Master of Technology Program
in
Electrical Engineering

July 2015

Indian Institute of Technology Jodhpur

Master of Technology (M. Tech.) Program in Electrical Engineering
(Specialization: Electronic Systems)

Curriculum

Cat.	*Course Number, Course Title*		*L-T-P*	*Credits*		*Cat.*	*Course Number, Course Title*		*L-T-P*	*Credits*
I Semester						***II Semester***				
C	EE616	Electronic System Design	3-0-3	4		C	EE623	Embedded Systems Design	3-0-3	4
C	EE617	Digital Signal Processing & Applications	3-0-0	3		C	EE624	VLSI Design Techniques	2-0-3	3
C	EE618	Digital IC Design	3-0-0	3		E		Elective	3-0-0	3
C	EE619	Sensors in Instrumentation	3-0-0	3		E		Elective	3-0-0	3
E		Elective	3-0-0	3		E		Elective	3-0-0	3
			Total	**16**					***Total***	**16**
III Semester						***IV Semester***				
TH	EE698	Thesis		15		TH	EE699	Thesis		15
			Total	**15**					***Total***	**15**

Electives	
Semester I	*Semester II*
EE651 Wireless Communications	EE660 Adaptive Signal Processing
EE657 DSP System Design and implementation	EE661 Mobile Communication Systems
EE658 Microelectronics Simulations	EE662 IC Technology
EE659 Biomedical Instrumentation	EE663 System Hardware Design
	EE664 Testing and Verification
	EE665 CMOS Anaolg VLSI Design

S. No.	*Category*	*Course Category Title*	*Total Courses*	*Total Credits*
1	C	Compulsory	6	20
2	E	Electives	4	12
3	TH	Thesis	1	30
			Total	**62**

Course Title	***Electronic Systems Design***	Course No.	**EE616**
Department	Electrical Engineering	Structure (LTPC)	3 0 3 4
Offered for	M. Tech and B. Tech. (IV Year) Students	Status	Compulsory
Pre-requisite	*Signals and Systems or Consent of Teacher*		

Objectives

To provide students various understanding related to analog signals and its digitization process, interfacing Analog/Digital signal processing blocks

Learning Outcomes

Students are expected to

1. Design of low noise circuits,
2. Connect various analog and digital blocks, and
3. Design electronic systems for measurement of signals with noise.

Course Content

Signal conditioning, Instrumentation & Isolation amplifiers, Analog filters, Analog switches, Programmable circuits, Switched-capacitors circuits and applications. A/D and D/A conversion: sampling and quantization, antialiasing and smoothening filters, Data converters, Interfacing with DSP blocks. Signal measurement in the presence of noise: synchronous detection, signal averaging. Noise in electronic systems; design of low noise circuits. Interfacing of analog and digital systems. System assembly considerations.

Reference Books

1. Sedra, A. S., and Smith K. C., (1998), *Microelectronic Circuits*, Oxford University Press
2. Soclof S., (1990), *Applications of Analog Integrated Circuits*, Prentice Hall
3. Schaumann,R., (2013), *Analog Filter Design*, Oxford University Press
4. Schaumann, R., Valkenburg, Mac E. Van, (2005), *Design of Analog Filters*, Oxford University Press
5. Lang T. T., (1987), *Electronics of Measuring Systems - Practical Implementation*, Wiley
6. Horowitz, P. and Hill, W. (1995), *The Art of Electronics*, Cambridge University Press
7. Ott, H.W., (1989), *Noise Reduction Techniques in Electronic Systems*, Wiley
8. Mitra S. K, (1998) *Digital Signal Processing: a Computer Based Approach*, McGraw Hill

e-Material

1. Electronics System Design; http://freevideolectures.com/Course/2317/Digital-Signal-Processing-IIT-Delhi

Course Title	***Digital Signal Processing and Applications***	Course No.	**EE617**
Department	Electrical Engineering	Structure (LTPC)	3 0 0 3
Offered for	M. Tech. and B.Tech. (IV Year) Students	Status	*Compulsory*
Pre-requisite	*Signals and Systems EE322*		

Objectives

To develop skills for analyzing and synthesizing algorithms and systems that process discrete time signals, with emphasis on realization and implementation

Learning Outcomes

By the end of this course, students should be able to:

1. Design equivalent realization of FIR/IIR filters.
2. Apply methods to analyse Multirate Signal Processing, Signal Correlations and Adaptive Filters
3. Utilize Matlab or other programming languages to simulate different window functions and digital filters
4. Apply the concepts and techniques of modern digital signal processing, which are fundamental to analyze the all modern aspects of life and sciences; from communication, entertainment to health and economics.

Course Contents:

1. *Discrete Time Signals:* Sequences, Discrete time processing of continuous time signals, Practical Sampling and reconstruction, sampling of band-pass signals
2. *Computation of the Discrete Fourier Transform:* Discrete Fourier transform (DFT); Sampling of Discrete Time Fourier Transform; Properties of DFT; Linear Convolution using DFT; Fourier Analysis of signals using DFT; Direct Computation of DFT; Decimation-in-time FFT Algorithms; Decimation-in-Frequency FFT Algorithm
3. *Design of FIR Filters:* FIR filters with linear phase, design of FIR filters by windowing and Park-McClellan's Method.
4. *Design of IIR Filters:* Introduction to IIR filter design; Design of continuous time low pass filters; Transformation of continuous time filters to discrete time filters; Design examples for low pass IIR filters; Frequency transformations of low pass filters.
5. *Multirate Signal Processing:* Sampling rate conversion; Implementation of Multirate Systems; Filter design for Multirate Systems; Two channel filter banks and multi-channel filter banks
6. *Finite Word Length Effects:* Number representation; Statistical analysis of quantization error; Quantization of Fixed-point and Floating point numbers; A/D and D/A conversion; A/D conversion noise analysis; Quantization of filter coefficients; Effects of finite wordlength on digital filters.
7. *Application of DSP to Speech and Radar Signal Processing*

Reference Books

1. Mitra, S. K., (2008), *Digital Signal Processing*, 3rd Edition, McGraw Hill
2. Manolakis D., and Ingle V., (2011), *Applied Digital Signal Processing*, Cambridge University Press, 2011
3. Proakis, J. G., and Manolakis, D., (1996), *Digital Signal Processing*: *Principles, Algorithms, and Applications*, 3rd Edition, Prentice Hall International Inc.

4. Rabiner, L.R. and Gold, B., (1992), *Theory and Application of Digital Signal Processing*, Prentice Hall
5. Johnson, J. R., (1992) *Introduction to Digital Signal Processing*, Prentice Hall
6. DeFatta , D. J., and Lucas, J. G., (1988) *Digital Signal Processing*, John Wiley & Sons

e-Material

1. Digital Signal Processing, NPTEL; http://nptel.ac.in/video.php?subjectId=117102060
2. Digital Signal Processing, MIT; http://ocw.mit.edu/resources/res-6-008-digital-signal-processing-spring-2011/

Course Title	***Digital Integrated Circuit Design***	Course No.	**EE618**
Department	Electrical Engineering	Structure (LTPC)	3 0 0 3
Offered for	M. Tech. Students	Status	Compulsory
Pre-requisite	*Semiconductor Physics*		

Objectives

This course is designed with objectives of

1. teaching students the basics of digital circuit design methods; and
2. offering understanding of necessary concepts for digital VLSI design according to design rules decided by various technologies

Learning Outcomes

Students are expected to

1. understand designing and optimizing digital circuits with different quality metrics: cost, speed, power dissipation, and reliability: and
2. learn major building blocks of digital systems

Course Content

1. *Introduction:* Review of VLSI, Historical Perspective; Issues in Digital IC Design; Quality Metrics
2. *Manufacturing:* CMOS Technology; Layout Design & Design Rules; IC Packaging, Future Trends in Process Technology
3. *Devices and Interconnects:* MOS Devices, MOS Transistor Models, Technology Scaling, Effect of Process Variations; Interconnect and Wire Models
4. *CMOS Circuits:* CMOS Inverter; Static and Dynamic Behaviour; Propagation Delay, Noise Margins, and Power Dissipation; Impact of Technology Scaling, Logical Efforts
5. *Designing Combinational Logic Gates:* Static CMOS Design; Ratioed Logic, Pseudo NMOS, Pass Transistors Logic, Dynamic CMOS design; Speed and Power Dissipation; choosing a logic style
6. *Design of Sequential Logic Circuits:* Static Latches and Registers; Dynamic Latches and Registers; Alternative Register Styles; Pipelining; choosing a Clock Strategy
7. *Timing Issues in Digital Circuits:* Timing classification; Synchronous Design; Synchronous Timing basics; Skew and Jitter; Clock distribution techniques
8. *Designing Arithmetic Blocks:* Data paths in Digital Processor Architecture, Adder, Multiplier, Shifter, Power and Speed Tradeoff.
9. *Designing Memories and Array Structures:* Memory Classification, Memory Architecture and Building Blocks, Memory Core, Read Only Memory, Read-Write Memories, Memory Peripheral Circuitry, Decoders, Sense Amplifiers, Buffers, Reliability, Power Dissipation, Future Trends Validation and Test. Implementation Strategies for Digital ICs, Design Validation and Test, Introduction to HDL

Reference Books

1. Rabaey. J. M., Chandrakasan, A., and Nikolic, B., (2011), *Digital integrated Circuits: A Design Perspective*, 2nd Edition, PHI Learning
2. Weste, N. H. E., and Harris, D. M., (2009), *CMOS VLSI Design*, 4th Edition, Pearson

e-Material

1. VLSI Design Course NPTEL; http://nptel.ac.in/downloads/117101058/
2. Digital VLSI Circuits Outline NPTEL; http://nptel.ac.in/syllabus/syllabus.php?subjectId=117108041
3. MIT; http://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-374-analysis-and-design-of-digital-integrated-circuits-fall-2003/

Course Title	***Sensors in Instrumentation***	Course No.	**EE6XX**
Department	Electrical Engineering	Structure (LTPC)	3 0 0 3
Offered for	M. Tech. and B. Tech. (IV Year) Students	Status	Compulsory
Pre-requisite	*Semiconductor Devices*		

Objective

To provide students various understanding related to various types of sensors, their working, and design.

Learning Outcomes

Students are expected to

1. design of various sensors, and implementation
2. non destructive characterization methods
3. deployment of these sensors in electronic systems

Course Content

Sensor characteristics; R, L and C sensors: Hall effect sensors; Piezoelectric materials and sensors; Micro and nano-sensors; principle and fabrications Sensors for displacement, pressure, temperature, flow etc. Optical sensors; Chemical and bio-sensors; Sensor applications in non-destructive testing; Interfacing sensors with microprocessors and micro controllers.

Reference Books

1. Murthy, D. V. S., (1995), *Transducers in Instrumentation*, Prentice Hall
2. Bentley, J. P., (1989) *Principles of Measurement Systems*, Wiley
3. Gardner, J. W., (1996) *Microsensors, Principles and Applications*, Wiley
4. Sze, S.M., (1994) *Semiconductor Sensors*, Wiley

e-Materials

1. http://www.nptel.ac.in/courses/108105064/34
2. http://www.colorado.edu/ASEN/asen5519/22sensors.pdf
3. http://www.eng.hmc.edu/NewE80/Sensors.html

Course Title	***Wireless Communications***	Course No.	**EE651**
Department	Electrical Engineering	Structure (LTPC)	3 0 3 4
Offered for	M. Tech. and B. Tech. (IV Year) Students	Status	*Elective*
Pre-requisite	*Consent of Teacher*		

Objectives

1. To provide students an understanding of the concepts related to wireless channel modelling.
2. To explore communication concepts and techniques for exploiting wireless channel characteristics and application of these concepts in a system context.
3. To familiarize students with the baseband generation software tools and the measurement instruments.

Learning Outcomes

1. Analyze and design point-to-point wireless communications systems, particularly with application to mobile communication networks.
2. Apply concepts and techniques from Multiple-Input Multiple-Output (MIMO) theory to communication systems.
3. Develop the ability to compare and contrast the strengths and weaknesses of various mobile networks.
4. Hands-on experience of designing and testing communication systems.

Course Contents

1. *Wireless Channels:* Modelling of wireless channels; physical channel modelling, time and frequency channel coherence: Doppler spread, coherence time, delay spread and coherence bandwidth; input/output channel models: discretization and discrete-time representation; the wireless channel as a random linear time varying (LTV) system; stochastic characterization of LTV systems; characterizing key parameters of wireless channels; multiple antenna channel characterization, multiple-input multiple-output (MIMO) systems
2. *Diversity:* Non-coherent and coherent reception; error probability for un-coded transmission; realizing diversity; time diversity: interleaving, constellation rotation; frequency diversity, antenna diversity, code design for wireless channels: the product distance design criterion; diversity order
3. *Wireless Channel Capacity:* Capacity of the Gaussian channel and of parallel Gaussian channels; capacity of fading channels: ergodic capacity and outage capacity; high versus low SNR regime; water-filling capacity, Capacity of MIMO systems; spatial multiplexing; space-time coding
4. *Cellular Systems:* Multiuser communications; multiple access and broadcast channels; narrow band communication system - GSM; wide band communication systems - CDMA and OFDM schemes

Laboratory

1. Error Vector Magnitude Measurement for GSM Signals: To measure the error vector magnitude of a GSM modulated RF signal.
2. Adjacent Channel Power Ratio Verification for GSM Signals: To measure the channel

power and ACPR of the GSM modulated RF signal.

3. Output RF Spectrum (ORFS) Measurement for GSM Signals: To measure the RF spectrum of a GSM modulated signal.
4. Power vs Time (PvT) Measurement for GSM Signals: To measure the PvT of a GSM modulated RF signal.
5. Modulation Accuracy (ModAcc) Measurement for GSM Signals: To measure the modulation accuracy of a GSM modulated RF signal.
6. End-to-End RF Transceiver Measurement.

Reference Books

1. Tse, D. and Viswanath, P., (2005), *Fundamentals of wireless communication*, Cambridge University Press
2. Goldsmith, A., (2005), *Wireless Communications*, Cambridge University Press
3. Simon, M. K. and Alouini, M. S., (2005), *Digital communication over fading channels*, John Wiley & Sons
4. Cover, T. A. and Thomas, J. A., (2006), *Elements of Information Theory*, John Wiley & Sons
5. Rappaport, T. S., (2002), *Wireless Communication Systems: Principles and Practice*, Prentice Hall
6. User manuals of various measurement equipment used in the experiment setup.

Course Title	***Embedded Systems Design***	Course No.	**EE655**
Department	Electrical Engineering	Structure (LTPC)	3 0 3 4
Offered for	M. Tech Students	Status	Compulsory
Pre-requisite	*Knowledge of Microprocessor*		

Objectives

1. To make students familiar with use of advanced embedded tools; it includes both aspects hardware and software.
2. To make students familiar with process and tools used to abstract different requirements of embedded system.
3. To provide hands-on experience of embedded system interfacing and programming.

Learning Outcomes

1. Assembly language programming for PIC processors and ARM processors.
2. Hardware design using microcontrollers.
3. Ability to use embedded system for real-life applications.

Course Content

1. Architecture of PIC Microcontrollers (PIC 18FXXX Series)
2. Assembly language programming; use of different peripherals UART, I2C, Timers, CCP modules, RTC, Watchdog timer; ADC; I/O Ports
3. *Specifications and Modelling:* Models of computation; sequence charts; communicating finite state machines; data flow; Petri nets
4. *ARM Architecture:* Register set, Processor modes, exception handling, etc; ARM Instruction set, DSP extensions, programming in assembly language
5. *Real Time Scheduling:* Requirements of real time system, fixed and variable priority algorithms RMA and EDF; real time operating system

Laboratory

1. Use of Integrated Development Environment (IDE) to program embedded processors
2. To provide delay through timers
3. Interfacing of LEDs, small dc motor with I/O ports
4. Use of interrupts to handle periodic and aperiodic tasks

Reference Books

1. Huang, H., (2012), *PIC Microcontrollers: An Introduction to Software and Hardware Interfacing*, Thomson Learning
2. Gaonkar, R., (2007), *Fundamentals of Microcontrollers and Applications in Embedded Systems with PIC*, Thomson Learning
3. Mazidi, M. A., McKinlay, R. D. and Causey, D., (2011), *PIC Microcontroller*, Prentice Hall
5. Hohl, W., (2009), *ARM Programming*, CRC Press

Course Title	***VLSI Design Techniques***	Course No.	**EE624**
Department	Electrical Engineering	Structure (LTPC)	2 0 3 3
Offered for	M. Tech. Students	Status	Compulsory
Pre-requisite	*Digital IC Design (EE618)*		

Objectives
1. To expose the students with various design tools for Integrated Circuits and Chips
2. To teach the complete VLSI Design process and challenges ahead
3. Exposure to the designing for newer technologies

Learning Outcomes
1. Learning the principles associated VLSI Design
2. Student shall be able to design a digital circuit starting from layout

Course Content

Theory:
1. Introduction to Unix; Circuit Simulation using SPICE, application of SPICE for Analog Design
2. Timing simulation, Design of Static and Dynamic Digital Circuits, using IRSIM or any other design software/tool such as Cadence/Synopsys
3. Layout of Integrated Circuits. Use of the layout tool for Analog and Digital Integrated Circuits

Laboratory:
1. Tutorials on UNIX and vi.
2. Tutorials and design exercises on linear circuit design with SPICE;
3. Tutorial and exercises on digital design and timing analysis using IRSIM or any other design software/tool such as Cadence/Synopsys
4. Tutorials and exercises on IC layout; Group projects on design, analysis and layout of integrated circuits.

Reference Books

1. Thomas, R. and Yates, J. (1985), *A User Guide to the Unix System*, McGraw Hill International
2. Weste, N. H. E. and Harris, D. M., (2009), *CMOS VLSI Design*, 4th Edition, Pearson
3. Rabaey, J. M., Chandrakasan, A. and Nikolic, B., (2011), *Digital integrated Circuits, A Design Perspective,* 2nd Edition, PHI Learning

e-Material
1. VLSI Circuits Course NPTEL; http://nptel.ac.in/courses/117106092/
2. Free Video Lectures; http://freevideolectures.com/Course/2327/VLSI-Circuits#
3. MIT; http://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-374-analysis-and-design-of-digital-integrated-circuits-fall-2003/

Course Title	***Mobile Communication Systems***	Course No.	**EE661**
Department	Electrical Engineering	Structure (LTPC)	3 0 0 3
Offered for	M. Tech. and B. Tech. (IV Year) Students	Status	*Elective*
Pre-requisite	*EE651*		

Objectives

1. To provide students an understanding of fundamental issues related to frequency planning, resource allocation and interference management techniques in cellular communication networks.
2. To explore concepts and techniques used in existing and emerging cellular communication systems.

Learning Outcomes

1. Ability to analyse and design operational mobile communications networks.
2. Develop the ability to compare and contrast the strengths and weaknesses of various mobile communication networks.

Course Content

1. *Mobile Radio Concept:* Channel impairments, network access methods, frequency reuse, communication networks: paging systems, mobile satellite communications, universal mobile telecommunications system, wireless local area networks; communication protocols
2. *Cellular Wireless Networks:* First generation: analog; Second generation: TDMA (GSM, Edge, GPRS) and CDMA (IS-95), Third generation systems: CDMA2000
3. *Emerging/Future Cellular Network Technologies:* Long Term Evolution (LTE)-Advanced-Frequency and channel specifications of LTE-A, Resource Allocation, Carrier Aggregation, MIMO-Spatial Multiplexing, Transmitting Diversity, Relay Nodes, Coordinated Multi-point operation; Heterogeneous Cellular Networks
4. *Wireless LAN Technology:* Infrared LANs, Spread spectrum LANs, Narrowband Microwave LANs, Bluetooth, Wireless PANs, MIMO wireless LANs

Reference Books

1. Schiller, J., (2003), *Mobile Communication*, 2nd Edition, Pearson Education Limited
2. Stallings, W., (2005), *Wireless* Communications *and Networks*, 2nd Edition, Pearson Education Limited
3. Freeman, R. L., (2004), *Telecommunication System Engineering*, 4th Edition, Wiley India
4. Simon, M. K., and Alouini, M. S., (2005), *Digital Communication over Fading Channels*, 2nd Edition, John Wiley and Sons
5. Bolcskei, H., Gesbert, D., Papadis, C. B., and Veen, A. V., (2006), *Space-time Wireless Systems*, Cambridge University Press
6. eMaterial

Course Title	***Adaptive Signal Processing***	Course No.	**EE660**
Department	Electrical Engineering	Structure (LTPC)	3 0 0 3
Offered for	M. Tech.and B. Tech. (IV Year)	Status	*Elective*
Pre-requisite	*Digital Signal Processing or Consent of Teacher*		

Objective

1. To provide students an understanding of fundamental issues related to adjustment of weights of processing filters based on requirement and signal characteristics.

Learning Outcomes

1. Students will be able to design various optimal filters such as Least Squares filters and its variants.
2. Students will be able to apply these filtering techniques in various application areas such as speech, image, and video processing.

Contents

1. Review of linear and non-linear estimation theory
2. Signal modelling. Optimal filtering.; Adaptive filtering as an extension of the optimal least mean square error case Adaptive algorithms
3. Adaptive equalization and echo cancellation
4. Adaptive lattice filters
5. Application to image processing, video processing, and communications (spread spectrum techniques)

Reference Books

1. Haykin, S., (1986), *Adaptive filter theory*, Prentice Hall
2. Widrow, B., and Stearns, S. D., (1984), *Adaptive Signal Processing*, Prentice Hall

eMaterial

1. http://nptel.ac.in/courses/117105075/

Course Title	***Integrated Circuit Technology***	Course No.	**EE662**
Department	Electrical Engineering	Structure (LTPC)	3 0 3 4
Offered for	M. Tech.	Status	Elective
Pre-requisite			

Objectives

1. Teaching the theory behind unit processes for device and CMOS fabrication
2. To teach the complete VLSI fabrication Technology and challenges ahead
3. Familiarization with cleaning and safety procedures
4. Hands on experience on the unit processes for device fabrication

Learning Outcomes

1. Learning the scientific principles associated with the technologies used in VLSI fabrication.
2. Understanding of the fabrication methods and unit processes for device and circuit fabrication. Student shall be able to design a fabrication process flow for any discrete device as well as basic circuits.
3. Ability to fabricate discrete devices and to understand the physical properties of the films for electronic device fabrication.

Course Content

1. *Introduction:* History of Integrated circuits, CMOS Process flow starting from Substrate selection to multilevel metal formation, Modern CMOS Technologies
2. *Wafer Manufacturing:* Single crystal growth, Czochralski and FZ growth methods, Wafer preparation and specifications, SOI Wafer manufacturing
3. *Cleaning Processes:* Clean Rooms, Wafer Cleaning
4. *Thermal oxidation of silicon:* Wet and Dry oxidation, growth kinetics and models, electronic defects, characterization methods.
5. *Optical lithography:* Light sources, Wafer exposure systems, Photo resists, Mask making, Mask Engineering, Limits and future trends
6. *Solid state diffusion:* Various Models for diffusion, Manufacturing and Characterization methods, Future trends
7. *Ion implantation:* Basic concepts, High/Low energy implants, Limits and future trends, RTA Process & dopant activation
8. *Thin Film Deposition:* Physical and chemical vapor deposition techniques,
9. *Etching:* Wet and dry etching, Reactive and plasma etching
10. *Back-end Technology:* Backend Technology and VLSI/ULSI process integration, Multi-level Interconnects, Silicide formation, planarization, packaging.
11. *Novel Processes:* Fabrication processes for large area and flexible electronics systems, challenges and future trends

Laboratory

1. Cleaning of Substrates
2. Thin film preparation by Spin coating
3. Metal Deposition by e-beam/thermal evaporation
4. Dielectric Deposition by Atomic layer deposition
5. Fabrication of parallel plate capacitor and Capacitance measurement

6. Fabrication of Schottky diode and Current-voltage (I-V) characterization
7. Optical lithography
8. Fabrication of MOS structure/OFET/sensor

Reference Books

1. Plummer, J. D., Deal, M. D., and Griffin, P. B., (2009), *Silicon VLSI Technology- Fundame Practice And Modelling*, Pearson Education
2. Sze, S. M., (2003), *VLSI Technology*, Tata McGraw-Hill
3. Campbell, S., (1996), *The Science and Engineering of Microelectronic Fabricatior* Edition, Oxford University Press

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EE2

Course Booklet for M.Tech.

(Electrical Engineering)

2015