive States, Frequencies and Relatives Frequencies for Positive Irreducible Chains, Costs and reward for Positive Irreducible Chains, Transient Behavior, Periodic and aperiodic States, Point wise Limits, Branching Processes, Reversed and Reversible Positive Irreducible chains, Stationary measures For Recurrent Irreducible ChainsContinuous-Time Markov Chains : Pure-Jump Continuous-Time Chains, Regular Chains, The Birth and Death Process, Time and Death Process, Time and Transition Averages for
Recurrent Irreducible Chains, Semi-Markov Processes. (9)

Unit 3:

Introduction to Queuing Theory: The M/M/I Queue with Queue limit, Birth and Death Models, The M/M/C Queue: Comparison with Single-channel Queues, Markovian Queues, The M/G/c Loss System-Insensitivity, Balancing Equitation's & Generating Functions, M/G/1 Queue, Poisson Arrivals See Time Averages (PASTA). (8)

Unit 4:

Reversible Chains: Tandem Queues, Jackson Networks Computing The throughput of Closed Jackson Networks, Approximating Closed Networks: The Fixed Population-Mean(FPM) Method, open Networks with General Customer Routes, Networks of Quasi-Reversible Stations, symmetric Queues, The two Stage Model, The G/M/∞ Queue, The G/M/l Loss System, The Two-Stage Model with Poisson Arrivals. (8)

Reference Books

1. Stochastic Modeling & The Theory of Queues- Ronald W. Wolff, (PH, International Edition).
2. Stochastic Processes- J Medhi (New Age International)
3. Performance Modeling of Automated Manufacturing System"- N. Viswanadham, Y. Narahari (PHI)

PAPER III
Ph. D. (Electronics & Telecommunication)
COMMUNICATION SYSTEM DESIGN

Teaching Scheme	Examination Scheme
Lect. 3 hrs./week	Theory Paper : 80 Marks,
Practical/Tutorial 1 hr. /week	Term work: 20 marks

Unit 1:
Designers perspective of communication system: Wireless channel description, path loss, multi path fading Communication concepts, Receiver Architectures: Introduction, Overview of Modulation Schemes, Classical Channel, Wireless Channel Description, Path Losses: Detailed Discussion, Multipath Fading: Channel model and Envelope Fading, Multipath Fading: Frequency Selective and Fast Fading, Summary of Standard Translation, Introduction Receiver Architectures, (9)

Unit 2:
Receiver front End: general discussion, Filter Design, rest of Receiver Front Eng: Nonideatlites and Design Parameters, Derivation of NF, IIP_3 of Receiver Front End, Partitioning of required NFrec_front and IIP3,rec_front into individual. (8)

Unit 3:
Low Noise Amplifier: Introduction, Wideband LNA, Design, Narrow band LNA: Impedance Matching, Narrowband LNA: Core Amplifier. Active Mixer: Introduction, Balancing, Qualitative Description of The Gilbert Mixer, Conversion Gain, Distortion, Low-Frequency Case: Analysis of Gilbert Mixer, Distortion, High- Frequency Case, Noise, A Complete Active Mixer, References, Problems. (9)

Unit 4:
Analog to Digital Converters: Demodulators, A to D Converters used in receivers, Low cost Sigma delta modulators and it's implementation.
Design Technology for Wireless Systems: Design entry / simulation, Validation and analysis tools (8)

Reference Books

1. VLSI for Wireless Communication- Bosco Leuing, (PE).
2. The design of CMOS Radio frequency integrated circuits – T Lee (Cambridge university press)
3. Analysis and design of analog integrated circuits – P Gray and R Meyer (John Wiley & Sons)
4. Microelectronics Transistor Amplifier, Analysis and design G Gonzalez (Prentice Hall)

PAPER III
Ph. D. (Electronics & Telecommunication)
OPTICAL NETWORKS

Teaching Scheme	Examination Scheme
Lect. 3 hrs./week	Theory Paper : 80 Marks,
Practical/Tutorial 1 hr. /week	Term work: 20 marks

Unit 1:
Architecture of OTN: Digital wrapper, control planes, Control signaling, Multiplexing hierarchies, Current digital hierarchy, revised hierarchies, Optical & Digital Transport hierarchies, Functionality stacks, Encapsulation & Decapsulation, GFP. Network Topologies & Protection schemes : Non-negotiable requirements of robust networks, Line & Path protection switching, Type of Topologies, Optical Channel Concatenation, Meshed topologies, PON's, Optical Ethernets, Wide area Backbones, Metro optical networking (9)

Unit 2:
Architecture of IP & MPLS based optical transport Networks : IP, MPLS & Optical control planes- Interworking, The three control planes, Framework for IP Vs. Optical networks, Generalized MPLS use in optical networks, Bidirectional LSP's in optical network, Next horizon of GMPLS, ODVK General communication channels, Traffic parameters Link Management protocol (LMP): What is managed, Data Bearing links, Basic function of LMP, LMP messages, LMP message header, TLW's control channel management, LPC, LCV, Fault management, Extending LMP operations to optical links (8)

Unit 3:
Optical Routers Management : Switching in optical internets: State of art in optical switching, clarification of Key terms, Evolution of switching technologies, Speeds of electronics & photonics, Optical routers, Control element, switching technologies MEMS, OSP, Setting up protection paths between nodes H, G & J, Expanding the Role of nodes G & I, Node failure, Coupling, decoupling, node to node wavelengths, Approach to problem of LSP & OSP interworking, Thermo-optic switches, Bubble switch. (9)

Unit 4:
Optical compilers : Building blocks, Serial Binary adder with carry delay, Fiber delay line memory loop, Bit serial, optical counter design, Lumped delay design, Distributed delay design, Time multiplex multiprocessor, Time slot interchange with $2 \log_2 (N-1)$ switch, Hatch design support system. (8)

Reference Books

1. Optical Networks– "Third generation transport system", Unless Black (Prentice Hall)
2. Opto Electronic computing system – Jordan

PAPER-III
Ph.D.[Electronics & Telecommunication]

DIGITAL DATA COMPRESSION

Teaching Scheme
Lect. 3 hrs./week
Practical/Tutorial 1 hr. /week

Examination Scheme
Theory Paper : 80 Marks,
Term work: 20 marks

Unit-1.: Data compression, Loss less compression, Lossy Compression, Performance Measures, Coding, Modeling, Grading Compression Algorithms.

The Shannon-Fano algorithm, The Huffman Algorithm,Adaptive coding: Adaptive Huffman Coding, Updating The Huffman trace, Decoding,The overflow problem, Rescaling Bonus, Arithmetic Coding: Difficulties, Practical Matters, a complication, Decoding. (**9**)

Unit-2 : Statistical Modeling: Higher order modeling, finite context modeling, adaptive modeling,Escape code as a fall back, Improvements. Static v/s Adaptive Compression: Adaptive Methods, Sliding window compression: The algorithm and encoding problem.
Speech compression: Digital audio concepts,fundamentals, sampling variables, PC- Based sound, Lossless compression of sound, problem and result, Lossy compression, silence compression, companding and other
techniques. (**9**)

Unit-3 :
Lossy Graphics Compression: Statistical and Dictionary compression methods, Lossy
Compression, Differential modulation, JPEG-overview, JPEG-Enhancement, Loss less

JPEG, JPEG Compression, The discrete cosine transform, Implementing The DCT,
Matrix Multiplication, Improvements, output of the DCT, quantization methods, selection
of quantization of coding: zigzag sequence, entropy encoding and about color. (**8**)

Unit-4 :

Speech Compression: MPEG, MP3.Video compression: Pixel details, Motion estimation,
quantization and bit packing, MPEG-2. Fractal Image compression: History, Iterated
function system (IFS), Basic IFS, Image compression with IFS and with partitioned IFS.
Fractal Image decoding, Resolution independence. Introduction to Wavelet based
compression Techniques. (**8**)

Reference Books

1) The Data Compression- Mark Nelson, Jean-Ioup Gailly, 2nd edition, (M&T pub.)
2) Data Compression: The complete Reference-David Saloman, D., 3rded, (Springer
publication.)
3) Introduction to Data Compression-Khalid Sayood, 2nd ed.
(Academic press ltd.)
4) Introduction to Information Theory and Data Compression- Darrel Hankerson, 2nd ed,
(Chapman and Hall/CRC publications.)
5) Handbook of Image and video Processing-Al Bovik(Academic press ltd. Publication.)
6) Compression Algorithms for Real Programmers- Peter Wayner
(Academic press ltd.)

PAPER-III
Ph.D.[Electronics & Telecommunication]
OPTIMIZATION TECHNIQUES

Teaching Scheme
Lect. 3 hrs./week
Practical/Tutorial 1 hr. /week

Examination Scheme
Theory Paper : 80 Marks,
Term work: 20 marks

Unit-1 :
Introduction : Historical development, Application to Engg. problems, Statement of optimization. Classification of Optimization, Multivariable optimization with and without constraints, linear programming standard form of linear programming, Geometry, Simplex programming, revised simplex algorithm, Revised simplex method. **(9)**

Unit-2 :
Duality in linear programming – Decomposition principle, Transportation problem. Nonlinear programming – single dimensional minimization methods, Exhaustive search, Fibonnaci method, Golden section, Quadrature interpolation, Cubic interpolation , Direct root method, Steepest decent method, Fletcher-Reeves method, David-Fletcher-Powell Method. **(9)**

Unit-3 :
Dynamic programming – Multistage decision process, principle of optimality, Computational procedures in dynamic programming, Linear programming as a case of dynamic programming. **(8)**

Unit-4 :
Optimization application for assignment & Network problems, Pareto optimality, Finite element based optimization. **(7)**

Reference Books
1. Optimization Theory & application - S.S. Rao (Wiely Eastern)
2. Linear Programming - G. Hadly (Welsly)
3. An Introduction to Optimization - Peithpler Philips Wilde (PHI)

4. Optimization concepts & application in Engg. -A. D. Belegundu, Tirupati R.
Chandrupatla (Pearson Edn.)

PAPER-III
Ph.D.[Electronics & Telecommunication]
MULTIRATE SYSTEMS AND FILTER BANKS

Teaching Scheme	Examination Scheme
Lect. 3 hrs./week	Theory Paper : 80 Marks,
Practical/Tutorial 1 hr. /week	Term work: 20 marks

Unit-1 :

Fundamentals of Multi-rate Systems: Basic multi-rate operations, interconnection of
building blocks, poly-phase representation, multistage implementation, applications of
multi-rate systems, special filters and filter banks. Multirate Filter Banks: Maximally decimated filter banks: Errors created in the QMF bank, alias-free QMF
system, power symmetric QMF banks, M-channel filter banks, poly-phase representation,
perfect reconstruction systems, alias-free filter banks, tree structured filter banks, transmultiplexers.**(9)**

Unit-2 :
Para-unitary Perfect Reconstruction Filter Banks: Lossless transfer matrices, filter bank
properties induced by paraunitariness, two channel Para-unitary lattices, M-channel FIR
Para-unitary QMF banks, transform coding. **(8)**

Unit-3 :
Linear Phase Perfect Reconstruction QMF Banks: Necessary conditions, lattice structures
for linear phase FIR PR QMF banks, formal synthesis of linear phase FIR PR QMF
lattice. Cosine Modulated Filter Banks: Pseudo-QMF bank and its design, efficient polyphase structures, properties of cosine matrices, cosine modulated perfect reconstruction systems. **(8)**

Unit-4 :
Wavelet Transform: Short-time Fourier transform, Wavelet transform, discrete-time
Ortho-normal wavelets, continuous-time Ortho-normal wavelets. Multidimensional Multirate Systems:- Introduction, Multidimensional signals,sampling a multidimensional signals, minimum sampling density,multirate fundamentals,Alias free decimation. Cascade connections, multifilter design. Special filters and filter
banks. **(9)**

Text Books:
1. P.P. Vaidyanathan, “Multirate Systems and Filter Banks," Pearson Education (Asia)
Pte. Ltd, 2004.
2. Gilbert Strang and Truong Nguyen, "Wavelets and Filter Banks," Wellesley-
Cambridge Press, 1996.
3. N. J. Fliege, "Multirate Digital Signal Processing,” John Wiley & Sons, USA, 2000.