DDU Gorakhpur University, Gorakhpur

Department of Electronics

Ph.D. COURSE WORK

in

Electronics

Department of Electronics

DDU Gorakhpur University, Gorakhpur

Faculty of Science

Course Work for Ph. D. Electronics

Every student admitted in Electronics for the Ph.D. programme will be required to pass a course work of minimum 21 credits. The 21 credit course work is divided in three categories: Category-A (9 credits) courses are *compulsory* for all Ph. D. students of Electronics. Category-B (6-credits) carrying *discipline-specific courses*.Category-C (6 credits) carrying *research theme-specific courses*.

Course Nature	Course Code	Core Courses	Credit
		(Compulsory Course)	
Compulsory Course	STAT 600	Research Methodology	4+0
	LIB 600	Research and Publication Ethics	1+1
	CSC 600	Computer Fundamentals and IT	1+1
	ELE 601	Credit Seminar	0+1
			09 Credits
		Elective Course (*Any two of the followings*)	
Discipline-Specific Courses	ELE 602	Microelectronic Devices	03
	ELE 603	Synthesis and Characterization of Electronic Materials	03
	ELE 604	Nanoelectronics	03
	ELE 605	Advanced Digital System Design	03
	ELE 606	Signal and System	03
			06 Credits
		Open Elective Course (*Any two of the followings*)	
Research Theme-Specific Courses	ELE 607	Advanced Digital Signal Processing	03
	ELE 608	VLSI Architectures for DSP Systems	03
	ELE 609	Digital IC Design using HDL	03
	ELE 610	Nanomaterials for Energy Applications	03
	ELE 611	Photovoltaic Devices, Sensors and Transducers	03
			06 Credits
		Thesis	Non Credit
		Total	**21 Credits**

Program Outcome

At the end of Ph.D.course, the student will be able to:

1. Produce a well-developed research proposal that addresses question of significance in a specific area of Electronics.

2. Demonstrate in-depth knowledge of a particular area in Electronics and broad knowledge of other areasof the discipline.

3. Choose an appropriate methodology to conduct the research work.

4. Understand the most advanced research in the area of Electronics which is selected for the purpose of undertaking research by the student, i.e. have an in-depth literature survey.

5. Identify the resources as well as tools needed to perform the research process.

6. Continue with the ethical standards during the entire research work.

COURSE CONTENTS

Seminar

Course Code: ELE 601 **Credits: 01**

The seminar paper will be related to the Research Theme- Specific Course of the candidate and the candidate should have to give a seminar presentation on it.

Discipline Specific Courses

Microelectronic Devices

Course code: ELE 602 **Credit: 03**

Course Objectives:

1. To provide students with rigorous foundation in various semiconductor devices.
2. To provide exposure to students and to equip them for semiconductor and VLSI industry,R & D organization in the area of Microelectronics.

Course Outcomes:

1. Acquire knowledge of basic semiconductor material physics.
2. Analyze the characteristics of various electronic devices like diode, transistor etc., and able to classify and analyze the various circuit configurations Transistor and MOSFETs.
3. Implement the logic circuits using MOS and CMOS technology.
4. Infer about the second order effects of MOS transistor characteristics.
5. Analyse various circuit configurations and their applications.

Syllabus

Si Crystal structure, crystal planes and directions, band formation in semiconductors, direct and indirect gap semiconductors, E-k diagram, concept of "hole" as charge particle, effective mass, carrier mobility, life time of carriers, recombination, doping of semiconductors, drift and diffusion currents in semiconductors

Metal-semiconductor contacts: Schottky barrier diode, C-V and I-V characteristics of Schottky diode, ohmic contacts in semiconductors, abrupt p-n junction, energy- band diagram, junction under zero-bias, forward bias and reverse bias; current calculations, break-down in p-n junction, diffused p-n junction; bipolar transistor: theory and operation; theory of MOSFET, ideal MOSFET, threshold voltage, sub-threshold conduction in MOSFET, C-V characteristics of MOS capacitor, short channel effects. CMOS Technology.

References:

1. Physics of Semiconductor Devices by S.M. Sze
2. Electronics Devices and Circuit Theory by R.L. Boylestad& L. Nasheisky
3. Electronic devices and circuit, Mottershead, Allen, 1973.
4. Solid state electronic devices, Streetman Ben G; Banerjee Sanjay Delhi, Pearson Education (Singapore)Pvt. Ltd. 2000
5. Electronic devices and circuits- Bell, David A 1986

Synthesis and CharacterizationofElectronic Materials

Course code: ELE 603 **Credit: 03**

Course Objective:

1. The main objective is to train the manpower/students in the field of semiconductorScience and technology relevant to modern electronic industry/technology.

Course Outcomes:

1. Understanding the fabrication and characterization technology for electronic (micro &nano) and opto-electronic devices based on Inorganic and Organic materials
2. Knowledge and skills necessary for device fabrication. This includes developing the ability to use clean room and vacuum techniques besides making them understand the basic concepts of electronic device fabrication at micro and nano-scale level.
3. Trained manpower will be conversant with various processes and instruments to characterize the electronic materials and devices at different level for real time application.

Syllabus

Introduction of Electronic materials: Basic Parameters: Miller Index, Energy Bands, Resistivity, Carrier Doping Density, Mobility, Carrier Lifetime, Contact Resistance, Series Resistance. Defects: Surface Defects, Deep Defects, Oxides and Interface traps. Synthesis techniques: Physical Vapor deposition, Chemical Vapor Deposition, Spin Coating etc. With idea on Vacuum units/ pumps (Rotary, Diffusion, Turbo molecular, Getter, Cryogenic and Ion pumps), Vacuum measurement system. Doping methods. Heterojunctions and Nanostructures: Heterojunctions in devices, Quantum well and Superlattice structures, Quantum dots, Nano-tubes and Nano-rods etc.

Structural/Morphological Characterization: X-Ray Diffraction (XRD), Scanning Electron Microscope (SEM), Transmission Electron Microscope (TEM), Atomic Force Microscope (AFM), Scanning Tunnelling Microscope (STM). Spectral Characterization Techniques: UV-Vis Spectroscopy, Fourier Transform Spectroscopy (FTIR), Photoluminescence (PL), Raman Spectroscopy. Electrical Characterization: Four-Point Probe, I-V characteristics of devices, C-V plots, Hall Effect. Evaluation of Optical Spectroscopy Data: Direct and In-direct band-gap, Urbach tail, refractive index and Defects analysis. Electron Microscopy and XPS data inference: Grain size, morphology, orientation, chemical composition and stoichiometry.

References:

1. Physics of Semiconductor Devices, S. M. Sze and Kwok K. Ng, Wiley (2013).

2. Semiconductor Material and Device Characterization, Dieter K. Schroder, John Wiley & Sons inc. (1998)

3. Modern Spectroscopy, MichealHollas, Wiley (2004).

4. Preparation of Thin Films, Joy George, Marcel Dekkar (1992).

Nanoelectronics

Course code: ELE 604 **Credit: 03**

Course Objective:

1. Study of operating principle of Nano electronic devices.
2. Demonstrate specialized practical and theoretical knowledge in the use ofparticular Nano devices in its context.
3. Study of electronic and optoelectronic property of molecular electronic devices.

Course Outcome:

1. Explain the fundamental science and quantum principle behind nanoelectronics and the concepts of a quantum well, quantum transport and tunnelling effects.
2. Differentiate between microelectronics and nanoelectronics.
3. Describe the latest emerging applications of nanotechnology and nanoelectronics.

Syllabus

Charge and spin in single quantum dots- Coulomb blockade– Electrons in mesoscopic structures - single electron transfer devices (SETs) – Electron spin transistor – resonant tunnel diodes, tunnel FETs - quantum interference transistors (QUITs) - quantum dot cellular automata (QCAs) - quantum bits (qubits). Electronic transport in 1,2 and 3 dimensions- Quantum confinement - energy subbands - Effective mass - Drude conduction - mean free path in 3D – ballistic conduction - phase coherence length - quantized conductance – ButtikerLandauer formula- electron transport in pn junctions - short channel NanoTransistor – MOSFETs - Advanced MOSFETs - Trigate FETs, FinFETs – Electronic and optoelectronic properties of molecular materials - Electrodes & contacts – functions – molecular electronic devices – elementary circuits using organic molecules- Organic materials based rectifying diode switches – TFTs- OLEDs- OTFTs – logic switches.

References:

1. V. Mitin, V. Kochelap, M. Stroscio, ―Introduction to Nanoelectronics, Cambridge University Press
2. Rainer Waser, ―Nanoelectronics and Information Technology: Advanced Electronic Materials and Novel Devices‖, Wiley.
3. Karl Goser, Peter Glosekotter, Jan Dienstuhl, ―Nanoelectronics and Nanosystems‖, Springer.
4. SadamichiMaekawa, ―Concepts in Spin Electronics‖, Oxford University Press.
5. L. Banyai and S.W.Koch, ―Semiconductor Quantum Dots‖, World Scientific .

Advanced Digital System Design

Course code: 605 **Credit: 03**

Course Objective:

1. To review basic techniques for the design of digital circuits and fundamental concepts used in the design of digital systems.
2. To implement logical operations using combinational logic circuits and sequential logic circuits with concept of faults and hazards therein.
3. Design of sequential circuits and analysis of sequential systems in terms of state machines and implementation of synchronous state machines using flip-flops.

Course Outcome:

1. Design and analyze combinational circuits and to use standard combinational functions/building blocks to build larger more complex circuits.
2. Design and analyze complex sequential circuits and devices and to use standard sequential functions/building blocks to build larger and more complex circuit like Microprocessor.

Syllabus

Definition of combinational logic, canonical forms, Generation of switching equations from truth tables, Karnaugh maps-3,4,5 and 6 variables, Incompletely specified functions (Don‘t care terms) Simplifying Max term equations, Quine-McClusky techniques – 3 & 4 variables. Decoders, Encoders, Digital multiplexers, Adders and subtractors, Look ahead carry, Binary comparators. Programmable Logic Devices, Complex PLD, FPGA.

Basic Bistable elements, Latches,: SR flip-flops, JK flip-flops, The master-slave flip flops (pulse-triggered flip-flops) Characteristic equations, Registers, binary ripple counters, and synchronous binary counters. Design of a synchronous counter, Design of a synchronous mod-n counter using clocked JK, D, T and SR flip-flops. Mealy and Moore models, State machine notation, Construction of state diagrams. Design of a Sequence Detector, Guidelines for construction of state graphs, Design Example – Code Converter, Design of Iterative Circuits (Comparator), Design of Sequential Circuits using ROMs and PLAs, CPLDs and FPGAs, Serial Adder with Accumulator, Design of Binary Multiplier, Design of Binary Divider.

References:

1. John M Yarbrough,-Digital Logic Applications and Design, Thomson Learning,2001.
2. Donald D. Givone, ―Digital Principles and Design‖, McGraw Hill, 2002.
3. Charles H Roth Jr., Larry L. Kinney ―Fundamentals of Logic Design, CengageLearning, 7th Edition.
4. D. P. Kothari and J. S Dhillon, ―Digital Circuits and Design‖, Pearson, 2016,
5. Morris Mano, ―Digital Design‖, Prentice Hall of India, Third Edition.

Signal and System

Course code: ELE 606 **Credit: 03**

Course Objective:

1. Knowledge about basic signal and system modeling concept and definitions.
2. Student understand continuous-time signals and discrete-time signals.
3. Student understand linear time-invariant systems theory and applications.
4. Student can perform mathematical and graphical convolution of signals and systems.

Course Outcome:

1. Student understand continuous-time and discrete-time Fourier series/transforms.
2. Student can sketch the magnitude and phase of signals in transform domains.
3. Student can solve complex signals and circuit problems.

Syllabus

Basic definitions, Classification of signals and systems. Signal operations and properties. Basic continuous time signals, signal sampling and quantization, discretization of continuous time signals, discrete time signals. Basic system properties, Representation of digital signals. Case study of different signals form communication and biomedical field.

Impulse response characterization and convolution integral for CT- LTI system, signal responses to CT-LTI system, properties of convolution, LTI system response properties from impulse response. Review of Laplace transform with reference to CT signals and systems.

Impulse response characterization and convolution sum, Causal signal response to DT-LTI systems. Properties of convolution summation, Impulse response of DT-LTI system. DT-LTI system properties from Impulse response. System analysis from difference equation model.

Representation of periodic functions, Fourier series, Frequency spectrum of aperiodic signals, Fourier Transform, Relation between Laplace Transform and Fourier Transform and its properties. DTFT and DFT and FFT.

The z-Transform, Convergence of z-Transform, Basic z-Transform, Properties of z-Transform, Inverse z-Transform and Solving difference equation using z-Transform.

References:

1. Signals and Systems by Alan V. Oppenheim, Alan S. Wilsky and Nawab, Prentice Hall
2. Signals and Systems by K. Gopalan, Cengage Learning (India Edition)
3. Signals and Systems by Michal J. Roberts and Govind Sharma, Tata Mc-Graw Hill Publications
4. Signals and Systems by Simon Haykin and Bary Van Veen, Wiley- India Publications
5. Linear Systems and Signals by B.P.Lathi, Oxford University Press
6. Signal, Systems and Transforms by Charles L. Philips, J. M. Parr and E. A. Riskin, Pearson Education

<u>Research Theme- Specific Courses</u>

Advanced Digital Signal Processing

Course code: ELE 607 **Credit: 03**

Course Objective

1. Understand the design of various types of digital filters and implement them using various implementation structures and study the advantages & disadvantages of a variety of design procedures and implementation structures.
2. Understand the concept and need for Multirate signal Processing and their applications in
3. various fields of Communication & Signal Processing
4. Study various Parametric & Non parametric methods of Power spectrum estimation techniques and their advantages & disadvantages
5. Understand the effects of finite word/register length used in hardware in implementation of various filters and transforms using finite precision processors.

Course Outcome

1. Design and implement a filter which is optimum for the given specifications.
2. Design a Mutirate system for the needed sampling rate and can implement the same using Polyphase filter structures of the needed order.
3. Estimate the power spectrum of signal corrupted by noise through a choice of estimation methods: Parametric or Non Parametric.
4. Can calculate the output Noise power of different filters due to various finite word length effects viz: ADC Quantization, product quantization, and can calculate the scaling factors needed to avoid Limit cycles: Zero input, overflow.
5. Can decide the stability of the system by studying the effect due to coefficient quantization while implementing different filters and transforms.

Syllabus

Representations of discrete signals and systems and basic operators, z-Transforms, Causality and Stability in terms of z-transform, Bilateral z-transform, Computation of z-transform. Discrete Fourier Transform (DFT) and Fast Fourier Transform (FFT): Discrete Fourier Series, Discrete Fourier Transform and its Properties, Efficient Computation of DFT using FFT algorithms, Linear Filtering Approach to Computation of DFT. Digital Filter Structure: Describing Equation, Structures for FIR Systems and Structure for IIR Systems, Representation of Structures using Signal Flow Graph. Design of Digital Filters: Introduction, Difference between analog filters and digital filters, Implementation of digital filter, Types of filters, LTI systems as filters, Design of IIR filters from analog filters, IIR filter design using Butterworth Approximation, Frequency transformation, FIR filters design, Least square filter design, Designing digital filter from pole-zero placement, Butterworth filter design using Bilinear transformation, FIR filter design using windows, Design of filters using pole-zero combination. Hardware Architecture of DSP Processor: Introduction, Desirable features of DSP processors, Types of architectures, Internal architecture of ADSP-21xx family, Features of

ADSP-21xx family processors, System interface, Instruction set of ADSP-21xx, ADSP-21xx Development tools, ADSP-210x Processors, TMS DSP processor.

Analysis of Finite Word-length Effects: Introduction, the quantization process and errors, Analysis of coefficient quantization effects in FIR filters, A/D conversion noise analysis, Analysis of arithmetic round-off errors, Dynamic range scaling, Low sensitivity digital filters, Reduction of product round off errors, Limit cycles in IIR filters, Round off errors in FFT algorithms. Applications: Dual-tone multi frequency signal detection, Spectral analysis using DFT, Short term DFT, Musical sound processing, oversampling A/D converter, Oversampling D/A converter, Protection.

References:

1. Proakis, J.G. and Manolakis, D.G., Digital Signal Processing, Prentice-Hall of India Private Limited (1996).
2. Rabiner, C.R. and Gold, B., Theory and Applications of Digital Signal Processing, Prentice-Hall of India Private Limited (2000).
3. Oppenhein, A.V. and Schafer, R.W., Digital Signal Processing, Prentice-Hall of India Private Limited (1998).

VLSI Architectures for DSP Systems

Course code: ELE 608 **Credit: 03**

Course Objective:

1. acquiring a deep knowledge of various Programmable Logic Devices and its architectures.
2. To provide sound foundation of digital signal processing (DSP) architectures and designing efficient VLSI architectures for DSP systems.
3. To acquire knowledge of unconventional number system.

Course Outcome

1. To exposes the design approaches using ROM's, PAL's and PLA's.
2. To provide exposure to various CPLDS and FPGAS available in market.
3. To acquire knowledge in one hot state machine design applicable to FPGA.
4. Can develop a deep understanding of the design flow using case studies

Syllabus

Programmable Logic Devices: The concept of programmable Logic Devices, SPLDs, PAL devices, PLA devices, GALdevices, CPLD-Architecture, Xilinx CPLDs- Altera CPLDs, FPGAs-FPGA technology,architecture, virtex CLB and slice- Stratix LAB and ALM-RAM Blocks, DSP Blocks, ClockManagement, I/O standards, Additional features..

Redundant arithmetic: Redundant number representations, carry free radix 2 addition and subtraction, Hybrid radix 4 addition. Radix 2 hybrid redundant multiplication architectures, data format conversion. Redundant to nonredundantconverter.Numerical strength reduction.

Synchronous pipelining: clocking styles, clock skew and clock distribution in bit level pipelined VLSI designs. Wave pipelining, constraint space diagram and degree of wave pipelining. Implementation of wave-pipelined systems.Asynchronous pipelining.

Design procedure for sequential circuits-design example, Code converter, Design of Iterative circuits, Design of a comparator, Design of sequential circuits using ROMs and PLAs, Sequential circuit design using CPLDs, Sequential circuit design using FPGAs, Simulation and testing of Sequential circuits, Overview of computer Aided Design.

References:

1. K.K. Parhi : VLSI Digital Signal Processing systems, John Wiley, 1999.

2. Proakis, Digital Signal Processing, PHI, Second edition.

3. Lars Wanhammar, DSP Integrated Circuits, Academic Press, First edition, 1999

4. K KParhi, VLSI Digital Signal Processing Systems: Design and Implementation, John Wiely, 2007

Digital IC Design using HDL

Course code: ELE 609 **Credit: 03**

Course Objective:

1. To understand basics of hardware description languages. To implement various examples of digital IC designs using hardware description languages.
2. To understand various techniques for digital IC design methodologies.

Course Outcome:

1. Understand the basic concepts of VHDL.
2. Model digital systems in VHDL at different levels of abstraction.
3. Know the simulation techniques and test bench creation.
4. Understand the design flow from simulation to synthesizable version.
5. Student can perform HDL simulation and synthesis of complex digital system

Syllabus

VLSI Design Flow, Basic concepts of hardware description languages. Design flow for VHDL based RTL/logic synthesis. Hierarchy, Concurrency, Logic, and Delay modeling, Structural, Data-flow and Behavioral styles of hardware description. Architecture of event driven simulators.

Syntax and Semantics of VHDL.Variable, signal types, arrays, attributes and tables. Data types, Operators, expressions and signal assignments. Entities, architecture specification and configurations. Component instantiation. Use of Procedures, Tasks and functions, Memory Modelling, Examples of design using VHDL. Concurrent and sequential constructs. Examples of design using Verilog. Sequential Circuit design, Finite State Machine Modeling. Synthesis of Combinational and sequential circuits.

References:

1. VHDL: A Guide to Digital Design and Synthesis,S. Palnitkar,"Prentice Hall NJ, USA,1996
2. Advanced Digital Design with the HDL, Michael D. Ciletti, Prentice Hall India, 2005
3. VHDL: Analysis and Modeling of Digital Systems, Z. Navabi, McGraw Hill International Ed. 1998.
4. VHDL Primer,J.Bhaskar,Pearson Education Asia,2001.
5. Fundamentals of Digital Logic with VHDL Design, Stephen Brown and ZvonkoVranesic, McGraw-Hill Higher Education.
6. Verilog Digital System Design, Z. Navabi,McGraw Hill Education 2nd Ed. 2008

Nanomaterials and their Applications

Course code: ELE 610 **Credit: 03**

Course Objectives:

1. The main objective is to train the students in the field of semiconductor science and technology relevant to modern electronic technology.

Course outcomes:

1. Understanding the change in crystal structure and defects therein as one goes from bulk to nano length scale
2. Characterization and Properties will provide an overview of nanostructures evincing their fascinating properties
3. Trained manpower will be conversant with various processes and instruments to characterize the electronic materials and devices at different level for real time application.

Syllabus

Introduction to Nanoscience: Definition of Nano, Scientific revolution-Atomic Structure and atomic size, emergence and challenges of nanoscience and nanotechnology, carbon age-new form of carbon (CNT to Graphene), influence of nano over micro/macro, size effects and crystals, large surface to volume ration, surface effects on the properties.

Types of nanostructure and properties of nanomaterials: One dimensional, Two dimensional and Three dimensional nanostructured materials, Quantum Dots shell structures, metal oxides, semiconductors, composites, mechanical-physical-chemical properties.

Application of Nanomaterial: Ferroelectric materials, coating, molecular electronics and nanoelectronics, biological and environmental, membrane based application, polymer based application. Advanced Energy Related Fields; Energy storage systems, Fuel Cells, Battery, Super-capacitors, air/water purification, and removal of domestic and outdoor air pollutants, Biomedical application, Aerospace and defense technology.

References:

1. Nanomaterials and Nanocomposite: Synthesis, Properties, Characterization Techniques and Applications by Rajendra Kumar Goyal, 2011
2. Chemistry of nanomaterials: Synthesis, properties and applications by CNR Rao et.al.
3. Nanoparticles: From theory to applications – G. Schmidt, Wiley Weinheim 2004.
4. Instrument E L Principe, P Gnauck and P Hoffrogge, Microscopy and Microanalysis(2005), Cambridge University Press.
5. Processing & properties of structural naonmaterials, Leon L. Shaw.

Photovoltaic Devices, Sensors and Transducers

Course code: ELE 611 **Credit: 03**

Course Objectives:

1. Developknowledge on Photovoltaic Devices, Sensors and Transducers.
2. Enablestudents to design, analysis, fabrication and testing the devices.
3. Learn how to introduce nanotechnology based techniques to design the photovoltaic cells, sensors and transducers and to explore design tradeoffs, circuit/system issues, device performance, and manufacturing of systems.

Course outcomes:

1. To understand the different established solar cell technologies and emerging technologies.
2. To understand the fundamental properties of materials used for solar cell devices and analysis
3. To gain a comprehensive details of parameters and applications of various sensors and transducers
4.To understand the fundamental principle of Acoustic and ultrasonic sensors and transducers

Syllabus

Solar cell materials and their properties. Solar cell research: technology (silicon, organic, Dye sensitized, perovskites), applications and limitations. Characterization and analysis: ideal cell under illumination- solar cell parameters, optical losses; electrical losses, surface recombination velocity, quantum efficiency - measurements of solar cell parameters; I-V curve characteristics, internal quantum yield measurements – effects of series and parallel resistance and temperature - loss analysis. Solar photovoltaic(PV) modules from solar cells, series and parallel connections, design and structure of PV modules.

Introduction to sensors and transducers, basic parameters andprinciples and applications of various sensors and transducers incharacterization of materials, devices, circuits and systems; Acousticand ultrasonic sensors and transducers; Magnetic and Electrical sensorsand transducers; Thermal sensors and transducers; Radiation includingoptical sensors and transducers; Smart Sensors for characterizationof RF materials, devices, circuits and systems; Typicalapplications and use of transducers in systems/instruments.

References:

1.Thin Film Solar Cellsby K. L. Chopra, S. R. Das, Springer 2013
2.Nanostructured Solar Cells by Narottam Das, 2017
3.Sensors and Transducers by Ian Sinclair, Elsevier, 2011
4.Micro- and Nano-Scale Sensors and Transducers by Ezzat G. Bakhoum, CRC Press, 2015