AC- 6.6.2012
Item No.4.63

UNIVERSITY OF MUMBAI

Revised Syllabus for the

M. E. (Electronics Engineering):

Program : M.E.

Course: Electronics Engineering

(As per Credit Based Semester and Grading System with effect from the academic year 2012–2013)

Program Structure for Master of Engineering-Electronics Engineering

(With Effect From 2012-2013)

Semester I

Subject Code	Subject Name	Teaching Scheme(Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
ExC101	System Modeling and simulation	04	--	--	04	--	--	04
ExC102	Modelling of Microelectronic Devices	04	--	--	04	--	--	04
ExC103	Embedded system	04	--	--	04	--	--	04
ExE101X	Elective I	04	--	--	04	--	--	04
ExE102X	Elective II	04	--	--	04	--	--	04
ExL101	Laboratory I	--	02	--	--	01	--	01
ExL102	Laboratory II -	--	02	--	--	01	--	01

Total		20	04	--	20		02	--	22
Subject Code	**Subject Name**	**Examination Scheme Sem-I**							
		Theory					**Term Work**	**Pract. /oral**	**Total**
		Internal Assessment			**End Sem.Exam.**	**Exam. Duration (in Hrs)**			
		Test1	**Test 2**	**Avg.**					
ExC101	System Modeling and simulation	20	20	20	80	03	--	--	100
ExC102	Modelling of Microelectronic Devices	20	20	20	80	03	--	--	100
ExC103	Embedded system	20	20	20	80	03	--	--	100
ExE101X	Elective I	20	20	20	80	03	--	--	100
ExE102X	Elective II	20	20	20	80	03	--	--	100
ExL101	Laboratory I	--	--	--	--	--	25	25	50
ExL102	Laboratory II -	--	--	--	--	--	25	25	50
Total		**100**	**100**	**100**	**400**	--	50	**50**	**600**

Semester II

Subject Code	Subject Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	**Pract.**	**Tut.**	**Theory**	**Pract.**	**Tut.**	**Total**
ExC201	Power Electronic Devices and Design	04	--	--	04	--	--	04
ExC202	Advance Processor Architecture	04	--	--	04	--	--	04
ExC203	Applications of DSP and IP	04	--	--	04	--	--	04
ExE201X	Elective III	04	--	--	04	--	--	04
ExE202X	Elective IV	04	--	--	04	--	--	04
ExL201	Laboratory III	--	02	--	--	01	--	01
ExL202	Laboratory IV	--	02	--	--	01	--	01
Total		**20**	**04**	**--**	**20**	**02**	**--**	**22**

Subject Code	Subject Name	Examination Scheme Sem-II							
		Theory					Term Work	Pract. /oral	Total
		Internal Assessment			End Sem.Exam.	Exam. Duration (in Hrs)			
		Test1	Test 2	Avg.					
ExC201	Power Electronic Devices and Design	20	20	20	80	03	--	--	100
ExC202	Advance Processor Architecture	20	20	20	80	03	--	--	100
ExC203	Applications of DSP and IP	20	20	20	80	03	--	--	100
ExE201X	Elective III	20	20	20	80	03	--	--	100
ExE202X	Elective IV	20	20	20	80	03	--	--	100
ExL201	Laboratory III	--	--	--	--	--	25	25	50
ExL202	Laboratory IV	--	--	--	--	--	25	25	50
Total		**100**	**100**	**100**	**400**	--	**50**	**50**	**600**

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Semester III

Subject Code	Subject Name	Teaching Scheme(Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
ExS301	Seminar	--	06	--	--	03	--	03
ExD301	Dissertation I	--	24	--	--	12	--	12
Total		--	30	--	--	15	--	15

Subject Code	Subject Name	Examination Scheme Sem-III						
		Theory				Term Work	Pract. / Oral	Total
		Internal Assessment			End Sem. Exam.			
		Test1	Test 2	Avg.				
ExS301	Seminar	--	--	--	--	50	--	50
ExD301	Dissertation I	--	--	--	--	100	--	100
Total		--	--	--	--	**150**	--	**150**

Semester IV

Subject Code	Subject Name	Teaching Scheme(Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
ExD401	Dissertation II	--	30	--	--	15	--	15
Total		--	30	--	--	15	--	15

Subject Code	Subject Name	Examination Scheme Sem-IV						
		Theory				Term Work	Pract. / Oral	Total
		Internal Assessment			End Sem.Exam.			
		Test1	Test 2	Avg.				
ExD401	Dissertation II	--	--	--	--	100	100	200
Total		--	--	--	--	**100**	**100**	**200**

Note:

- In case of Seminar, 01 Hour / week / student should be considered for the calculation of load of a teacher
- In case of Dissertation I, 02 Hour / week / student should be considered for the calculation of load of a teacher
- In case of Dissertation II, 02 Hour / week / student should be considered for the calculation of load of a teacher

Electives: ME –Electronics Engineering

Elective I	Elective II
1. Advance Digital Communication	1. Wireless and Mobile Networks
2. Instrumentation System Design	2. Advance Digital Image Processing
3. Optical Fiber communication	3. Internetworking Technologies
4. Analogue IC Design	4. Digital System Design

Elective III	Elective IV
1. Advance Networking Technologies	1. Real Time Operating System
2. Machine Learning	2. Modeling and Synthesis with VHDL
3. Microwave IC	3. Cryptography and Network Securities
4. Fabrication of Microelectronic IC	4. Application Specific IC Design

Internal: Assessment consists of two tests, which are compulsory class test.

End Semester Examination: In all six questions to be set, each of 20 marks, out of these any four questions to be attempted by students. Each question will comprise of mixed questions from different units of the subjects.

Laboratory (I, II, III and IV)

This is with the intention of developing research culture among the PG students.

Various project/practical topics related to the syllabus' subject should be provided to students and team should be formed for them to work in groups.

They can take assistance from the laboratory equipment and software present in the laboratory specifically equipped by the Institute for ME course referring to the syllabus.

Every year project/ practical topics should be revised to maintain continuity with the previous year projects.

Projects/ practical can be hardware/software based or combination of the two.

Students should be graded based on these projects/ practicals.

Project/ practical activity should be allotted two hours per week.

The TW and Practical/ oral should be assessed jointly by internal and external examiner.

Detailed Syllabus- ME Electronics Engineering

Semester –I

Compulsory

I -C1.

System Modeling and Simulation

1. Introduction – System modeling, Concept of a Model and Model building, Model classification, Identification, Simulation softwares
2. Continuous Time and Discrete Time Systems – Continuous-Time Linear systems, simple electrical circuits, Laplace transform, transfer functions, state-space model,
3. Discrete time systems, Z-transform, a-b tracking system, Feedback system, stability, controllability and observability.
4. Nonlinear System Analysis and Modeling – Mathematical models for nonlinear systems, phase trajectory and local linearization, system stability, controllability and observalibility, Input-output mapping and system invertibility, Linearization and linearizability, nonlinear system modeling and simulation
5. Computer Simulation – Numeric integration, state space simulation techniques, simulation of discrete-time systems, digital simulation languages
6. Robotic Systems and Automation – Modeling of robot, control of robots, modeling of mobile robots and control, applications
7. Design and analysis of Simulation Experiments – Design of simulation Experiments, analysis of simulation experiments, variance reduction techniques.
8. Digital Control systems – Basic Digital Control system, design approaches, implementation

Text Books:

1. Naim A Kheir, System Modeling and Computer Simulation, Marcel Dekker Inc, 1996
2. Modeling & Simulation Using Metlab-Dr.Sailendra Jain(Wiley)

Reference Books

1. Louis Birta, Gilbert Arbez, Modeling and Simulation, Springer
2. Donald Boyo, System Analysis and Modeling, Academic Press, 2001.
3. System Modeling and Simulation –Frank L.Severance(Wiley)
4. I. Mitrani, Simulation Techniques for Discrete Event Systems, Cambridge
5. Theory of Modeling and Simulation, 2nd Edition, Zeigler & Kim & Praehofer, 2000, Academic Press, Elsevier

I -C 2.

Modeling of Microelectronic Devices

1. **Basic Semiconductor physics:** Quantum Mechanical Concepts, Carrier Concentration, Transport Equation Band gap, Mobility and Resistivity, Carrier Generation and Recombination, Avalanche Process, Noise Sources

2. **Semiconductor Devices** P-n junction diode : its behavior ,Majority carrier diodes, Microwave Diode: The Varactor Diode, the p-i-n Diode, the IMPATT Diode, The TRAPATT Diode, The BARITT Diode, Transferred – Electron Devices Optoelectronic Devices: Static and Dynamic Models, Rate Equations, Numerical Technique, Equivalent Circuits, Modeling of LEDs, Laser Diode and Photo Detectors.

3. **Modeling Bipolar Device Phenomena** Injection and Transport Model, Continuity Equation, Transistor Models: Ebber - Molls and Gummel Port Model, Mextram model, SPICE modeling temperature and area effects.

4. **MOSFET Modeling**

Introduction Interior Layer, MOS Transistor Current, Threshold Voltage, Temperature Short channel and Narrow Width Effect, Models for Enhancement, Depletion Type MOSFET, CMOS Models in SPICE.

5. Parameter measurement

General Methods, Specific Bipolar Measurement, Depletion Capacitance, Series Resistances, Early Effect, Gummel Plots, MOSFET: Long and Short Channel Parameters, Statistical Modeling of Biopolar and MOS Transistors.

6. CAD for VLSI

Graph algorithms and their application in IC design, Number solution and Monte carlo simulations, Design for testability,

Text Book:

1. Introduction to Semiconductor Materials and Device By M. S. Tyagi, John WILEY & SONS, 1991

2. Solid State Electronic Devices, 6th ed., Ben G. Streetman, S.K. Banerjee, Prentice Hall, 2000

3. N.A. Sherwani, "Algorithms for VLSI Physical Design Automation", Kluwer Academic Publishers, 2002.

References:

R. T. Howe and C. G. Sodini, Microelectronics: an Integrated Approach, Prentice-Hall, 1997.

Fundamentals of Microelectronics-Behzad Razavi (Wiley)

S.M.Sze, Semiconductor Devices: Physics and Technology, John Wiley & Sons, Inc

Physics and Technology of Semiconductor Devices, A.S. Grove, John Wiley, 1967

Silicon VLSI Technology - Fundamentals, Practice and Modeling" by James D Plummer et al. Pearson Education 2001.

Donald A.Neamen,"Semiconductor physics and devices", McGraw-Hill,3rd edition,2007

Snowden C. M., Introduction to Semiconductor Device Modeling, World Scientific Press, Singapore, 1986

M. H. Rashid, *SPICE for Circuits and Electronics using PSpice*, Prentice Hall, 1995

A. Vladimirescu, *The SPICE Book*, New York : J. Wiley, 1994.

S.H. Gerez, "Algorithms for VLSI Design Automation", John Wiley & Sons-2002.

I -C 3.

Embedded Systems

EMBEDDED ARCHITECTURE

Embedded Computers – Characteristics of Embedded Computing Applications – Challenges in Embedded Computing system design- Embedded memories – Embedded System design process – Requirements – Specification – Architectural Design – Designing Hardware and Software Components – System Integration –Design Example.

EMBEDDED PROCESSOR AND COMPUTING PLATFORM

MSP 430 RISC Controllers, parallel I/O, external interrupts.

ARM processor fundamentals – introduction to ARM and THUMB instruction set--processor and memory organization – CPU Bus configuration – ARM Bus –Memory devices – Input/output devices – Component interfacing – designing with microprocessor development and debugging – Design Example

Instruction set with enhanced DSP features with ARM core, mix mode programming as Thumb+ ARM core, Assembly programming concept, compare with ARM7, ARM9, ARM11 with new features additions

INTERFACING

Sensors and interfacing techniques, Analog interfacing and data acquisition , Timing generation and measurements, --Distributed Embedded Architecture – Networks for Embedded Systems- serial bus protocols like I2C, RS485, CAN and USB--wireless protocols and interfacing of IRDA and SMART card – Design Example wireless protocols and interfacing of IRDA and SMART card – Serial communications: I2C – CAN Bus – Design Example

REAL TIME CONCEPTS

Real-time concepts, hard and soft real time systems, real-time operating systems, Required RTOS services/capabilities (in contrast with traditional OS).

Resource Management/scheduling paradigms: static priorities, static schedules, dynamic scheduling

Real-world issues: blocking, unpredictability, interrupts, caching, Examples of OSs for embedded systems

SYSTEM DESIGN

Design Methodologies – Requirement Analysis – Specification – System Analysis and Architecture Design – modeling techniques --Testing and debugging ---Quality Assurance – Design Example: Data base applications (smart cards), process-control (Fuzzy logic), robotics (wireless), CCD camera (data compression), network appliances (e-server), MSP 430 applications e.g. electricity metering, wireless communication, capacitive touch screen as examples of embedded systems.

References:

1. Introduction to Embedded Systems, Jonathan W. Valvano , Cengage 2009,
2. ARM System Developer's Guide, 1st Edition, Sloss & Symes & Wright , 2004, Morgan Kaufmann
3. Embedded Real Time Systems: Concepts, Design & Programming, Dr.K.V.K.K. Prasad, Dreamtech Publication.
4. Introduction to embedded systems, shibu k v, 2009, McGraw-Hill
5. An Embedded Software Primer, David E. Simon, Pearson Education Publication.
6. Embedded Systems-James K Peckol(Wiley)
7. Embedded Systems Design, 2nd Edition, S Heath, 2002 , Newnes Publication
8. Building Parallel, Embedded, and Real-Time Applications with Ada, John W. McCormick Frank Singhoff , JérômeHugues , Cambridge University Press
9. TEXAS MSP430, ARM Technical Publications
10. Embedded system design by Frank Vahid & Tony Givargis, Pearson Education
11. Kritee Ramamritham – Real Time Operating Systems, IEEE Press

Semester –I

Elective-I (any one)

I –E-I 1.

Advance Digital Communication

1. Block & Convolution codes
   Linear Block codes
   Convolution Block codes
   Coded modulation for Bandwidth Constrained Channels
2. Signal Design for Band Limited Channels
   characterization of Band Limited Channels
   Signal Design for Band Limited Channels
3. Communication through Band Limited Linear Filters
   Optimum receiver for Channels with ISI & AWGN
   Linear Equalization
   Design Feedback Equalization
4. Adaptive Equalization
   Adaptive Linear Equalization
   Adaptive Design Feedback Equalization
5. Multichannel & Multicarrier System
6. Spread Spectrum Signals for Digital Communication
7. Digital Communication through fading multipath channels

REFERENCES:

Digital Communication - John G. Proakis, McGraw Hill(1989)
Principles of Digital Communication & coding - Viterbi & Omura, McGraw Hill(1979)
Wireless Communication : Principles & Practice, 2 ed Edition, Theodore Rappaport, Prentice Hall
Digital Communication and Signal Processing, K. Vasudevan, Universities Press

I –E-I 2.

Instrumentation System Design

1. Smart sensors, Micro sensors and actuators and recent trends in sensor technologies.

2. Introduction to Model Predictive Control & Controllers Model based control schemes

3. Special Purpose Instrumentation

4. Generalized Predictive Control and Multivariable regulatory control. Role of PLC in Automation

5. Control of time-varying and non-linear systems

6. Virtual Instrumentation

Text Book

1. John G Webster , Measurement , Instrumentation and Sensors Handbook , CRC press

IEEE press, 1998

2. Model Based Predictive Control – A Practical Approach by J A Rossitor, CRC Press

3. Bequette, B.W., "Process Control Modeling, Design and Simulation", Prentice Hall of

India, 2004

4. Seborg, D.E., Edgar, T.F. and Mellichamp, D.A., "Process Dynamics and Control",

Wiley John and Sons, 2nd Edition, 2003.

5.R. Baican ,D. S Necsulescu "Applied Virtual Instrumentation "WIT Press,2000

REFERENCE BOOKS

1. Seborg, D.E., Edgar, T.F. and Mellichamp, D.A., "Process Dynamics and Control",

Wiley John and Sons, 2nd Edition, 2003.

2.Coughanowr, D.R., "Process Systems Analysis and Control", McGraw - Hill

International Edition, 2004.

3. Ness S.A. Air monitoring for Toxic explosions, Air integrated Approach, Von

Nostrand (1991).

4. Ewing G., Analytical Instrumentation hand book, Dekker (1991).

5. Alans V., Water and Waste water examination manual, Lewis Chele

6. E. Ikonen and K. Najim, " Advanced Process Identification and Control", Marcel Dekker, Inc. Newyork, 2002

7. P. Albertos and S. Antonio, " Multivariable Control Systems An Engineering

I –E-I 3.

Optical Fiber communication

A Review of Optical Fibers

- Introduction
- Ray theory
- Theory of optical wave propagation
- Classification of optical fibers
- Signal Degradation
- Non Zero Dispersion Shifted Fibers
- Plastic optical fibers
- Splicing efficiency and optical fiber alignment
- Fiber optic cable

Advanced Optical Sources and Detectors

- Quantum well lasers
- Charge capture in Quantum well lasers
- Multi Quantum well Laser diodes
- Surface Emitting Lasers: Vertical cavity Surface Emitting Lasers
- Resonant cavity enhancement (RCE) Photo Detector
- Material requirement for RCEPD
- Wavelength selectivity
- High speed comparison of conventional and RCEPD
- RCE Schottky Photodiode
- RCE Avalanche Photodiode

Optical Amplification

- Properties of Erbium Doped glass
- Optical Pumping
- Erbium Doped Amplifier
- Semiconductor Laser Amplifier
- Raman Amplifier
- Raman Gain and Bandwidth
- Multiple pump Raman Amplifier
- Raman Induced signal gain
- Noise Figure of Raman Amplifier
- Optical Signal to noise ratio
- Electrical Signal to noise ratio
- Application

Integrated Optics

- Planar and channel waveguides
- Coupled mode theory for waveguides
- Beam Splitters, Directional couplers and Photonic Switch
- Optical Modulators
- Arrayed waveguide Grating (AWG)
- Multimode interference coupler (MMI)
- Opto Electronic Integration
- Fabrication Techniques
- Material

Non linear Optics

- General Overview of nonlinearties
- Effective area and length
- Stimulated Raman Scattering
- Stimulated Brillouin Scattering
- Self Phase modulation
- Cross –Phase modulation
- Four wave mixing and its mitigation
- Solitons
- Properties of Solitons
- Loss managed Soliton
- Dispersion managed Soliton
- Dispersion Management:
- Dispersion problems and its solution,
- Dispersion compensating Fibers ,its design,
- Fiber Brag Grating,
- Dispersion Equalizing Filters
- Optical Phase conjugation
- PMD Compensation

Optical Networks

- Network concepts
- Network Topologies
- FDDI
- SONET/SDH
- DWDM Networks

Advanced Topics in OFC:

- Biophotonics
- Optical computing
- Optical MEMS
- Photonics Crystals Fibers and Waveguides

References;

1. Fiber optic Communication Systems, Govind . P. Agrawal, Wiley India.
2. Fiber Optic Communication - J.Keiser , McGraw Hill
3. Optical Fibers for transmission -J.E.Midwinter, John Whiley
4. "An Introduction to Fiber Optic Systems"-John Power-McGrawHill-(Second Edition 2000)
5. Mathematical Principles of Optical Fiber Communication, J. K. Shaw, 2004, Cambridge
6. Optical Communication systems - J.Gowar, Prentice Hall
7. Optical Fibers Telecommunications - S.E.Miller and A.G.Chynoweth ,Academic Press
8. Non linear fibers optics - G.Agarwal , Academic Press.
9. "Fiber Optics Communications"- Harold Kolimbris-Pearson Education(First Indian Reprint 2004)
10. "Optical Fiber Communications Principles and Practice"-John.M.Senior-Pearson Education(Third Edition,2009)
11. "Fundamentals of Optoelectronics"-Pollock-Irwin Publications (2003)
12. "Opto-Electronics, an introduction"-Wilson and Hawkes,Prentice Hall (Third Edition,)
13. "An Introduction to Nonlinear Optics"-Geoffrey New-Cambridge University Press (2010)
14. "Photonic Crystal Fibers"-Anders Bjarkler and JesBrong-Kluwer Academic Publishers (2011)
15. "Optical Fiber Communication System: Theory and Practice with MATLAB and Simulink" by Le Nguyen Binh, CRC Press, 2010
16. "Introduction to Biophotonics", Paras N. Prasad, Wiley-Interscience, 2003

I –E-I 4.

Analogue IC Design

1: Band gap references - PTAT current generation and constant Gm biasing
2: First and second order switched capacitor circuits - switched capacitor amplifiers-switched capacitor filters.
3: CMOS oscillators -ring oscillators-LC oscillators-VCO CMOS PLLs - non-ideal effects in PLLs - Delay locked loops and applications.
4: CMOS data converters -Medium and High-speed CMOS data converters- Over sampling converters. CMOS comparators-multipliers and wave shaping circuits

Text Books

1. David A Johns & Ken Martin, 'Analog Integrated Circuit Design' John Wiley and Sons, 2001

2. Behzad Razavi, 'Design of Analog CMOS Integrated Circuit' Tata-McGrawHill, 2002

3. 3.Philip Allen & Douglas Holberg, CMOS Analog Circuit Design, Oxford University Press, 2002

4. R. Gregorian, G.C. Temes, "Analog MOS ICs for Signal Processing", Wiley 1986.

Elective –II (any one)

I –E-II 1.

Wireless and Mobile Network

1. Introduction to wireless and Mobile communication, Introduction to GSM system, Cell design concept, Interference issues in Wireless system.
2. Mobility management, handoff management- Detection , Assignment and Radio link transfer
3. IS-41 signaling, Intersystem handoff and Authentication in IS-41, PACS Network Signalling
4. Cellular Digital Packet data, GSM system overview, GSM network Signalling, GSM Mobility management, GSM Short message service and international Roaming for GSM
5. GSM Operations, Administration and Maintenance
6. General Packet Radio Service (GPRS)
7. Wireless application Protocol (WAP)
8. 3G Mobile services and Wireless Local Loop (WLL)
9. Mobile IP : Introduction ,Mobility requirements and constraints in an IP environment, Mobile IP Protocol Overview, Route Optimization, Mobility Support for IPv6, Connectivity with 3G Networks

Reference Books:

1. Wireless and Mobile network Architectures, Yi-Bang Lin and Imrich Chlamtac, Wiley-India Edition.
2. Mobile and Personal Communication Systems and Services, Raj Pandya, PHI, 2001.
3. Wireless Communications & Networks, William stallings, 2/e, Pearson,Prentice Hall, 2009.
4. Handbook of Wireless Networks and Mobile Computing ,Ivan Stojmenivic, Wiley india Edition,2009
5. Mobile IP : Design Principles And Practice By Charles E. Perkins Addition Wesley Wireless Commu.Series.
6. Wireless Communication by Andreas Molisch (WILEY)
7. Wireless Networking, 1st Edition, Kumar & Manjunath & Kuri, 2008, Morgan Kaufmann

I –E-II 2.

Advance Digital Image Processing

1. Fundamentals of Image Processing: Introduction – Steps in Image Processing Systems, image Acquisition – Sampling and Quantization – Pixel Relationships – Colour Fundamentals and Models, File Formats. Image Enhancement and Restoration : Spatial Domain Gray level Transformations Histogram Processing Spatial Filtering – Smoothing and Sharpening.
2. Image Segmentation and Feature Analysis: Detection of Discontinuities – Edge Operators – Edge Linking and Boundary Detection – Thresholding – Region Based Segmentation – Motion Segmentation, Feature Analysis and Extraction.
3:Frequency Domain: Filtering in Frequency Domain – DFT, FFT, DCT, Smoothing and Sharpening filters – Homomorphic Filtering., Noise models, Constrained and Unconstrained restoration models.Image Pyramids – Multi resolution expansion – Wavelet Transforms, Fast Wavelet transforms,Wavelet Packets.Image Compression
4: Image Classification techniques:Introduction,feature extraction,supervised and unsupervised training,hybrid-supervised and unsupervised training,Non parametric classification-level slice classification,histogram estimation classifier,nearest neighbhour classiier,ANN classifier (BPN),introduction to fuzzy set classifier.
5: Introduction to remote sensing information extraction from Remote-sensing Images spectral Factors in Remote sensing, spectral signatures, remote sensing systems- spatial and radiometric characteristics, spectral characteristics.

6: Applications of Image Processing: Representation and Description, Image Recognition-

Video Motion Analysis – Image Fusion , Steganography , Colour Image Processing.

References:

1. Rafael C.Gonzalez and Richard E.Woods, “Digital Image Processing”, Third Edition, Pearson Education, 2008.
2. Milan Sonka, Vaclav Hlavac and Roger Boyle, “Image Processing, Analysis and Machine Vision”, Third Edition, Third Edition, Brooks Cole, 2008.
3. Anil K.Jain, “Fundamentals of Digital Image Processing”, Prentice-Hall India, 2007.
4. Madhuri A. Joshi, ‘Digital Image Processing: An Algorithmic Approach”, Prentice-Hall India, 2006.
5. Rafael C.Gonzalez , Richard E.Woods and Steven L. Eddins, “Digital Image Processing Using MATLAB”, First Edition, Pearson Education, 2004.
6.Robert schowengerdt,Remote sensing modules and methods for Image processing Elsevier publication IIIrd edition

7. Applied Digital Signal Processing, Dimitris G. Manolakis, Vinay K. Ingle, Cambridge University Press

I –E-II 3.

Internetworking Technologies

1: Introduction to Internetworking

Introduction to OSI model ,TCP/IP protocol suite. Application layer-

Web and HTTP, DNS and Socket Programming

2: Transport Layer

UDP, TCP, Reliable Data Transfer, Congestion Control

3: Network Layer and Routing

Internet Protocol, Addressing and Routing, IPv6, Multicast and Mobility

4: Advanced Network Architectures:

IP forwarding architectures, Overlay model, MPLS, Integrated services in Internet, RSVP, Differentiated services etc.

5: Wireless and Mobility:

Wi-Fi, wireless links characteristics, Cellular access, Mobility principles

6: Multimedia Information and Networking:

Compression Fundamentals, Digital representation, compression techniques, Multimedia communication across networks: RTP, RTSP, SIP, H.323

Reference Books

1. J F. Kurose & KW. Ross: **Computer Networking- A Top-down Approach featuring the Internet**, 3rd edition, Pearson, 2005.
2. A. Leon-Garcia & I. Widjaja :**Communication Networks** 2/e McGraw-Hill Publications
3. K. R. Rao et al: **Multimedia Communication Systems,** Prentice-Hall of India,
4. Behrouz A. Forouzan **TCP/IP Protocol suit** Tata McGraw Hill PVt Forth edition.

I –E-II 4.

Digital System Design

1. Overview of synchronous FSM design – architectures and system level design – State machine designs centered around non registered PLDs ,

2. Programmable logic devices (PLDs). Programmable gate arrays.FPGA- based system design. FPGA fabrics. Types of FPGAs and their architectures.

3. Combinational logic design overview, combinational network delay, Power and energy optimization, overview of arithmetic circuits , implementation for FPGAs,

4. .Sequential machine design Process, design styles. Rules for clocking. Performance analysis. Power optimization.

5. ASYNCHRONOUS SEQUENTIAL CIRCUIT DESIGN
   Analysis of Asynchronous Sequential Circuit (ASC) - Flow Table Reduction - Races in ASC - State Assignment - Problem and the Transition Table - Design of ASC - Static and Dynamic Hazards - Essential Hazards - Data Synchronizers - Designing Vending Machine Controller - Mixed Operating Mode Asynchronous Circuits.

6. FAULT DIAGNOSIS AND TESTABILITY ALGORITHMS
   Fault Table Method - Path Sensitization Method - Boolean Difference Method – Kohavi Algorithm - Tolerance Techniques - The Compact Algorithm - Practical PLA's - Fault in PLA - Test Generation -Masking Cycle - DFT Schemes - Built-in Self Test.

Text Books

1. Richard Tinder, Engineering Digital Design, Academic Press, second edition

2. W.Wolf, FPGA- based System Design, Pearson, 2004

3. Mark Zwolinski, "Digital System Design with VHDL", Pearson Education, 2004.

4. Digital Integrated Circuit Design, Hubert Kaeslin, Cambridge University Press

5. Digital Design- Vahid- Wiley

Semester – II

Compulsory

II –C 1.

Power Electronic Devices and Design

1.Review of power devices - Power transistor, Power MOSFET,SCR,IGBT .Review of Drive circuits for SCR, BJT, IGBT/MOSFET. Isolation between control circuit and power circuit -techniques and circuits..Protection circuits:-Anti saturation protection for BJT& IGBT. Overload protection, thermal protection.

2. Chopper circuits using IGBT. Classes of chopper-A, B, C,D & E. Working quadrants.

3. Inverters:-Single phase and three phase using IGBT. Single pulse & multi pulse PWM inverters. Sine wave and modified sine wave techniques.

4. DC motor drives:-constant torque/constant power region.

(i)converter circuits, (ii)Chopper circuits (iii)Rheostatic chopper brake circuit

5.AC motor drives for induction motors :-single phase and three phase, variable stator voltage control, v/f control, slip power recovery schemes-static Kramer and scherbius.

6.UPS & SMPS:- schematic diagrams, working of SMPS, advantages of UPF operation.

7. Unity Power Factor converters-Basic principle of working.

8.Smart Grid & renewable energy sources:-Schematic diagrams of smart grid using solar power and wind energy.

Textbooks

1.Power Electronics by Joseph Vidyathil

2.M.H.Rashid ,Power Electronics, PHI India.

3. Power Electronics-L umanand, wiley

4.Ned Mohan, Converters Application and Design ,Jhon Willey

5.M.D.Singh and K.B. Khanchandani, Power Electronics,TMH

References:-

6..Rai G.D ,Solar Energy Utilization, Khanna Publishers,1993.

7.B.H Khan, Non conventional Energy sources, Tata McGraw-Hill.

II –C 2.

Advanced Processor Architectures and Organization

1. A Top Level View of Computer functions and Interconnections Computer Components, Computer Functions, Interconnection Structures Bus Interconnections
2. Advanced Processor Architectures CISC and RISC processor design fundamentals, Pipelined Processors, Superscalar Processors, Out of Order Execution, Instruction Level Parallelism, Branch Prediction Logic, Multi-core Architectures
3. Case studies : Power PC architecture RISC architecture
4. Memory Semiconductor Memories / DRAM organization, Cache Memory : Principles, Coherency, Cache Design, External Memories: Magnetic , Optical, RAID Virtual memory management
5. I/O Types of I/Os, I/O Interfacing Concepts, I/O Buses: PCI, PCI-X, PCI-E, Universal Serial Bus(USB)
6. Operating System support OS Overview, Scheduling, Memory Management, Case studies: Pentium Power PC
7. Parallel Processing Multiple Processor Organizations, Symmetric Multiprocessors, Cache Coherence and the MESI Protocol, Multithreading and Chip multiprocessors, Clusters, Non-Uniform Memory Access, Vector Computation

Text Books:

1. Computer Organization and Architecture : Designing for Performance by William Stallings
1. Advanced Microprocessors – Daniel Tabak

References: Various company's Manuals

II –C 3.

Applications of DSP and IP

1. Overview of DSP and its Hardware.
2. Statistical Signal Processing and Adaptive Filtering.
3. DSP Application
- Speech and Audio Signal Processing
- Biomedical Signal Processing
- DTMF receiver and Transmitter
- Radar
1. Image Compression techniques based on DCT and Wavelet transform.
2. Advanced Image Modeling Techniques.
3. Image Reconstruction
4. Application of Image Processing
- Object Recognition
- Medical Application
- Forensics
- Remote Sensing
- Industrial Sensing.

References:-

1. Statistical Digital Signal Processing & Modeling, Monson Hayes.,
--Wiley
2. Digital Signal Processing with FPGA, U Meyer- Baese 3rd Edition.,
--Springer
3. Biomedical Signal Processing & Signal Modeling, Eugene N Bruce., --Wiley.
4. Fundamentals of Speech Recognition, Rabiner, Jaung PHI
5. Digital Image processing-Pratt
6. Theory and Implementation of Digital Signal Processing, Rabiner-Gold. ,-- PHI
7. Digital Image Processing, Rafael Gonzalez, Richard E Woods.,-- PHI
8. DIP for Medical Applications, Geoff Dougherty., -- Cambridge

Semester –II

Elective-III (any one)

II –E-III 1.

Advanced Networking Technologies

1 Overview of OSI model and TCP/IP protocol suite, optical networking: SONET/SDH standards, DWDM, performance and design considerations, optical routing.

2 Mobile Networks :

Mobile IP: Goals, assumptions and requirements, Entities and Terminology, IP packet delivery, Agent advertisement and discovery, Registration, Tunneling and Encapsulation, Optimizations, Reverse tunneling, IPv6, Dynamic host configuration protocol, Ad hoc networks MANET: ROUTING, DESTINATION SEQUENCE DISTANCE VECTOR, Dynamic source routing, Hierarchical algorithms, Alternative metrices**.**

3 Wireless Sensor Networks**:** Introduction and Applications, Mobile Internet connectivity and Personal area Networks. Mobile computing Architecture: Three Tire Architecture for Mobile computing, Design considerations, Mobile computing through Internet.

4 Routing in the Internet: Intra and interdomain routing, Unicast Routing Protocols: RIP, OSPF, BGP,Multicast Routing Protocols, MOSPF, DVMRP, Drawback of traditional routing methods, IP over ATM, Storage Area Network (SAN).

5 Traffic Engineering and Capacity Planning:

Traffic Engineering basics: Requirement definition: Traffic sizing, characteristics, Protocols, Time Delay considerations, Connectivity, Reliability, Availability and Maintainability, Throughput calculations

Quality of service: Introduction, Application, Queue Analysis: M/M/1 as a packet processing Model, QoS Mechanisms Queue management Algorithms, feedback, Resource reservation: Queued data and Packet switched traffic modeling. Application and QoS.

Network Performance Modeling, Creating Traffic Matrix, Capacity Planning and Network vision, Design Tools.

6 Cloud computing: Cloud Computing Evolution, Definition, SPI framework of Cloud Computing, Cloud service delivery models, Cloud deployment models, key drivers to adoption of cloud, impact of cloud computing on users, examples of cloud service providers: Amazon, Google, Microsoft, Salesforce etc.

Reference Books

1. Behrouz A. Forouzan **TCP/IP Protocol suit** Tata McGraw Hill PVt Forth edition.
2. Darren Spohn Data Network Design McGraw Hill Publications
3. Wireless and Mobile N/W Architecture yi Bang Lin and Inrich b(Wiley)
4. Cloud Security and Privacy: An Enterprise Perspective by Tim Mather, Subra Kumaraswamy

II –E-III 2.

Machine Learning

1. Introduction: Types of learning - supervised; unsupervised learning; reinforcement learning and adaptive control. Designing learning system, perspectives and issues in Machine Learning
2. Decision tree learning – Decision tree representation, basic decision tree learning algorithm, inductive bias in decision tree learning, issues in decision tree learning
3. Artificial Neural Network – neural network learning, Single layer perceptron, multilayer perceptron, backpropagation algorithm, Radial basis and recurrent neural network, application of neural network such as character recognition, face recognition.
4. Bayesian learning – Bayes theorem, Concept learning, Minimum description length principle, Gibb's algorithm, Baysian Belief network, EM algorithm
5. Instance based learning – k-nearest neighbor learning, locally weighted regression, radial basis functions, case based reasoning
6. Reinforcement learning – Learning task, Q-learning, Temporal difference learning, dynamic programming
7. Recent applications of machine learning, such as to robotic control, autonomous navigation, speech recognition, face recognition, character recognition, etc.

Text Books:

1. Tom Mitchell, Machine Learning. McGraw-Hill, 1997.
2. Ethem Alpaydin, Introduction to Machine Learning, Prentice Hall of India, 2004.

Reference Books:

1. Christopher Bishop, Pattern Recognition and Machine Learning. Springer, 2006.
2. Richard Duda, Peter Hart and David Stork, Pattern Classification, 2nd ed. John Wiley & Sons, 2001.
3. Richard Sutton and Andrew Barto, Reinforcement Learning: An introduction. MIT Press, 1998
4. Hagan, Demuth, Beale, Neural Network Design., Thomson Learning
5. Scaling up Machine Learning - Parallel and Distributed Approaches, *Ron Bekkerman* , *Mikhail Bilenko* , *John Langford* ,Cambridge University Press
6. V. Shusheela Devi, N.M. Murty, Pattern Recognition-An introduction, Universities Press

II –E-III 3.

MICROWAVE INTEGRATED CIRCUITS

1. Hybrid MICs : Definition, Characteristics, Comparison with conventional circuits, fields of application and limitations and criteria for the choice of substrate material, thin film hybrid circuits, thick film hybrid circuits, artwork, mask making, photolithography, resistor stabilization, sawing, brazing process, wire bonding.
Monolithic MICs: Definition, substrate structure, doping by ion implantation ohmic contact, metal resistive layers, gate metal, dielectric second level metal, dielectric and air bridge vias, substrate vias, final wafer process steps.

2. Microstrip Lines: Planar wave guides, non-TEM propagation, line impedance definitions, quasi-static approximations, quasi-static line parameters, micropstrip open circuits and gaps, microstrip corners, step changes in width, dispersion analysis, microstrip characteristic impedance, symmetric T junction, full wave analysis of microstrip propagation, LSE and LSM potentials, spectral domain analysis, dispersion relation for open microsrip, spectral domain impedance analysis, dispersion relation for open microstrip, spectral domain impedance analysis, Green's functions, millimeter wave modeling of microstrip lines.

3. Coupled Line Propagation: Wave equations for coupled lines, propagation models, coupled line parameters, coupled line parameter variations with frequency, directional couplings, Lange coupler coupled line pair treated as a four port, coupled line pair operated as a two port assuming 0e = 0o, low pass filter design assuming 0e =0o, coupled line pair analysed to a two port 0e not equal to 0o, narrow band filter using coupled resonator, narrow band coupled line filters, suspended substrate strip lined filters, suspended substrate strip line filter design using method 1 and method 2.

4. Slot Lines : Analysis, design consideration, transitions and applications. Coplanar Waveguide,

Analysis, design considerations and coplanar line circuits.

5. Devices: GaAs FET, Bipolar Transistors, Varactor diodes, PIN diodes, YIC resonators, Dielectric resonators.

6. Microwave Computer Aided Workstations for MMIC Requirement. Introduction, Integrated Microwave Workstation Approach, Nonlinear Tools, Role CAD, Yield Driven Design, Rethinking Design, Designing Nonlinear Circuits Using Harmonic Balance Method. Programmable Microwave Tuning System, GaAs MMIC Layout Software, Practical Design. CAD Applications.

Text And Reference Books

1. Microstrip Circuit Analysis – David H. Schrader , Prentice Hall PTR, New Jersey 07458.

2. Microstrip Lines and Slot Lines, K.C. Gupta, R. Garg and I.J. Bahl , Artech House.

3.Microwave Circuit Design using Linear and Non Linear Techniques: George Vendelin, Pavio and Rohde, Wiley

4. MIC and MMIC Amplifier and Oscillator Circuit Design 1990 edition, Allen Sweet, Artech House.

5. MMIC Design : GaAs FETs and HEMTs, Peter Ladbrooke , Artech House.

6. Handbook of Microwave Integrated Circuits Reinmut K. Hoffman , Artech House.

7. Foundations for Microstrip Circuit design T.C. Edwards, John Wiley and Sons

II –E-III 4.

Fabrication of Microelectronic IC

1 **. Introduction to IC Design:**

Types of ICs, P-N Junction, Transistor, Designing an IC, Future trends and issues in IC Design, Introduction to Microelectronic Fabrication, Semiconductor Substrates and Optical and Electronic Properties.

(1.Semiconductor Manufacturing Handbook by Hwaiyu Geng (McGrawHill)

2. The Science and Engineering of Microelectronic Fabrication by Stephen A. Campbell (Oxford University Press))

3. **Integrated Circuit Manufacturing for VLSI :**

Vacuum Technology, Physical & Chemical Vapor Deposition, Diffusion, Thermal Oxidation, Silicide & Epitaxial formation on silicon. PhotoMask, Opitcal Lithography – Ion implantation, Rapid Thermal Annealing, Wet Etching, Plasma Etching, Nanolithography. Device Isolation, Contacts, Metalization, CMOS Techniques, GaAS Technologies, Silicon Bipolar Technologies Environmental, Health & Safety Considerations in Semiconductor Facilities.

(3. Semiconductor Manufacturing Handbook by Hwaiyu Geng (McGrawHill)

4. The Science and Engineering of Microelectronic Fabrication by Stephen A. Campbell (Oxford University Press)

5. Nano : The Essentials by T. Pradeep (McGraw-Hill))

6. **Characterization of Micro/Nano Structures :**

Small Angle X-ray Scattering (SAXS), Transmission Electron Microscope (TEM), Scanning Electron Microscope (SEM), Scanning Probe Microscope (SPM), Microwave Spectroscopy, Auger Electron Microscopy, Raman Microscopy, Atomic Force Microscopy, Helium Ion Microscopy

(Nanostructuring Operations in Nanoscale Science and Engineering by: Kal Renganathan Sharma)

7. **Micro Electro-Mechanical Structures (MEMS):**

Fundamentals of mechanics; stress in thin films; mechanical to electrical transduction; mechanics of common MEMS devices; bulk micromachining etching techniques; bulk micromachining process flow; surface micromachining basics; surface micromachining process flow; MEMS actuators; and high aspect ratio microsystems technology (HARMST).

(The Science and Engineering of Microelectronic Fabrication by Stephen A. Campbell)

8. **Carbon Nanotubes :**

Synthesis & Purification, Mechanism of Growth, Electronic Structure, Transport Properties, Mechanical Properties, Physical Properties, Characterization and Applications (Electron Field

(Nano : The Essentials by T. Pradeep (McGraw-Hill))

REFERENCES:

1 The Science and Engineering of Microelectronic Fabrication by Stephen A. Campbell (Oxford University Press)

2 Semiconductor Manufacturing Handbook by: Hwaiyu Geng (McGrawHill)

3 Nano : The Essentials by T. Pradeep (McGraw-Hill)

4 Nanostructuring Operations in Nanoscale Science and Engineering by: Kal Renganathan Sharma (McGraw-Hill)

5 Carbon Nanoforms and Applications by Maheshwar Sharon, Madhuri Sharon (McGraw-Hill)

7 System on Package: Miniaturization of the Entire System

by Rao R. Tummala (McGraw-Hill)

Semester –II

Elective-IV (any one)

II –E-IV 1.

REAL TIME OPERATING SYSTEMS

1. Software Architectures, Software Developments Tools, Program Modeling Concepts, Software Development Process Life Cycle and its Model, Software Analysis, Design and Maintenance,

2. Hard versus Soft Real-time systems – examples, Jobs & Processors, Hard and Soft timing constraints, Hard Real-time systems, Soft Real-time systems. Classical Uniprocessor Scheduling Algorithms – RMS, Preemptive EDF, Allowing for Preemptive and Exclusion Condition.

3. Concept of Embedded Operating Systems, Differences between Traditional OS and RTOS. Real-time System Concepts, RTOS Kernel & Issues in Multitasking – Task Assignment, Task Priorities, Scheduling, Intertask Communication & Synchronization – Definition of Context Switching, Foreground ISRs and Background Tasks. Critical Section – Reentrant Functions, Interprocess Communication (IPC) – IPC through Semaphores, Mutex, Mailboxes, Message Queues or Pipes and Event Flags.

4. Real Time Operating Systems (μC/OS):Real-Time Software Concepts, Kernel Structure, Task Management, Time Management, Inter task Communication & Synchronization, Memory Management, and Porting μCos-II.

5. Linux/RT Linux: Features of Linux, Linux commands, File Manipulations, Directory, Pipes and Filters, File Protections, Shell Programming, System Programming, RT Linux Modules, POSIX Threads, Mutex Management, Semaphore Management.

6. Introduction to multiprocessor scheduling , resource access control and synchronization

References:

1. μC/OS-II, The real time Kernel, Jean J. Labrossy, Lawrence: R & D Publications.
2. Embedded Real Time Systems: Concepts, Design & Programming, Dr.K.V.K.K. Prasad, Dreamtech Publication.
3. An Embedded Software Primer, David E. Simon, Pearson Education Publication.
4. . Jane W.S.Liu, Real Time Systems, Pearson Education, Asia, 2001.
5. Real Time Systems, C.M.Krishna and G.Shin, McGraw-Hill Companies Inc., McGraw Hill International Editions, 1997.
6. Kritee Ramamritham – Real Time Operating Systems, IEEE Press

II –E-IV 2.

Modeling and Synthesis with VHDL

CIRCUIT DESIGN

1. Introduction to VHDL, Design Flow, EDA tools, Behavioral and Structural Description.
2. Code Structure: Fundamentals of VHDL Units, Library Declarations, Entity, Architecture.
3. Data Types, Operators and Attributes.
4. Concurrent Code and Sequential Code
5. Signals and Variables
6. State Machines
7. Datapath /Controller Partioning
8. Advanced VHDL Circuit Design Examples.

SYSTEM DESIGN

1. Packages, Components and Configurations
2. Functions & Procedures
3. Advanced VHDL System Design Examples

SYNTHESIS ON AN FPGA

1. Introduction to PLDs, CPLDS and FPGAS.
2. FPGA Design and I/O Resources
3. Memory and Clocking
4. Xilinx Spartan and Virtex Series FPGA
5. Configuring an FPGA: RTL synthesis, constraints, behavioral synthesis, place and route etc.
6. Application and End-Markets

References:

Volnei A. Pedroni, Circuit Design with VHDL, MIT Press, 2004.

Ashenden P.J., The Students Guide to VHDL, Elsevier, 1999.

Zwolinski M., Digital System Design with VHDL, Pearson, 2004

Xilinx Online Resources: www.xilinx.com

II –E-IV 3.

CRYPTOGRAPHY AND NETWORK SECURITY

1: **Introduction and Mathematics of Cryptography**

Introduction to System Security, security goals, Basic terminology, mathematics of cryptography, Basic number theory, prime numbers, congruence, modular arithmetic, Euclidian algorithm, Information theory, Entropy of information.

2: **Classical Cryptography**

Symmetric key cryptography : Stream ciphers, A 5/1, RC4, Block ciphers, Fiestel cipher, DES, Triple DES, AES

Public key crypto: RSA, Diffie Hellman, uses of public key crypto, Signature and Non-repudiation, Confidentiality and Non-repudiation, PKI

3: **Hash functions and Access control**

Hash Functions: The Birthday problem and its relevance, MD5, SHA-512, Uses of Hash functions

Access Control: Authentication and Authorization, authentication methods, passwords, biometric, authentication protocols, Kerberos. Access control matrix, ACLs, and Capabilities, CAPTCHA

4: **Network Security Basics and Application layer security**

Network security basics, TCP/IP Model and protocol flaws, Network vulnerabilities, Packet sniffing, session hijacking, ARP spoofing, web site and web server vulnerabilities, Email security, PGP, S/MIME

5: **Security at Transport layer**

Vulnerabilities at transport layer, SSL protocol and IPSEC protocol and their working

6: **Security at Network layer**

Firewall, IDS/ IPS systems, Honey Pots, IPSEC protocol and its operation

Reference Books

Cryptography and network Security by B.A Forouzan (TMH publication)

Cryptography And Network Security by William Stallings (Pearson /prentice hall)

Information security principles and practice by Mark Stamp (Wiley publication)

Foundations of Cryptography - Volume 1 and 2 : Basic Tools, *Oded Goldreich* , Cambridge University Press
Security in computing by Pfleeger and Pfleeger (Pearson Education)

II –E-IV 4.

Application Specific Integrated Circuit Design

1. Types of ASICs. ASIC design flow. Programmable ASICs. Antifuse, SRAM, EPROM, EEPROM based ASICs. Programmable ASIC logic cells and I/O cells. Programmable interconnects.
2. An overview of advanced FPGAs and programmable SOCs : Architecture and configuration of Spartan II and Virtex II FPGAs . Apex and Cyclone FPGAs. Virtex II PRO kits and Nios kits. OMAP. ASIC physical design issues. system partitioning, interconnect delay models and measurement of delay.
3. ASIC Construction Physical Design, floor planning, placement and routing, CAD tools estimating ASIC size, Power dissipation
4. Design issues in SOC. Design methodologies. Processes and flows. Embedded software development for SOC. Techniques for SOC testing. Configurable SOC. Hardware/software codesign.
5. High performance algorithms for ASICS/ SOCS. SOC case studies- DAA and computation of FFT and DCT. High performance filters using delta-sigma modulators. Case Studies: Digital camera, Bluetooth radio/modem, SDRAM and USB controllers.

Text book

1. M.J.S. Smith : Application Specific Integrated Circuits,,Pearson, Education, 2003

References:

1. Maclon R. Haskard, Lan C. May, " Analog VLSI Design- NMOS and CMOS" Prentice Hall, 1998
2. Andrew Brown" VLSI Circuits and Systems in Silicon" McGraw Hill,1991
3. S.D. Brown , R.J. Francis J. Rox, Z. G. Uranesie, "Field Programmable Gate Arrays" , Kluwer Academy Publishers, 1992.
4. RazakHossain, High Performance ASIC Design, Cambridge.