Model Curriculum for Three/Four Year Degree Course

(With Multiple Entry /Exit Option)

Based on NEP-2020

Electronics

Odisha State Higher Education Council, Bhubaneswar

Government of Odisha

Semester	Subjects
I	Core I - Electronic Devices and Circuits
	Core II- Analog and Digital Electronics
II	Core III- Electronic Instrumentation
	Core IV - Microcontroller Programming and Applications
III	Core V- Semiconductor Materials and Devices
	Core VI- Communication Electronics
	Core VII- Industrial Electronics
IV	Core VIII- Power Electronics and e-Vehicle
	Core IX- Mathematical Methods for Electronics
	Core X- Electromagnetics
V	Core XI- Digital VLSI Design using Verilog
	Core XII- Digital Signal Processing
	Core XIII- RF and Microwave
VI	Core XIV- Antenna and Wave Propagation
	Core XV- Embedded Systems Design
VII	Core XVI- IoT and Applications
	Core XVII- Network and Control
	Core XVIII- Nano electronics
	Core XIX- Quantum Electronics
VIII	Core XX- 5G Networks
	Core XXI- Mobile App Development
	Core XXII- Optoelectronics and Photonics
	Core XXIII- Sensors and Actuators

Programme Outcome

- To prepare the students for a career in Electronics.
- To prepare the students for Higher Education and Research in Electronics.
- To develop a conceptual understanding of the subject and to develop an inquisitiveness in the subject.
- To enable the student to acquire basic skills necessary to understand the subject and to master the skills to handle equipment's utilized to learn the subject.
- To generally promote wider reading on the subject and allied inter disciplinary subject.

Core I **Semester -I**

Electronic Devices and Circuits

Course Outcomes (COs):

- At the end of the course the student should be able to:
- Aptitude to apply Logic thinking and Basic Science knowledge for problem solving in various fields of electronics both in industries and research.
- To acquire experimental skills, analysing the results and interpret data.
- Ability to design/develop/manage/operation and maintenance of sophisticated electronic gadgets/systems/processes that conforms to a given specification within ethical and economic constraints.
- Capacity to identify and implementation of the formulate to solve the electronic related issues and analyze the problems in various sub disciplines of electronics.
- Capability to use the Modern Tools / Techniques.

Unit-1

- Electronic Components: Electronic passive and active components, types and their properties, Concept of Voltage and Current Sources, electric energy and power (Qualitative only).
- Network Theorems: Superposition, Thevenin's, Norton's, Maximum Power Transfer, and Reciprocity Theorems. DC and AC analysis of RC and RL circuits, RLC series and parallel Resonant Circuits.
- PN junction diode: Ideal and practical diodes, Formation of Depletion Layer, Diode Equation and I-V characteristics. Idea of static and dynamic resistance, Zener diode, Reverse saturation current, Zener and avalanche breakdown.
- Rectifiers: Half wave and Full wave (centre tap and bridge) rectifiers, expressions for output voltage, ripple factor and efficiency (mention only), Shunt capacitor filter. (Numerical examples wherever applicable).

Unit-2

- Voltage regulator: Block diagram of regulated power supply, Line and Load regulation, Zener diode as voltage regulator – circuit diagram, load and line regulation, disadvantages. Fixed and Variable IC Voltage Regulators (78xx, 79xx, LM317), Clippers (shunt type) and clampers (Qualitative analysis only), Voltage Multipliers.
- Bipolar Junction Transistor: Construction, types, CE,CB and CC configurations (mention only), VI characteristics of a transistor in CE mode, Regions of operation (active, cut off and saturation), leakage currents (mention only), Current gains α , β and γ and their inter-relations, dc load line and Q point. Applications of transistor as amplifier and switch - circuit and working. (Numerical examples wherever applicable).

Unit-3

- Transistor biasing and Stabilization circuits: Fixed Bias and Voltage Divider Bias. Thermal runaway, stability and stability factor. Transistor as a two-port network, h-parameter equivalent circuit.
- Amplifier: Small signal analysis of single stage CE amplifier using h- parameters. Input and Output impedances, Current and Voltage gains. Advantages of CC amplifier. Class A, B and C Amplifiers (qualitative), Types of coupling, two stage RC Coupled Amplifier – circuit, working and its Frequency Response, loading effect, GBW product, Darlington transistor, Current gain.
- Special semiconductor diodes: Varactor diode, Schottky diode, Tunnel diode - construction, characteristics, working, symbol, and applications for each. LED, LCD and solar cell – construction, operation and applications, 7-segment display, concept of common anode and common cathode types (Numerical problems, wherever applicable)

Unit-4

- JFET–Types - p-channel and n-channel, working and I-V characteristics, n-channel JFET, parameters and their relationships, Comparison of BJT and JFET. MOSFET: E–MOSFET, D–MOSFET – n-channel and p-channel, Construction, working, symbols, biasing, drain and transfer characteristics, VMOS, UMOS Power MOSFETs, handling, MOS logic, symbols and switching action of MOS, NMOS inverter, CMOS logic, CMOS – inverter, circuit and working, CMOS characteristics, IGBT construction and working. UJT: Construction, working, equivalent circuit and I-V characteristics, intrinsic stand-off ratio, Relaxation oscillator. SCR: Construction, VI characteristics, working, symbol, and applications – HWR and FWR. Diac and Triac: Construction, working, characteristics, applications, (Numerical examples wherever applicable)

Suggested References

- ✓ *Robert L Boylestad, "Introductory circuit analysis", 5thedition., Universal Book 2003.*
- ✓ *R S Sedha, "A Text book of Applied Electronics", 7thedition., S. Chand and Company Ltd. 2011.*
- ✓ *A.P. Malvino, "Principles of Electronics", 7thedition, TMH, 2011.*
- ✓ *Electronic devices and circuit theory by Boylestad, Robert Nashelsky, 11thEdn., Pearson, 2013*
- ✓ *David A. Bell "Electronic Devices and Circuits", 5th Edition, Oxford University Press, 2015*
- ✓ *Thomas L. Floyd, Digital Fundamentals, Pearson Education Asia, (1994)*
- ✓ *"Electrical Circuits", Schaum"s Outline Series, TMH, 2005 S. A. Nasar,"*
- ✓ *Electrical Circuits", Schaum"s outline series, Tata McGraw Hill, 2004*
- ✓ *J. Millman and C. C. Halkias, "Integrated Electronics", Tata McGraw Hill, 2001*
- ✓ *A.S. Sedra, K.C. Smith, A.N. Chandorkar "Microelectronic circuits", 6thEdn., Oxford University Press, 2014*
- ✓ J. J. Cathey, "2000 Solved Problems in Electronics", Schaum"s outline Series, TMG, 1991.

Practical

1. Verification of Thevenin's and Maximum Power Transfer Theorem.
2. Verification of Superposition Theorem.
3. Study of the I-V Characteristics of (a) P-n junction diode, and (b) Zener diode.
4. Study of the I-V Characteristics of LEDs of two different colours and 7-segment display.
5. Study of Half wave rectifier without and with shunt capacitor filter– ripple factor for different values of filter capacitors.
6. Study of full wave bridge rectifier without and with shunt capacitor filter – ripple factor for different values of filter capacitors.
7. Study of Zener diode as a Voltage Regulator using bridge rectifier with shunt capacitor filter [Load and line regulation].
8. Study of Clipping, Clamping and Voltage Multiplier circuits.
9. Designing and testing of fixed positive and negative voltage regulators using 78xx and 79xx series ICs (Using bridge rectifier and shunt capacitor filter).
10. Designing and testing of variable voltage regulator using IC LM317 (Using bridge rectifier and shunt capacitor filter).
11. Study of Transistor characteristics in CE configuration – determination of h-parameters.
12. Study of Fixed Bias and Voltage divider bias circuits – comparison for different β values.
13. Study of single stage CE amplifier (frequency response, input and output impedances in mid-band
14. Study of two-stage RC-coupled CE amplifier (AV1, AV2, AV) at mid-band frequency.
15. Study of Series and Parallel Resonance circuits – determination of its
    (a) Resonant frequency
    (b) Impedance at resonance
    (c) Bandwidth
    (d) Quality Factor
16. Verification of truth tables of OR, AND, NOT, NAND, NOR, XOR and XNOR gates using
    respective ICs. Realization of XOR and XNOR using basic gates.
17. Universal property of NAND and NOR gates.

Core-II **Analog and Digital Electronics**

Course Outcomes

- After the completion of the course, one will be able to perform the following tasks:
- Be able to design amplifier circuits using BJT/FET/OP-Amp and observe the amplitude and frequency responses.
- Observe the effect of negative feedback on different parameters of an Amplifier and different types of negative feedback typologies.
- Observe the effect of positive feedback and able to design and working of different Oscillators using BJTS. Develop the skill to build, and troubleshoot Analog circuits.
- Binary systems, Boolean Function and their Minimization for Circuit Implementation
- Combination and Sequential Circuit Implementation
- Memory organization in Digital Systems

Unit-1

- Op-Amp: Differential Amplifier, Block diagram of Op-Amp, Characteristics of an Ideal and Practical Op-Amp, Open and closed loop configuration, Frequency Response, CMRR, Slew Rate and concept of Virtual Ground. Applications of op-amps: Concept of feedback, negative and positive feedback, advantages of negative feedback (Qualitative Study). Inverting and non- inverting amplifiers, Summing and Difference Amplifier, Differentiator, Integrator, Comparator and Zero-crossing detector. Filters: First and Second order active Low pass, High pass and Band pass Butterworth filters. Oscillators: Barkhausen criterion for sustained oscillations, Colpitt's oscillator and crystal oscillators using transistor, Phase Shift oscillator, Wien-bridge oscillator – (no derivation for each) 555 Timer: Introduction, Block diagram, Astable and Monostable multivibrator circuits. (Numerical Examples wherever applicable)

Unit-2

- Number System: Decimal, Binary, Octal and Hexadecimal number systems, base conversions. Representation of signed and unsigned numbers, Binary arithmetic; addition, subtraction by 1"s and 2"s complement method, BCD code (8421, 2421, Excess-3), Gray code, error checking and correction codes (Only parity check).
- Boolean Algebra: Constants, variables, operators, basic logic gates- AND, OR, NOT, Positive and negative logic, Boolean laws, Duality Theorem, De Morgan"s Theorem, simplification of Boolean expressions-SOP and POS. Derived logic gates (NAND, NOR, XOR & XNOR). Universal property of NOR and NAND gates. (Numerical examples wherever applicable).

Unit-3:

- Logic Families: Pulse characteristics, Logic Families-classification of digital ICs. Characteristics of logic families, circuit description of TTL NAND gate with totem pole and open collector. TTL IC terminology. CMOS NAND, Comparison of TTL and CMOS families. Combinational Logic Circuits: Minimisation techniques using K-maps - SOP and POS, Minterm, Maxterm, SSOP, SPOS, Simplification of Boolean expressions, K-Map for 3 and 4 variables.

- Digital to Analog Converter: DAC with binary weighted resistor and R-2R resistor ladder network. Analog to Digital converter: Successive approximation method-performance characteristics.
- Design of Arithmetic Logic Circuits: Half Adder, Full Adder, Half Sub tractor, Full Sub tractor. 4-bit parallel binary adder, 2-bit and 4-bitmagnitude comparator. Encoder, decimal to BCD priority encoder. Decoder, 2:4 decoder using AND gates, 3:8 decoder using NAND gates, BCD to decimal decoder, BCD to 7- Segment decoder, Multiplexer - 4:1 and 8:1 multiplexer, Demultiplexer - 1:4 and 1:8 demultiplexer (logic diagram and truth table of each), Realization of Full adder and Full Sub tractor using Mux and Decoder.

Unit-4

- Sequential Logic Circuits: Flip-Flops - SR Latch, RS, D and JK Flip- Flops. Clocked (Level and Edge Triggered) Flip-Flops. Preset and Clear operations. Race-around conditions in JK Flip-Flop. Master- Slave JK and T Flip-Flops. Applications of Flip-Flops in semiconductor memories, RAM, ROM and types.
- Registers and Counters: Types of Shift Registers, Serial-in-Serial- out, Serial-in-Parallel-out, Parallel-in-Serial-out and Parallel-in-Parallel-out Shift Registers (only up to 4 bits), applications. Ring counter, Johnson counter applications. Asynchronous Counters: Logic diagram, Truth table and timing diagrams of 4bit ripple counter, modulo-n counters,4bit Up-Down counter, Synchronous Counter: 4-bit counter, Design of Mod 3, Mod 5 and decade Counters using K-maps.

Suggested References:

- ✓ *Robert L Boylestad, "Introductory circuit analysis", 5th edition., Universal Book 2003.*
- ✓ *Electronic Devices Conventional Current Version by Thomas L. Floyd, 10th edition, Pearson, 2018*
- ✓ *David A. Bell "Electronic Devices and Circuits", 5th Edition, Oxford Univesity Press, 2015*
- ✓ *OP-Amps and Linear Integrated Circuit, R. A. Gayakwad, 4th edn., Prentice Hall., 2000*
- ✓ *Operational Amplifiers and Linear ICs, David A. Bell, 3rd Edition, Oxford University Press. 2011,*
- ✓ *R S Sedha, "A Text book of Applied Electronics", 7th edn., S Chand and Company Ltd., 2011*
- ✓ *Thomas L. Floyd, Digital Fundamentals, Pearson Education Asia, 1994*
- ✓ *Digital Principles and Applications, A.P. Malvino, D P Leach and Saha, 7th Edition, TMH, 2011.*
- ✓ *Fundamentals of Digital Circuits, Anand Kumar, 2ndEdn, PHI Learning Pvt. Ltd. 2009*
- ✓ *Digital Circuits and Systems, K R Venugopal and K Shyla, Tata McGraw Hill, 2011*
- ✓ *Digital Circuits and systems, Venugopal, Tata McGraw Hill. 2011*

- ✓ *Digital Systems: Principles & Applications, R.J.Tocci, N.S.Widmer, PHI Learning. 2001*
- ✓ *Digital Principles, Schaum"s Outline Series, R. L. Tokheim, TMH., 1994*
- ✓ *Digital Electronics, S.K. Mandal, 1st Edition, McGraw Hill., 2010.*

Practical:

1. Study of JFET/MOSFET characteristics – determination of parameters.
2. Study of single stage JFET amplifier. (frequency response and band width)
3. UJT characteristics and relaxation oscillator
4. SCR characteristics – determination of IH and firing voltage for different gate currents.
5. Design of inverting and non-inverting amplifier using Op-amp & study of frequency response.
6. Op-amp inverting and non-inverting adder, subtractor and averaging amplifier.
7. Study of the zero-crossing detector and comparator.
8. Design and study of differentiator and integrator using op-amp for different input waveforms.
9. 9 Design and study of Wien bridgeand RC phase shift oscillator using op-amp.
10. Design and study of first order high-pass and low-pass filters using op-amp. 11. Study of Colpitt"s and crystal oscillator using transistor.
11. Astablemultivibrator using IC - 555 timer.
12. Monostablemultivibrator using IC-555 timer.
13. Half Adder and Full Adder using (a) logic gates (b) using only NAND gates.
14. Half Subtractor and Full Subtractor(a) logic gates (b) using only NAND gates.
15. 4 bit parallel binary adder and Subtractor using IC7485.
16. Study of BCD to decimal decoder using IC7447
17. Study of the Encoders and priority encoders.
18. Study of Multiplexer and Demultiplexer using ICs.
19. Study of 2-bit and 4-bit magnitude comparators.
20. Study of Clocked RS, D and JK Flip-Flops using NAND gates.
21. Study of 4-bit asynchronous counter using JK Flip-Flop IC7476, modify to decade
22. Counter and study their timing diagrams.
23. Study of 4-bit Shift Register – SISO, modification to ring counter using IC 7495.

Core-III **Semester-II**

Electronic Instrumentation

Course Outcomes (COs)

- Explain the principles of electronic measurement and instrumentation, including the performance characteristics of different measurement systems.
- Identify the various parameters that are measurable in electronic instrumentation.
- Employ appropriate instruments to measure given sets of parameters.
- Design and evaluate complete measurement systems for various applications, considering factors such as performance, precision, and calibration.
- Practice the construction of testing and measuring set up for electronic systems.
- To have a deep understanding about instrumentation concepts.

Unit-1

- Qualities of Measurement: Specifications of instruments, their static and dynamic characteristics, Error (Gross error, systematic error, absolute error and relative error) and uncertainty analysis. Statistical analysis of data and curve fitting.
- Basic Measurement Instruments: PMMC instrument, galvanometer, DC measurement - ammeter,
- voltmeter, ohm meter, AC measurement, Digital voltmeter systems (integrating and non-integrating
- types), digital multimeters, digital frequency meter system (different modes and universal counter).
- Connectors and Probes: low capacitance probes, high voltage probes, current probes, identifying electronic connectors – audio and video, RF/Coaxial, USB etc.

Unit-2

- Measurement of Resistance and Impedance: Low Resistance: Kelvin's double bridge method, Medium Resistance by Voltmeter Ammeter method, Wheatstone bridge method, High Resistance by Megger. A.C. bridges, Measurement of Self Inductance, Maxwell's bridge, Hay's bridge, and Anderson's bridge, Measurement of Capacitance, Schering's bridge, DeSauty's bridge, Measurement of frequency, Wien's bridge.
- A-D and D-A Conversion: 4 bit binary weighted resistor type D-A conversion, circuit and working. Circuit of R-2R ladder. A-D conversion characteristics, successive approximation ADC. (Mention of relevant ICs for all).

Unit-3

- Oscilloscopes: CRT, wave form display and electrostatic focusing, time base and sweep synchronization, measurement of voltage, frequency and phase by CRO, Oscilloscope probes, Dual trace oscilloscope, Sampling Oscilloscope, DSO and Powerscope: Block diagram, principle and working, Advantages and applications, CRO specifications (bandwidth, sensitivity, rise time).
- Signal Generators: Audio oscillator, Pulse Generator, Function generators.

Unit-4

- Transducers and sensors: Classification of transducers, Basic requirement/characteristics of transducers, active & passive transducers, Resistive (Potentiometer, Strain gauge – Theory, types, temperature compensation and applications), Capacitive (Variable Area Type – Variable Air Gap type –Variable Permittivity type), Inductive (LVDT) and piezoelectric transducers. Measurement of displacement, velocity and acceleration (translational and rotational). Measurement of pressure (manometers, diaphragm, bellows), Measurement of temperature (RTD, thermistor, thermocouple, semiconductor IC sensors), Light transducers (photoresistors, photovoltaic cells, photodiodes).

Suggested References:

- ✓ *1. H. S. Kalsi, Electronic Instrumentaion, TMH(2006)*
- ✓ *W.D. Cooper and A. D. Helfrick, Electronic Instrumentation and Measurement Techniques, Prentice-Hall (2005).*
- ✓ *Instrumentation Measurement and analysis: Nakra B C, Chaudry K, TMH*
- ✓ *E.O.Doebelin, Measurement Systems: Application and Design, McGraw Hill Book - fifth Edition (2003).*
- ✓ *Joseph J Carr, Elements of Electronic Instrumentation and Measurement, Pearson Education (2005)*
- ✓ *David A. Bell, Electronic Instrumentation and Measurements, Prentice Hall (2013).*
- ✓ *Oliver and Cage, ―Electronic Measurements and Instrumentation‖, TMH (2009).*
- ✓ *Alan S. Morris, ―Measurement and Instrumentation Principles‖, Elsevier (Buterworth Heinmann-2008).*
- ✓ *A. K Sawhney, Electrical and Electronics Measurements and Instrumentation, DhanpatRai and Sons (2007).*
- ✓ *C. S. Rangan, G. R. Sarma and V. S. Mani, Instrumentation Devices and Systems, Tata Mcgraw Hill (1998).*

Practical

1. Design of multi range ammeter and voltmeter using galvanometer.
2. Measurement of resistance by Wheatstone bridge and measurement of bridge sensitivity.
3. Measurement of Capacitance by de‘Sautys.
4. Measure of low resistance by Kelvin‘s double bridge.
5. To determine the Characteristics of resistance transducer - Strain Gauge (Measurement of Strain using half and full bridge.)
6. To determine the Characteristics of LVDT.
7. To determine the Characteristics of Thermistors and RTD.
8. Measurement of temperature by Thermocouples and study of transducers like AD590 (two terminal temperature sensor), PT-100, J- type, K-type.
9. To study the Characteristics of LDR, Photodiode, and Phototransistor:
10. (i) Variable Illumination.
    (ii) Linear Displacement.
11. Characteristics of one Solid State sensor/ Fiber optic sensor

Core-IV **Microcontroller Programming and Applications**

Course Outcomes (COs):

- Understand the architecture of microprocessor, microcontroller, and fundamental operating concepts.
- Learn the design aspects of interfacing circuits and communication techniques
- Demonstrate programming proficiency using the various addressing modes and design microcontroller based solutions to problems.

Unit-1

- Fundamentals of Microprocessor:
- Compare microprocessor and microcontroller, Architecture of 8085 microprocessor, Pin details and functional operation of 8085, Memory and I/O interfacing, Basics of Programming.

Unit-2

- Introduction to 8051 Architecture : The 8051 Architecture- Hardware- Oscillator and clock-
- program counter –data pointer-registers-stack and stack pointer-special function registers- memory organization-program memory-data memory -Input / Output Ports –External memory counter and timer-serial data Input / output-Interrupts.

Unit-3

- 8051 Programming in Assembly Language : Basics of 8051 Assembly Language Programming-
- Structure of Assembly language-Assembling and running an 8051 program- Moving Data, Different Addressing modes-Accessing memory using various addressing modes- Arithmetic operations and Programs-Logical operations and Programs - Branching - I/O Port Programs – bit level instructions and Programs –Timer and counters - and application Programs, Interrupt programming, 8051 programming in 'C'.

Unit-4

- Peripheral Interfacing: Memory Interfacing, 7-Segment LED Display, LCD and Keyboard
- Interfacing, ADC, DAC interfacing, relay, Stepper Motor Interfacing, DC motor control, different
- Sensors and relevant application programs.

Suggested References:

✓ *Microprocessor Architecture: Programming and Applications with the 8085, Penram*

✓ *International Publishing by R. S. Gaonkar.*

✓ *The 8051 Microcontrollers Architecture, Programming & Applications by Kenneth J. Ayala.*

- ✓ *The 8051 Microcontrollers and Embedded Systems by Muhammed Ali Mazidi.*
- ✓ *Embedded Systems, Shibu K, Tata McGraw Hill Publishing, New Delhi.*
- ✓ *Programming and Customizing the 8051 Microcontroller, Myke Predko, Tata McGraw-Hill Edition.*

Practical:

1. Use 8051 Simulation tool
2. Test and verify the features of 8051 Trainer Kit
3. Write and execute assembly language programs based on Data transfer Instructions
4. Develop assembly language programs based on Arithmetic Instructions (e.g. 8 bit Addition , Subtraction, Multiplication, Division)
5. Develop Assembly Language Programs based on Logical Instructions (And, Or etc.)
6. Develop Assembly Language Programs based on Branch Instructions
7. Develop Assembly Language Programs based on Looping, Counting and Indexing concept
8. Develop Assembly Language Programs to introduce delay (e.g.1ms Delay) using Timer/Counter
9. Develop Assembly Language Programs for Interrupts
10. Develop Programs for serial communication
11. Develop a program to interface LED with 8051
12. Develop a program to interface 7 segment Display with 8051
13. Develop a program to Interface 8 bit DAC with 8051
14. Develop a program to interface a DC Motor with 8051
15. Develop a program to interface LCD Module with 8
16. Develop a 4 bit binary counter with 8051 and display out put on LCD
17. Develop a program to interface a Stepper Motor with 8051
18. Develop a data acquisition system using ADC0804 and Microcontroller

Semester-III

Core V

Semiconductor Materials and Devices

Course Outcomes

- Explain the properties of semiconductors and their significance in Electronics, including concepts such as energy band diagrams, doping, and carrier transport mechanisms.
- Describe the operation and characteristics of semiconductor diodes and transistors, including their biasing, small-signal models, and applications in electronic circuits.
- Analyze and design single-stage transistor amplifiers, considering aspects such as gain, input/output impedance, frequency response, and stability.
- Identify the different types of field-effect transistors (FETs) and describe their operation modes, including MOSFETs and JFETs, and analyze their characteristics and applications.
- Explain the operation and characteristics of thyristors, optoelectronic devices (such as LEDs and photodiodes), and power semiconductor devices (such as power diodes and power transistors), considering their applications in power electronics and optoelectronics.

Unit 1

Semiconductor Materials Basics: Introduction to Semiconductor Materials, Crystal Structure, Planes and Miller Indices, Energy Band in Solids, Concept of Effective Mass, Density of States, Carrier Concentration at Normal Equilibrium in Intrinsic Semiconductors, Derivation of Fermi Level for Intrinsic & Extrinsic Semiconductors, Donors, Acceptors, Dependence of Fermi Level on Temperature and Doping Concentration, Temperature Dependence of Carrier Concentrations. Carrier Transport Phenomena: Carrier Drift, Mobility, Resistivity, Hall Effect, Diffusion Process, Einstein Relation, Current Density Equation, Carrier Injection, Generation And Recombination Processes, Continuity Equation.

Unit 2

P-N Junction Diode : Formation of Depletion Layer, Space Charge at a Junction, Derivation of Electrostatic Potential Difference at Thermal Equilibrium, Depletion Width and Depletion Capacitance of an Abrupt Junction. Concept of Linearly Graded Junction, Derivation of Diode Equation and I-V Characteristics. Zener and Avalanche Junction Breakdown Mechanism. Tunnel diode, varactor diode, solar cell: circuit symbol, characteristics, applications

Unit 3

Bipolar Junction Transistors (BJT): PNP and NPN Transistors, Basic Transistor Action, Emitter Efficiency, Base Transport Factor, Current Gain, Energy Band Diagram of Transistor in Thermal Equilibrium, Quantitative Analysis of Static Characteristics (Minority Carrier Distribution and Terminal Currents), BaseWidth Modulation, Modes of operation, Input and Output Characteristics of CB, CE and CC Configurations. Metal Semiconductor Junctions: Ohmic and Rectifying Contacts.

Unit 4

Field Effect Transistors: JFET, Construction, Idea of Channel Formation, Pinch-Off and Saturation Voltage, Current-Voltage Output Characteristics. MOSFET, types of MOSFETs, Circuit symbols, Working and Characteristic curves of Depletion type MOSFET (both N channel and P Channel) and Enhancement type MOSFET (both N channel and P channel).

Complimentary MOS (CMOS). Power Devices: UJT, Basic construction and working, Equivalent circuit, intrinsic Standoff Ratio, Characteristics and relaxation oscillator-expression. SCR, Construction, Working and Characteristics, Triac, Diac, IGBT, MESFET, Circuit symbols, Basic constructional features, Operation and Applications.

Suggested References:

- ✓ *S. M. Sze, Semiconductor Devices: Physics and Technology, 2ndEdition, Wiley India edition (2002).*
- ✓ *Ben G Streetman and S. Banerjee, Solid State Electronic Devices, Pearson Education (2006)*
- ✓ *Dennis Le Croissette, Transistors, Pearson Education (1989)*
- ✓ *Jasprit Singh, Semiconductor Devices: Basic Principles, John Wiley and Sons (2001)*
- ✓ *Kanaan Kano, Semiconductor Devices, Pearson Education (2004)*
- ✓ *Robert F. Pierret, Semiconductor Device Fundamentals, Pearson Education (2006)*

- ✓ *CORE-3(LAB)*

Practical:

1. Study of the I-V Characteristics of Diode – Ordinary and Zener Diode.
2. Study of the I-V Characteristics of the CE configuration of BJT and obtain ri, ro, β.
3. Study of the I-V Characteristics of the Common Base Configuration of BJT and obtain ri, ro, α.
4. Study of the I-V Characteristics of the Common Collector Configuration of BJT and obtain voltage gain, ri, ro.
5. Study of the I-V Characteristics of the UJT.
6. Study of the I-V Characteristics of the SCR.
7. Study of the I-V Characteristics of JFET.
8. Study of the I-V Characteristics of MOSFET.
9. Study of Characteristics of Solar Cell
10. Study of Hall Effect.

Online Resources:

1. MIT OpenCourseWare: "Introduction to Solid State Chemistry" (https://ocw.mit.edu/courses/materials-science-and-engineering/3-091sc-introduction-to-solid-state-chemistry-fall-2010/)
2. All About Circuits: "Semiconductor Basics" (https://www.allaboutcircuits.com/textbook/semiconductors/)
3. Electronics Tutorials: "Semiconductor Diodes" (https://www.electronics-tutorials.ws/diode/diode_1.html)
4. Semiconductor Engineering: (https://semiengineering.com/)

Core-VI **Communication Electronics**

Course Outcomes:

- Know the basic concept of Analog Communication, means and medium of communication.
- Understand the principle of Analog and digital modulation.
- Familiar with “AM” and “FM “techniques.
- Understand the basic concept of Pulse Modulation, Carrier Modulation for digital transmission and able to construct simple pulse modulation.

Unit-1

Electronic communication: Block diagram of an electronic communication system, electromagnetic spectrum-band designations and applications, need for modulation, concept of channels and base-band signals. Concept of Noise, Types of Noise, Signal to noise ratio, Noise Figure, Noise Temperature, Friss formula.

Unit-2

Amplitude Modulation: Amplitude Modulation, modulation index and frequency spectrum. Generation of AM, Amplitude Demodulation (diode detector), Concept of Double side band suppressed carrier, Single side band suppressed carrier, other forms of AM (Pilot Carrier Modulation, Vestigial Side Band modulation, Independent Side Band Modulation). Block diagram of AM Transmitter and Receiver Angle modulation: Frequency and Phase modulation, modulation index and frequency spectrum, equivalence between FM and PM, Generation of FM (direct and indirect methods), FM detector (PLL). Block diagram of FM Transmitter and Receiver Comparison between AM, FM and PM.

Unit -3

Pulse Analog Modulation: Channel capacity, Sampling theorem, PAM, PDM, PPM modulation and detection techniques, Multiplexing, TDM and FDM. Pulse Code Modulation: Need for digital transmission, Quantizing, Uniform and Non-uniform Quantization, Quantization Noise, Companding, Coding, Decoding, Regeneration.

Unit -4

Digital Carrier Modulation Techniques: Block diagram of digital transmission and reception, Information capacity, Bit Rate, Baud Rate and M-ary coding. Amplitude Shift Keying (ASK), Frequency Shift Keying (FSK), Phase Shift Keying (PSK), Binary Phase Shift Keying (BPSK) and Quadrature Phase Shift Keying (QPSK)

Suggested References:

- ✓ *Electronic communication systems- Kennedy, 3 edition, McGraw international publications*
- ✓ *Principles of Electronic communication systems – Frenzel, 3 edition, McGraw Hill*
- ✓ *Communication Systems, S. Haykin, Wiley India (2006)*
- ✓ *Advanced electronic communications systems – Tomasi, 6 edition, PHI.*
- ✓ *Communication Systems, S. Haykin, Wiley India (2006)*

Practical:

1. Study of Amplitude Modulation
2. Study of Amplitude Demodulation
3. Study of Frequency Modulation
4. Study of Frequency Demodulation
5. Study of Pulse Amplitude Modulation
6. AM Transmitter/Receiver
7. FM Transmitter/Receiver
8. Study of TDM, FDM
9. Study of Pulse Width Modulation
10. Study of Pulse Position Modulation
11. Study of Pulse Code Modulation
12. Study of Amplitude Shift Keying
13. Study of Phase Shift Keying,
14. Study of Frequency Shift Keying.

Core-VII **Industrial Electronics**

Course Outcomes:

- Know the basic uses of 555 timer and PLL.
- Understand concepts of various industrial sensors.
- Familiar with A/D and D/A conversion.
- Understanding applications of OpAmp.

Unit – 1

Timer and PLL: Functional block diagram of 555 Timer, Monostable operation and its Application, Astable operation and its Applications. Phase Locked Loop: Functional block diagram – Phase detector / Comparator, Voltage Controlled Oscillator, Low pass filter, Applications: Frequency multiplier/ Division, AM detection.

Unit – 2

Operational Amplifier: Inverting and non-inverting amplifier, Op-amp parameters, Summing Amplifier, Difference Amplifier, Integrator, Differentiator, Instrumentation Amplifier, Audio Amplifier (LM386), Voltage to current converter, Current to Voltage converter, Sample and Hold circuits. First order active filters: Construction, working and applications of Low pass, High pass, Band pass, Band reject and all pass filters. Phase-shift and Wein bridge oscillator using op-amp (Circuit diagram and formula only).

Unit – 3

Transducers: Transducers, types, working of transducers., Displacement transducers - Resistive (Potentiometric, Strain Gauges – Types, Gauge Factor, bridge circuits, Semiconductor strain gauge), Capacitive (diaphragm), Hall effect sensors, Magnetostrictive transducers, Microphone, Touch Switch, Piezoelectric sensors, light (photo-conductive, photo emissive, photo voltaic, semiconductor, LDR), Temperature (electrical and non-electrical), Pressure sensor.

Unit – 4

A-D and D-A Conversion: D-A conversion: 4bit binary weighted resistor type, circuit and working. Circuit of R-2R ladder- Basic concept. A-D conversion characteristics, successive approximation ADC. (Mention the relevant ICs for all).

Suggested References:

- ✓ *Analog Electronics: Devices and Circuits., B. C. Sarkar and S. Sarkar, 1 st Edition, Damodar Group publisher., 2016*
- ✓ *Measurement Systems, Doeblin., 4 th edition, TMH, New York, 1992.*
- ✓ *Electrical Measurements & Electronic Measurements., A.K. Sawhney., Dhanpat Rai & Co. (P) Limited., 2015*
- ✓ *Digital Electronics: Circuits and Systems, B. C. Sarkar and S. Sarkar, S U T Prakashani Burdwan, 2018*

- *Instrumentation- Devices and Systems., Rangan, Sarma, and Mani, 2 nd Edition., Tata-McGrawHill., 2008*
- *Electronic Instrumentation., H.S Kalsi, 3 rd Edition., McGraw Hill., 2017*
- *Instrumentation measurements and analysis., Nakra&Choudhary., 3 rd Edition., TMH., 2017*
- *Op-Amps and Linear IC"s, R. A. Gayakwad, 4 th Edition., Pearson Education., 2000*
- *Electronic Sensor Circuits and Projects, III Volume, Forrest M Mims, Master Publishing Inc.,2006.*
- *Timer, Op Amp, and Optoelectronic Circuits & Projects, Forrest M Mims, 1 st Edition., Master Publishing Inc., 2004.*

Practical:

1. Arithmatic operations using OpAmp
2. R-2R ladder D/A converter using ICS
3. Study of PLL and 555 timer Ics
4. Low pass filter design
5. Familiarization of sensors

Core VIII **Semester-IV**

Power Electronics and e-Vehicle

Course Outcomes:

- Upon the completion of this course, students will demonstrate the ability to:
- Understand the basic operating principles of power electronic devices like SCR, Diac, Triac, IGBT, and power MOSFET.
- Understand working of Electric Vehicles and recent trends
- Analyse different power converter topology used for electric vehicle application
- Develop the electric propulsion UNIT and its control for application of electric vehicles

Unit- 1

- Power Devices: Need for semiconductor power devices, Power diodes, Enhancement of reverse blocking capacity, Introduction to family of thyristors.
- Silicon Controlled Rectifier (SCR): structure, I-V characteristics, Turn-On and Turn-Off characteristics, ratings, Factors affecting the characteristics/ratings of SCR, Gate-triggering circuits, Control circuits design and Protection circuits, Snubber circuit.

Unit- 2

- Diac and Triac: Basic structure, working and V-I characteristic of, application of a Diac as a triggering device for a Triac.
- Insulated Gate Bipolar Transistors (IGBT): Basic structure, I-V Characteristics, switching characteristics, device limitations and safe operating area (SOA) etc. Application of SCR: SCR as a static switch, phase controlled rectification, single phase half wave, full wave and bridge rectifiers with inductive & non-inductive loads; AC voltage control using SCR and Triac as a switch.
- Power MOSFETs: operation modes, switching characteristics, power BJT, second breakdown, saturation and quasi-saturation state.

Unit- 3

Generation of DC power – Mention of batteries. Single phase, Two phase and Three phase. Transformers. Power transmission and distribution. Domestic electrical wiring – connection from AC line to the meter, sockets, mention of phase neutral and the need of earthing. Mention of electric shock and safety. Mention of power type (ac or dc) and current ratings for home appliances. Mention of tester. Electric motor working principle. Inverter, Uninterrupted Power supply (UPS) – online and off line UPS, SMPS.

Unit-4

E-Vehicles: Electric and Hybrid Electric Vehicles Configuration of Electric Vehicles, Performance of Electric Energy storage for EV and HEV Energy storage requirements, Battery parameters, Types of Batteries, Modelling of Battery, Fuel Cell basic principle and operation, Types of Fuel Cells, Super Capacitors. Power Electronic Converter for Battery Charging, charging methods for battery, Termination methods, charging from grid.

Suggested References:

- ✓ *Power Electronics, P.C. Sen, TMH*
- ✓ *Power Electronics & Controls, S.K. Dutta*
- ✓ *Power Electronics, M.D. Singh & K.B. Khanchandani, TMH*
- ✓ *Power Electronics Circuits, Devices and Applications, 3rd Edition, M.H. Rashid, Pearson Education*
- ✓ *Power Electronics, Applications and Design, Ned Mohan, Tore.*
- ✓ *Power Electronics, K. HariBabu, Scitech Publication.*
- ✓ *Power Electronics, M.S. Jamil Asghar, PHI.*
- ✓ *A Textbook of Electrical Technology-Vol-II, B.L. Thareja, A.K. Thareja, S.Chand*
- ✓ *Electrical Circuits, K.A. Smith and R.E. Alley, Cambridge University Press, 2012.*
- ✓ *A Text Book in Electrical Technology - B L Theraja - S Chand & Co., 2005*
- ✓ *Performance and design of AC machines - M G Say, CBS Publishers and Distributers Pvt Ltd., 3rd Edition, 2002, e-book edition 2017.*
- ✓ *Basic Electrical Engineering - V K Mehta and Rohit Mehta, 6th Edition, S Chand and Company, 2006*
- ✓ *M. Ehsani, Y. Gao, S. Gay and Ali Emadi, Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals, Theory, and Design, 1st edition, CRC Press, 2004*
- ✓ *Iqbal Husain, Electric and Hybrid Vehicles: Design Fundamentals, 3rd Edition, CRC Press, 2021*
- ✓ *Sheldon S. Williamson, Energy Management Strategies for Electric and Plug-in Hybrid Electric Vehicles, Springer, 2013.*
- ✓ *C.C. Chan and K.T. Chau, Modern Electric Vehicle Technology, OXFORD University Press, 2001*
- ✓ *Chris Mi, M. AbulMasrur, David Wenzhong Gao, Hybrid Electric Vehicles Principles and Applications with Practical Perspectives, Wiley Publication, 2011.*

Practical:

1. Study of I-V characteristics of DIAC
2. Study of I-V characteristics of a TRIAC
3. Study of I-V characteristics of a SCR
4. SCR as a half wave and full wave rectifiers with R and RL loads 5. DC motor control using SCR.
5. DC motor control using TRIAC.
6. AC voltage controller using TRIAC with UJT triggering.
7. Study of parallel and bridge inverter.
8. Design of snubber circuit
9. VI Characteristic of MOSFET and IGBT (Both)
10. Study of chopper circuits
11. Un boxing and assembling of desktop computers.
12. Types of motors and transformers used in household appliances.
13. Understanding voltage, current, frequency etc. of ac mains
14. Up gradation of RAM, hard disk and SSD
15. SMPS: Block diagram and working Inverter

16. Types of motors and transformers used in household appliances.
17. SMPS: Block diagram and working Inverter.
18. Simulation and analysis of electrical systems using MATLAB.

Core-IX **Mathematical Methods for Electronics**

Course outcomes

- Understand and apply vector calculus concepts, including scalar and vector fields, gradient, divergence, and curl, in the analysis of physical phenomena and mathematical models.
- Calculate line, surface, and volume integrals and apply fundamental theorems such as Gauss's Divergence Theorem, Stoke's Theorem, and Green's Theorem to solve problems in diverse areas of science and engineering.
- Express vector operators (gradient, divergence, curl, and Laplacian) accurately in both Cartesian and spherical polar coordinates, enabling precise calculations and interpretations in different coordinate systems.
- Solve ordinary differential equations (ODEs) using various techniques, including exact equations, auxiliary equations, power series, and the Frobenius method, allowing for the analysis and prediction of dynamic systems.

Unit 1

- Vector Calculus (10hrs): Scalar and Vector Fields, Gradient of a Scalar function, Divergence of a Vector function, Curl, Line, Integral, Surface Integral and Volume Integral (Simple Problems), Gauss Divergence Theorem, Stoke’s Theorem and Green’s Theorem (Statement and Proof), Spherical Polar Coordinates, Expressions for Gradient, Divergence, Curl and Laplacian Operator in Cartesian and Spherical, Polar, Coordinates
- Ordinary Differential Equation (10hr): Linear first-order ODEs, Wronksian, exact ODEs, auxiliary equation. Inhomogeneous second order, ODEs, method of undetermined coefficients Green’s function method, power series method, Frobenius method, Beta and Gamma Functions, Series Solutions for Bessel, Legendre and Hermite, Differential Equations

Unit 2

Transforms and their applications (10hrs): Periodic functions, Series expansion, Fourier coefficients, Completeness relation, Dirichlet’s, Conditions (Statement Only), Fourier transforms, Laplace transforms, Solving ODEs using Laplace transforms, Dirac Delta function

Unit 3

COMPLEX VARIABLES (10hrs): Basics of Complex Numbers and their Graphical Representation, Euler’s Formula, De-Moivre’s Theorem, Functions of Complex Variables, Limit, Continuity and Differentiability, Analytic Function, Definition, Cauchy-Riemann Conditions, Examples of Analytic Functions, (Analyticity), Cauchy-Riemann Conditions in Polar Form

Unit 4

MATRICES (10Hours): Special Types of Matrices, Symmetric and Skew, symmetric Matrices, Hermitian and Skew-ermitian Matrices, Orthogonal Matrices, Unitary Matrices, Characteristics Equation, Determination of Eigen values and Eigen vectors, Statement and Proof of Cayley-Hamilton Theorem, Simple Problems, Inverse of Matrix by CH Theorem, Diagonalization of 2x2 Real Symmetric Matrices

Suggested References:

- ✓ *Mathematical Physics, H. K. Dass, S. Chand & Co. Ltd. (2010).*
- ✓ *Mathematical Physics, Sathya Prakash, Sultan Chand & Sons, New Delhi, Fifth Revised and Enlarged Edition, 2006, (Reprint 2007).*
- ✓ *Mathematical Physics ,B. D. Gupta, Vikas Publishing house Pvt. Ltd. (2010)*
- ✓ *Mathematical Methods for Physicists , G. Arfken, (5th Edition) ,Academic Press, (2000).*
- ✓ *Mathematical Physics , B.S. Rajput, 8th Edition,Pragati Prakashan(1978).*
- ✓ *Foundations of Mathematical Physics , Sadri Hassani, Second Edition.Springer*
- ✓ *Mathematical methods for Physics and Engineering, K.F.Riley, M.P.Hobson &S.J.Bence , Cambridge University Press, 3rd Edition.*

Core- X **Electromagnetics**

Course outcomes:

- Understand the fundamentals of Electricity and Magnetism, including concepts such as electric fields, magnetic fields, and electromagnetic waves.
- Analyze the behaviour of electromagnetic waves, including reflection, refraction, and wave propagation in different materials.
- Demonstrate knowledge of Maxwell's equations and their application in understanding the electromagnetic properties of materials

Unit-I

Electrostatic Fields: Coulomb‘s Law and Electric Field, Field due to Discrete and Continuous Charge Distributions, Electric Flux Density, Gauss‘s Law and Applications, Divergence Theorem and Maxwell‘s First Equation. Electric Potential, Potential due to a Charge and Charge distribution, Electric dipole. Electric Fields in Conductors, Current and Current Density, Continuity of Current, Metallic Conductor Properties and Boundary Conditions, Method of Images. Dielectric materials, Polarization, Dielectric Constant, Isotropic and Anisotropic dielectrics, Boundary conditions, Capacitance and Capacitors. Electrostatic Energy and Forces.

Unit- II

Poisson’s Equation and Laplace’s Equation: Derivation of Poisson‘s and Laplace‘s equation, Uniqueness Theorem, Examples of Solution of Laplace‘s Equation: Cartesian, Cylindrical and Spherical Coordinates. Magnetostatics: Biot Savert‘s law and Applications, Magnetic dipole, Ampere‘s Circuital Law, Curl and Stoke‘s Theorem, Maxwell‘s Equation, Magnetic Flux and Magnetic Flux Density, Scalar and Vector Magnetic Potentials. Magnetization in Materials and Permeability, Anisotropic materials, Magnetic Boundary Conditions, Inductors and Inductances, Magnetic Energy, Magnetic Circuits. Inductances and Inductors, Magnetic Energy, Forces and Torques.

Unit-III

Time-Varying Fields and Maxwell’s Equations: Faraday‘s Law of Electromagnetic Induction, Stationary Circuit in Time-Varying Magnetic Field, Transformer and Motional EMF, Displacement Current, Maxwell‘s Equations in differential and integral form and Constitutive Relations. Potential Functions, Lorentz gauge and the Wave Equation for Potentials, Concept of Retarded Potentials. Electromagnetic Boundary Conditions. Time-Harmonic Electromagnetic Fields and use of Phasors

Unit-IV

Electromagnetic Wave Propagation: Time- Harmonic Electromagnetic Fields and use of Phasors, the Electromagnetic Spectrum, Wave Equation in a source free isotropic homogeneous media, Uniform Plane Waves in Lossless and Lossy unbounded homogeneous media, Wave Polarization, Phase and Group velocity, Flow of Electromagnetic Power and Poynting Vector. Uniform Plane wave incident on a Plane conductor boundary, concept of reflection and standing wave.

Suggested References:

- ✓ *W. H. Hayt and J. A. Buck, Engineering Electromagnetics, Tata McGraw Hill*
- ✓ *Electromagnetic Field Theory Fundamentals, B.S. Guru and H.R. Hiziroglu, PWS Publishing*
- ✓ *Company, a division of Thomson Learning Inc.*
- ✓ *D. C. Cheng, Field and Wave Electromagnetics, Pearson Education*
- ✓ *M. N. O. Sadiku, Elements of Electromagnetics, Oxford University Press*
- ✓ *J. A. Edminster, Electromagnetics, Schaum Series, Tata McGraw Hill*
- ✓ *Introduction to Electrodynamics, D.J. Griffiths, Pearson Education*

Core-XI **Semester-V**

Digital VLSI Design using Verilog

Course Outcomes:

- Understand the fundamentals of VLSI Design, including its applications and emerging trends.
- Analyze CMOS technology and design CMOS logic gates, considering factors such as voltage levels, fan-out, and noise margins.
- Design and simulate combinational and sequential circuits, ensuring proper functionality and timing requirements.
- Design and analyze arithmetic circuits and memories, considering factors such as speed, power, and area efficiency.
- Apply VLSI Design methodologies, including simulation and testing techniques, to ensure the correctness and reliability of VLSI circuits.

Unit 1:

Introduction to VLSI Design (10 Hours): VLSI Design flow: Full Custom, ASIC and FPGA. Design Tools: CAD Tool Taxonomy, Editors, Simulators, Simulation System, Simulation Aids, Applications of Simulation, Synthesis Tools, and Introduction to Hardware Description Languages (HDL)

Unit 2:

Verilog HDL (12 Hours): Introduction to Verilog HDL, Abstraction levels, basic concepts, Verilog primitives, keywords, data types, nets and registers, Verilog Modules and ports, Logical Operators, Bitwise and Reduction Operators, Concatenation and Conditional Operators, Relational and Arithmetic, Shift and Equality Operators, Operator Execution Order.

Unit 3:

Verilog Modelling (12 Hours): Gate Type, Design Hierarchy, Gate Delay, Propagation Delay, Logic Simulation Dataflow-Level Modelling: Assignments, Behavioural Modeling: Always Block, Flow Control, If-Else, Case, Cases, While Loop, For Loop, Repeat

Unit 4: Logic Circuit Design (15 Hours): Logic Synthesis, RTL Synthesis, High-Level Synthesis, Synthesis Design Flow, Design and Analysis of Combinational Circuits, Synthesis of Combinational Circuits, Arithmetic Circuits, Initial Design and Optimization, Encoder, Decoder, De-Multiplexer Circuits, Multiplexer Circuits and their Implementation Using Verilog, Design of a 4-Bit Comparator, Synthesis of Sequential Circuits, Study of Synchronous and Asynchronous Sequential Circuits, Flip Flops, Shift Registers, Counters and their Design Using Verilog.

Suggested References:

- ✓ *Palnitkar, Samir. "Verilog HDL: A Guide To Digital Design and Synthesis", Pearson Education India, 2003*
- ✓ *Navabi, Zainalabedin, and Yuwen Xia. "Verilog Digital System Design: Register Transfer Level Synthesis, Testbench, and Verification", McGraw-Hill, 2006*

- ✓ *Mishra, Kishore K. "Advanced chip design: Practical examples in Verilog", Create Space Independent Publishing Platform, 2013*

Practical:

1. Design and Create Simulation Waveform for Full Adder Using Continuous Assignment and Procedural Assignments
2. Design and Create Simulation Waveform for Encoder and Decoder Using Continuous Assignment and Procedural Assignments
3. Design and Create Simulation Waveform for De-Multiplexer Using Continuous Assignment and Procedural Assignments
4. Design and Create Simulation Waveform for 4-Bit Comparator Using Continuous Assignment and Procedural Assignments
5. 1. Design And Create Simulation Waveform For SR-Flip Flop and D-Flip Flop Using Continuous Assignment And Procedural Assignments
6. Design and Create Simulation Waveform for JK-Flip Flop and T-Flip Flop Using Continuous Assignment and Procedural Assignments
7. 3. Design and Create Simulation Waveform for Shift Registers (SISO,SIPO,PISO,PIPO) Using Continuous Assignment and Procedural Assignments
8. Design and Create Simulation Waveform for 2-Bit Ripple Counter using Continuous Assignment and Procedural Assignments
9. Design and Create Simulation Waveform for 8-Bit Up/Down Synchronous Binary Counter Using Continuous Assignment and Procedural Assignments

Online Resources:

- VLSI Design Tutorials, Projects, and Resources www.vlsidesignworld.org
- IEEE Transactions on Very Large-Scale Integration (VLSI) Systems www.computer.org/csdl/journal/tv

Core XII

Digital Signal Processing

Course outcome

- Knows basic discrete-time signal and system types, convolution sum, impulse and frequency response concepts for linear, time-invariant (LTI) systems, difference equation realization of LTI systems and discrete-time Fourier transform and basic properties of these.
- Understands periodic sampling of analog signals and the relation between Fourier transforms of the sampled analog signal and the resulting discrete-time signal.
- Grasps z and inverse z transform, region of convergence concepts and their properties, performs simple transform calculations, understands the system function concept with its relations to impulse and frequency responses.
- Understands signal flow graph and block diagram representations of difference equations that realize digital filters: (i) Learns direct forms 1 and 2 for IIR filter realization. (ii) Learns direct form for FIR filter realization.
- Understand uses of FFT.

Unit 1

Discrete-Time Signals and Systems: Classification of Signals, Transformations of the Independent Variable, Periodic and Aperiodic Signals, Energy and Power Signals, Even and Odd Signals, Discrete-Time Systems, System Properties. Impulse Response, Convolution Sum; Graphical Method; Analytical Method, Properties of Convolution; Commutative; Associative; Distributive; Shift; Sum Property System Response to Periodic Inputs, Relationship Between LTI System Properties and the Impulse Response; Causality; Stability; Invertibility, Unit Step Response.

Unit 2

Discrete-Time Fourier Transform: Fourier Transform Representation of Aperiodic Discrete-Time Signals, Periodicity of DTFT, Properties; Linearity; Time Shifting; Frequency Shifting; Differencing in Time Domain; Differentiation in Frequency Domain; Convolution Property. The Z-Transform: Bilateral (Two-Sided) Z-Transform, Inverse Z-Transform, Relationship Between Z-Transform and Discrete-Time Fourier Transform, Z-plane, Region-of-Convergence; Properties of ROC, Properties; Time Reversal; Differentiation in the Z-Domain; Power Series Expansion Method (or Long Division Method); Analysis and Characterization of LTI Systems; Transfer Function and Difference-Equation System. Solving Difference Equations.

Unit 3

Filter Concepts: Phase Delay and Group delay, Zero-Phase Filter, Linear-Phase Filter, Simple FIR Digital Filters, Simple IIR Digital Filters, All pass Filters, Averaging Filters, Notch Filters. Discrete Fourier Transform: Frequency Domain Sampling (Sampling of DTFT), The Discrete Fourier Transform (DFT) and its Inverse, DFT as a Linear transformation, Properties; Periodicity; Linearity; Circular Time Shifting; Circular Frequency Shifting;

Circular Time Reversal; Multiplication Property; Parseval's Relation, Linear Convolution Using the DFT (Linear Convolution Using Circular Convolution), Circular Convolution as Linear Convolution with aliasing.

Unit 4

Fast Fourier Transform: Direct Computation of the DFT, Symmetry and Periodicity Properties of the Twiddle factor (WN), Radix-2 FFT Algorithms; Decimation-In-Time (DIT) FFT Algorithm; Decimation-In-Frequency (DIF) FFT Algorithm, Inverse DFT Using FFT Algorithms. Realization of Digital Filters: Non-Recursive and Recursive Structures, Canonic and Non Canonic Structures, Equivalent Structures (Transposed Structure), FIR Filter structures; Direct-Form; Cascade-Form; Basic structures for IIR systems; Direct-Form I.

Practical (Use Octave/Scilab):

1. Generation of Basic Signals.
2. Generation of Basic Signals.
3. Basic operations on Matrices.
4. Perform Linear Convolution of two sequences.
5. To perform Linear Convolution.
6. To perform Circular Convolution.
7. Perform circular convolution of two given discrete sequences.
8. Evaluate DFT of given sequence.
9. Verify Blackman and Hamming windowing techniques sequences.
10. Implement IIR Butterworth analog Low Pass for a 4 KHz cut off frequency.

Suggested References:

- ✓ *Digital Signal Processing, Tarun Kumar Rawat, 2015, Oxford University Press, India*
- ✓ *Digital Signal Processing, S. K. Mitra, McGraw Hill, India.*
- ✓ *Principles of Signal Processing and Linear Systems, B.P. Lathi, 2009, 1 st Edn. Oxford University Press.*
- ✓ *Fundamentals of Digital Signal processing using MATLAB, R.J. Schilling and S.L. Harris, 2005, Cengage Learning.*
- ✓ *Fundamentals of signals and systems, P.D. Cha and J.I. Molinder, 2007, Cambridge University Press.*
- ✓ *Digital Signal Processing Principles Algorithm & Applications, J.G. Proakis and D.G. Manolakis, 2007, 4 th Edn., Prentice Hall.*

Core XIII

RF and Microwave

Course Outcomes

- Explain different types of waveguides and their respective modes of propagation.
- Analyze typical microwave networks using impedance, admittance, transmission and scattering matrix representations.
- Design microwave matching networks using L section, single and double stub and quarter wave transformer.
- Explain working of microwave passive circuits such as isolator, circulator, Directional couplers, attenuators etc.

Unit-I

Transmission line: Transmission line characteristics; Transmission line equations and solution; Reflection coefficient and Transmission equation; Standing wave and standing wave ratio; Terminated Lossless Line impedance and admittance; Smith chart.

Waveguides & Planar Transmission Lines: Rectangular Waveguide - TE & TM modes, Dominant Mode, Cut-off frequency; Circular Waveguide - TE & TM modes, Dominant Mode, Surface wave concept - TM & TE Modes. Planar Transmission Line: Strip Line, Microstrip Line, Coplanar Waveguide (CPW). Wave Velocity & Dispersion- Group Velocity.

Unit-II

Resonators & Networks: Series & Parallel Resonances, Transmission Line Resonator - Open & Short Circuited half-wavelength resonators; Dielectric Resonator - Resonant Frequencies.

Impedance & Equivalent Voltages & Currents - Even & Odd Properties; Z & Y Matrices - Reciprocal networks, Loss less networks; ABCD Matrix - Relation to Z Matrix, Equivalent Circuit for 2-Port Network; S Matrix - Reciprocal & Lossless Networks, Shift in Reference Planes. Signal Flow Graphs - Decomposition.

Unit-III

Single & Double Stub Matching; Quarter Wave Transformer; Small Reflections – Single-Section & Multi-section transformers; Binomial & Chebyshev Multi-section Matching Transformers; Bode-Fano Criterion.

Unit-IV

Dividers & Couplers: Basic Properties - 3 & 4 Port Networks; T-Junction Divider - Loss Less, Resitive; Wilkinson Divider - Even-Odd Mode Analysis; Quadrature (90 0) Hybrid; Coupled Line Directional Coupler (Excluding Multi section Coupler); Lange Coupler; The 180 0 Hybrid (only Ring Type).

Suggested References:

✓ *Microwave Engineering – D. M. Pozar, Wiley Publication*

✓ *Microwave Engineering – R. E. Collin, McGraw Hill Publication.*

✓

Core XIV **Semester-VI**

Antenna and Wave Propagation

Course Outcomes

- Explain the radiation through antenna and identify different types of antennas.
- Identify and measure the basic antenna parameters
- Design and analyze wire and aperture antennas
- Design and analyze antenna arrays
- Identify the characteristics of radio-wave propagation

Unit-I

- ELECTROMAGNETIC RADIATION: Radiation phenomenon from an oscillation dipole in free space, induction and radiation fields, Retarded potentials, Radiated power and radiation resistance from a short dipole , half wave dipole and quarter wave monopole.

- ANTENNA BASICS: Directional properties of antennas, Radiation patterns, antenna gain and aperture, antenna terminal impedance, self and mutual impedance, front to back ratio, antenna beam width and bandwidth, antenna efficiency, antenna beam area, polarization, antenna temperature and
- Reciprocity properties of antennas.

Unit-II

- ANTENNA ARRAYS: Classification of arrays, linear arrays of two point sources, linear arrays of n-point sources, pattern multiplication, array factor, linear arrays of equal amplitude and spacing (Broadside and end fire arrays) of n-point sources, directivity and beam width, non-uniform arrays excitation using Binomial series.

Unit-III

- SPECIAL ANTENNAS: VLF and LF antennas(Hertz and Marconi antennas), effects of antenna height and effect of ground on performance of antenna , Rhombic antennas, Loop antennas , receiving antenna and radio direction finders. Folded dipole antennas, Yagi-uda antenna, horn antennas, microwave dish, helical antennas, frequency independent antennas, microstrip antennas, fractal antennas.

Unit-IV

- GROUND WAVE PROPAGATION: Characteristics for ground wave propagation, reflection at the surface of a finitely conducting plane and on earth, Attenuation Calculation of field strength at a distance.
- IONOSPHERE PROPAGATION: The ionosphere, formation of the various layers, their effective characteristics, reflection and refraction of waves by ionosphere, virtual height, maximum frequency, skip distance, regular and irregular variation of ionosphere, Fading and Diversity reception, ordinary and extraordinary waves.
- SPACE WAVE PROPAGATION: Space wave, range and effect of earth, Troposphere waves-reflection, refraction, duct propagation, Troposphere scatter propagation link

Suggested References:

- ✓ *J.D. Krauss, Antennas for all applications, 3RD Edition (TMH)*
- ✓ *R. E. Collin, Antennas and Radiowave Propagation, McGraw Hill.*
- ✓ *Jordan & Balmain, Electromagnetic wave & radiating systems, PHI Publication*
- ✓ *C. Balanis, Antenna Theory: Analysis and design, Wiley India*

Core XV

Embedded Systems Design

Course Outcomes:

- Upon completion of this course, the students will be able to:
- Understand the design process of an embedded system
- Understand typical embedded System & its components
- Understand embedded firmware design approaches
- Learn the basics of OS and RTOS

Unit 1: INTRODUCTION TO EMBEDDED SYSTEMS

- History of embedded systems, Classification of embedded systems based on generation and complexity, Purpose of embedded systems, The embedded system design process-requirements, specification, architecture design, designing hardware and software, components, system integration, Applications of embedded systems, and characteristics of embedded systems.
- Typical Embedded System: Core of the embedded system-general purpose and domain specific processors, ASICs, PLDs, COTs; Memory-ROM, RAM, memory according to the type of interface, memory shadowing, memory selection for embedded systems, Sensors, actuators, I/O components, other sub-systems: reset circuit, brownout protection circuit, oscillator circuit real time clock, watch dog timer.

Unit 2: COMMUNICATION INTERFACE

Onboard communication interfaces-I2C, SPI, CAN, parallel interface; External communication interfaces-RS232 and RS485, USB, infrared, Bluetooth, Wi-Fi, ZigBee, GPRS, GSM.

Unit 3: EMBEDDED FIRMWARE DESIGN AND DEVELOPMENT

Embedded firmware design approaches-super loop based approach, operating system based approach; embedded firmware development languages-assembly language based development, high level language based development.

Unit 4: RTOS BASED EMBEDDED SYSTEM DESIGN

Operating system basics, types of operating systems, tasks, process and threads, multiprocessing and multitasking, task scheduling: non-pre-emptive and pre-emptive scheduling; task communication-shared memory, message passing, Remote Procedure Call and Sockets, Task Synchronization: Task Communication/ Synchronization Issues, Task Synchronization Techniques.

Suggested References:

- ✓ *Introduction to Embedded Systems - shibu k v, Mc Graw Hill Education.*
- ✓ *Computers as Components –Wayne Wolf, Morgan Kaufmann (second edition).*
- ✓ *Embedded System Design -frank vahid, tony grivargis, john Wiley.*
- ✓ *Embedded Systems- An integrated approach - Lyla b das, Pearson education, 2012.*
- ✓ *Embedded Systems – Raj Kamal, TMH*

Core XVI **Semester VII**

IoT and Applications

Course Outcomes:

Upon completion of this course, students will acquire knowledge about:

- Design a portable IoT using Arduino/ equivalent boards and relevant protocols.
- Develop web services to access/control IoT devices.
- Deploy an IoT application and connect to the cloud.
- Analyze applications of IoT in real time scenario.

Unit-1: Fundamentals of IoT

Introduction, History of IoT, Definitions & Characteristics of IoT, IoT Architectures, Physical & Logical Design of IoT, Enabling Technologies in IoT, Components of an IoT Solution, IoT frameworks, IoT and M2M, Open Source and Commercial Examples, Competing Standards for IoT

Unit – 2: Sensors Networks

Definition, Traditional Data Storage, Analog and Digital I/O Basics, Types of Sensors, Types of Actuators, Examples and Working, IoT Development Boards: Arduino IDE and Board Types, RaspberriPi Development Kit, RFID Principles and components, Wireless Sensor Networks: History and Context, The node, Connecting nodes, Networking Nodes, WSN and IoT.

Unit – 3: Wireless Technologies for IoT

WPAN Technologies for IoT: IEEE 802.15.4, Zigbee, HART, NFC, ZWave, BLE, Bacnet, Modbus. IP Based Protocols for IoT IPv6, 6LowPAN, RPL, REST, AMPQ, CoAP, MQTT. Edge connectivity and protocols

Unit – 4: Data Handling& Analytics

Introduction, Bigdata, Types of data, Characteristics of Big data, Data handling Technologies, Flow of data, Data acquisition, Data Storage Applications of IoT: Home Automation

Suggested References:

- ✓ *Internet of Things, Vasudevan, Nagrajanand and Sundaram, Wiley India.*
- ✓ *Srinivasa K G "Internet of Things", Cengage Learning, India 2017.*
- ✓ *David Hanes, Gonzalo Salgueiro, Patrick Grosstete, Robert Barton, Jerome Henry, IoT fundamentals: Networking Technologies, Protocols and uses cases for the Internet of things, 1st Edition, Pearson Education.*
- ✓ *Iot Fundamentals, David Hence et al, Cisco press.*

Core XVII **Network and Control**

Course outcomes

- Evaluate two-port network parameters and understand network functions.
- Categorize different types of system and identify a set of algebraic equations to represent and model a complicated system into a more simplified form.
- Interpret different physical and mechanical systems in terms of electrical system to construct
- equivalent electrical models for analysis.
- Employ time domain analysis to predict and diagnose transient performance parameters of the system for standard input functions.
- Formulate different types of analysis in frequency domain to explain the nature of stability of the system.

Unit-1

- Characterization of linear time invariant two port network, Open circuit Impedance Parameter, Short circuit Admittance parameter, Transmission parameter, Inverse transmission parameter, Hybrid parameter, Inverse hybrid parameter, Hybrid parameter in terms of other parameter, Reciprocity and symmetry, Output impedance, Image impedance, interconnection of two port networks.
- Network functions: Network functions for one port and two port networks, calculation of network functions Ladder network and general network, Poles and Zeros of network function, restriction of Poles and Zeros Location on transfer function and driving function.

Unit-2:

Concept of control systems - Open & closed loop systems, Linear & Non-linear Systems, Difference between open & closed loop systems. Mathematical models of physical systems: Electrical systems, Mechanical systems & their conversions, Transfer function, Block diagrams and signal flow graph, Mason's gain formula, Application of SFG. Types of Feedback, Difference between positive and negative feedbacks, effects of feedback on control systems.

Unit-3:

Time Domain Analysis - Types of standard signals (step, ramp, impulse & parabolic), 1st & 2nd Order Systems, Time response of 1st & 2nd order systems to Unit Step and Ramp input signals, Time Specifications, Steady State and transient response of systems, steady state error.

Unit-4:

- Stability Analysis of Control System - Necessary conditions of stability, Hurwitz stability criterion, Routh stability criterion and its applications. Root Locus concepts, Rules for construction of root loci.

- Frequency domain analysis - Bode plot, Stability from bode plots, Nyquist criterion & its application to determine stability. Gain & phase margin.

Suggested References:

✓ *Valkenburg V., "Network Analysis", 3rd Ed., Prentice Hall International Edition, 2007.*

✓ *Modern Control Engineering by K. Ogata (PHI*)

Core-XVIII **Nano electronics**

Course Outcomes:

- Understand the principles of Nano Electronics.
- Analyze and design nanoscale electronic devices and circuits.
- Apply nano materials in Electronics for various applications.
- Evaluate fabrication techniques for nanoscale devices.
- Recognize the challenges and opportunities in Nano Electronics.

Unit-I:

Multi-Electron Atom and Molecules: Structure of atoms, Ionic compounds, Nature of light, Line spectra and Bohr Atom, Matter of Waves, Quantum number in Hydrogen atom, Energy level of multi-electron atom, Electrons in multi-electron atoms. Periodic table and electronic structures, Sizes of atoms and ions. Ionization Energy, Electron affinity.

Unit-II:

Chemical Bonds, Molecular Structure and Bonding Theories: Lewis symbols, Ionic bonding, Covalent bonding, Formal charges & resonance in Lewis structure. Molecules that do not satisfy the octet rule, Bond energies. Valence shell electron pair repulsion model. Polarity of molecules, Valence bond theory, Multiple bonds, Molecular orbitals: Homonuclear Diatomic Molecules, Heteronulcar Diatomic Molecules.

Unit-Ill:

Fundamentals of Nanotechnology: Introduction to Nanoscicncc and Nanotechnology, Nanoscale material, implications for Physics, Chemistry, Engineering & Biology, and Motivation for Nanotechnology study. History & development of Nanoscience and Nanotechnology with the emphasis on history of Nano-metals, Chalcogenides and Boron Nitrite and Carbon Nanomaterials

Unit-IV:

Structures and Classification of Nanomaterials : Nano-structures: various types of nano-structures and nano-crystals. Classification: of bulk Nano-structured materials. Size Effects, quantum confinement: Quantum dots, quantum wires, and quantum well (0D, ID. 2D) structures. Fraction of Surfaces, Surface Energy and Surface Stress, Effect on the Lattice Parameter. Phonon Density of States, Nano-particles. Quantum dots. Coulomb blockade in quantum dots, single electron transistors, Nano-wires, and Ultra-thin films. Multi-layered materials.

Suggested References:

- ✓ *C. Brechignac P. Houdy M. Lahmani, Nanomaterials and Nanochemistry, Springer Berlin I Icidelberg, Germany (2006).*
- ✓ *Kenneth J. Klabundc, Nanscalc materials in chemistry! I, Wiley Interscienc Publications (2001).*
- ✓ *Ilans Lautenshlagcr, Emulsions□, Kosmetik International, (2002).*

✓ *Roque Hidalgo- Alvarez, Structure and Functional properties of Colloids! , CR.C Press, (2009). 5. Richard .1. Fann. Chemistry and Technology of Surfactants I, Wiley-Blackwell, (2006)*

Online Resources:

1. NanoHub Online resource for nanotechnology simulation tools and educational materials
2. IEEE Nanotechnology Council Online platform for the latest research and publications in nanoElectronics and nanotechnology

Core-XIX **Quantum Electronics**

Course Outcomes:

- The student has gained knowledge about the time-dependent and time-independent Schrödinger equation for simple potentials like for instance the harmonic oscillator and hydrogen like atoms.
- The applications of quantum mechanics for realization of quantum gates.
- Basic knowledge on quantum computing.

Unit 1:

Time dependent Schrodinger equation: Time dependent Schrodinger equation and dynamical evolution of a quantum state; Properties of Wave Function. Interpretation of Wave Function. Probability and probability current densities in three dimensions; Conditions for Physical. Acceptability of Wave Functions. Normalization. Linearity and Superposition Principles. Eigenvalues and Eigenfunctions. Position, momentum and Energy operators; commutator of position and momentum operators; Expectation values of position and momentum. Wave Function of a Free Particle.

Unit 2:

Time independent Schrodinger equation-Hamiltonian, stationary states and energy eigenvalues; expansion of an arbitrary wavefunction as a linear combination of energy eigenfunctions; General solution of the time dependent Schrodinger equation in terms of linear combinations of stationary states; Application to spread of Gaussian wave-packet for a free particle in one dimension; wave packets, Fourier transforms and momentum space wavefunction; Position-momentum uncertainty principle.

Unit 3:

General discussion of bound states in an arbitrary potential- continuity of wave function, boundary condition and emergence of discrete energy levels; application to one-dimensional problem-square well potential; Quantum mechanics of simple harmonic oscillator-energy levels and energy eigenfunctions using Frobenius method; Hermite polynomials; ground state, zero-point energy & uncertainty principle.

Unit 4:

Quantum Gates and Algorithms: Linear algebra for quantum mechanics, Quantum states in Hilbert space, The Bloch sphere, Density operators, generalized measurements. Bell inequalities and entanglement, Schmidt decomposition, Universal set of gates, quantum circuits, basic idea and aspects of spintronics, quantum computers, quantum entanglement, and teleportation

Suggested References

- ✓ *A Text book of Quantum Mechanics, P.M.Mathews and K.Venkatesan, 2nd Ed., 2010, McGraw Hill*
- ✓ *Phillip Kaye, Raymond Laflamme et. al., An introduction to Quantum Computing, Oxford University press, 2007.*
- ✓ *Quantum Mechanics, Robert Eisberg and Robert Resnick, 2nd Edn., 2002, Wiley.*
- ✓ *Quantum Mechanics, Leonard I. Schiff, 3rd Edn. 2010, Tata McGraw Hill.*
- ✓ *Quantum Mechanics, G. Aruldhas, 2nd Edn. 2002, PHI Learning of India.*
- ✓ *Quantum Mechanics, Bruce Cameron Reed, 2008, Jones and Bartlett Learning.*
- ✓ *Quantum Mechanics: Foundations & Applications, Arno Bohm, 3rd Edn., 1993, Springer*
- ✓ *Quantum Mechanics for Scientists & Engineers, D.A.B. Miller, 2008, Cambridge University Press*
- ✓ *Quantum Mechanics, Eugen Merzbacher, 2004, John Wiley and Sons, Inc.*
- ✓ *Introduction to Quantum Mechanics, D.J. Griffith, 2nd Ed. 2005, Pearson Education*
- ✓ *Quantum Mechanics, Walter Greiner, 4th Edn., 2001, Springer*

Core-XX **Semester-VIII**

5G Networks

Course Outcomes

Upon completion of the course students will be able to:

- Understand and explain the channel models of 5G and the use cases for 5G.
- Analyze use of MIMO in 5G and its techniques.
- Draw and explain 5G architecture, its components and functional criteria.
- Study the in-depth functioning of 5G radio access technologies.
- Understand interference management, mobility management and security issues in 5G

Unit 1:

5G channel modelling and use cases: Modeling requirements and scenarios, Channel model requirements, Propagation scenarios, Relaying multi-hop and cooperative communications: Principles of relaying, fundamentals of relaying, Cognitive radio: Architecture, spectrum sensing, Software Defined Radio (SDR).

Unit 2:

Multiple-input multiple-output (MIMO) systems : Introduction to Multi-antenna Systems, Motivation, Types of multi-antenna systems, MIMO vs. multi-antenna systems. Diversity, Exploiting multipath diversity, Transmit diversity, Space-time codes, The Alamouti scheme, Delay diversity, Cyclic delay diversity, Space-frequency codes, Receive diversity, The rake receiver, Combining techniques, Spatial Multiplexing.

Unit 3:

The 5G architecture: Introduction, NFV and SDN, Basics about RAN architecture, High-level requirements for the 5G architecture, Functional architecture and 5G flexibility, Functional split criteria, Functional split alternatives, Functional optimization for specific applications, Integration of LTE and new air interface to fulfill 5G Requirements, Enhanced Multi-RAT coordination features, Physical architecture and 5G deployment

Unit 4:

The 5G radio-access technologies: Access design principles for multi-user communications, Orthogonal multiple-access systems, Spread spectrum multiple- access systems, Capacity limits of multiple-access methods, Sparse code multiple access (SCMA), Interleave division multiple access (IDMA), Radio access for dense deployments, OFDM numerology for small-cell deployments, Small-cell sub-frame structure, Radio access for V2X communication, Medium access control for nodes on the move, Radio access for massive machine- type communication.

Suggested References:

- ✓ *5G Mobile and Wireless Communications Technology, Afif Osseiran, Jose F. Monserrat, Patrick Marsch Cambridge University Press, Second Edition, 2011*

- ✓ *5G NR: The Next Generation Wireless Access Technology, Erik Dahlman, Stefan Parkvall, Johan Sköld, Elsevier, First Edition, 2016*
- ✓ *Fundamentals of 5G Mobile Networks, Jonathan Rodriguez, Wiley, First Edition, 2010*

Core-XXI

Mobile App Development

Course Outcomes:

At the end of the course the student should be able to:

- Aptitude to apply Logic thinking and Basic Science knowledge for problem solving in various fields of electronics both in industries and research.
- To acquire experimental skills, analysing the results and interpret data.
- Ability to design / develop / manage / operation and maintenance of sophisticated electronic gadgets / systems / processes that conforms to a given specification within ethical and economic constraints.
- Capacity to identify and implementation of the formulate to solve the electronic related issues and analyze the problems in various sub disciplines of electronics.
- Capability to develop mobile app

Unit 1:

- Introduction: What is mobile Application Programming, Different Platforms, Architecture and working of Android, iOS and Windows phone 8operating system, Comparison of Android, iOS and Windows phone 8
- Android Development Environment: What is Android, Advantages and Future of Android, Tools and about Android SDK, Installing Java, Eclipse, and Android, Android Software Development Kit for Eclipse, Android Development Tool: Android Tools for Eclipse, AVDs: Smartphone Emulators, Image Editing
- Android Software Development Platform: Understanding Java SE and the Dalvik Virtual Machine, Directory Structure of an Android Project, Common Default Resources Folders, The Values Folder, Leveraging Android XML, Screen Sizes, Launching Your Application: TheAndroidManifest.xml File, Creating Your First Android Application.

Unit 2:

- Android Framework Overview: The Foundation of OOP, The APK File, Android Application Components, Android Activities: Defining the User Interface, Android Services: Processing in the Background, Broadcast Receivers: Announcements and Notifications, Content Providers: Data Management, Android Intent Objects: Messaging for Components, Android Manifest XML: Declaring Your Components.
- Views and Layouts, Buttons, Menus, and Dialogs, Graphics Resources in Android: Introducing the Drawable, Implementing Images, Core Drawable Subclasses, Using Bitmap, PNG, JPEG and GIF Images in Android, Creating Animation in Android. Handling User Interface (UI) Events: An Overview of UI Events in Android, listening for and Handling Events, Handling UI Events via the View Class, Event call back methods, Handling Click Events, Touch screen Events, Keyboard Events, Context Menus, Controlling the Focus.

Unit 3:

Content Providers: An Overview of Android Content Providers, defining a Content Provider, Working with a Database. Intents and Intent Filters: Intent, Implicit Intents and Explicit Intents, Intents with Activities, Intents with Broadcast Receivers. Advanced Android: New Features in Android 4.4. iOS Development Environment: Overview of iOS, iOS Layers, Introduction to iOS application development. Windows Phone Environment: Overview of windows phone and its platform, Building windows phone application. Compulsory activity: Development of mobile App

Suggested References:

- ✓ *Beginning Android 4, Onur Cinar, Apress Publication, 2012*
- ✓ *Professional Android 4 Application Development, Reto Meier, 2nd Edition, Wrox Publisher, 2012*
- ✓ *Beginning iOS 6 Development: Exploring the iOS SDK, David Mark, 1st Edition, Apress, 2013*
- ✓ *Beginning Windows 8 Application Development, IstvánNovák, ZoltanArvai, György Balássy and David Fulop, Wiley, 2012.*
- ✓ *Professional Windows 8 Programming: Application Development with C# and XML, Allen Sanders and Kevin Ashley, John Wiley & Sons, 2012*

Core XXII **Optoelectronics and Photonics**

Course Outcomes:

- Understand and apply the principles of photonics and opto Electronics.
- Design and analyze optical Communication Systems and fiber optics.
- Design and characterize photonic integrated circuits.
- Apply optical communication techniques to solve real-world problems.
- Demonstrate proficiency in using industry-standard software tools for photonics and opto Electronics.

Unit-1

- Light as an Electromagnetic Wave: Plane waves in homogeneous media, concept of spherical waves. Reflection and transmission at an interface, total internal reflection, Brewster‘s Law. Interaction of electromagnetic waves with dielectrics: origin of refractive index, dispersion. Interference: Superposition of waves of same frequency, Concept of coherence, Interference by division of wavefront, Young‘s double slit, Division of Amplitude, thin film interference, anti-reflecting films, Newton‘s rings; Michelson interferometer. Holography.
- Diffraction: Huygen Fresnel Principle, Diffraction Integral, Fresnel and Fraunhoffer approximations. Fraunhoffer Diffraction by a single slit, rectangular aperture, double slit, Resolving power of microscopes and telescopes; Diffraction grating: Resolving power and Dispersive power

Unit-2

Polarization: Linear, circular and elliptical polarization, polarizer-analyzer and Malus‘ law; Double refraction by crystals, Interference of polarized light, Wave propagation in uniaxial media. Half wave and quarter wave plates. Faraday rotation and electro-optic effect.

Unit-3

Light Emitting Diodes: Construction, materials and operation. Lasers: Interaction of radiation and matter, Einstein coefficients, Condition for amplification, laser cavity, threshold for laser oscillation, line shape function. Examples of common lasers. The semiconductor injection laser diode. Photodetectors: Bolometer, Photomultiplier tube, Charge Coupled Device. Photo transistors and Photodiodes (p-i-n, avalanche), quantum efficiency and responsivity. LCD Displays: Types of liquid crystals, Principle of Liquid Crystal Displays, applications, advantages over LED displays.

Unit-4

Guided Waves and the Optical Fiber: TE and TM modes in symmetric slab waveguides, effective index, field distributions, Dispersion relation and Group Velocity. Step index optical fiber, total internal reflection, concept of linearly polarized waves in the step index circular dielectric waveguides, single mode and multimode fibers, attenuation and dispersion in optical fiber.

Suggested Books:

- ✓ *Ajoy Ghatak, Optics, Tata McGraw Hill, New Delhi (2005)*
- ✓ *E. Hecht, Optics, Pearson Education Ltd. (2002)*

- ✓ *J. Wilson and J. F. B. Hawkes, Optoelectronics: An Introduction, Prentice Hall India (1996)*
- ✓ *S. O. Kasap, Optoelectronics and Photonics: Principles and Practices, Pearson Education (2009)*
- ✓ *5. Ghatak A.K. and Thyagarajan K., ―Introduction to fiber optics,‖ Cambridge Univ. Press. (1998)*
- ✓ *CORE-14(LAB)*

Practical:

1. To verify the law of Malus for plane polarized light.
2. To determine wavelength of sodium light using Michelson‘s Interferometer.
3. To determine wavelength of sodium light using Newton‘s Rings.
4. To determine the resolving power and Dispersive power of Diffraction Grating.
5. Diffraction experiments using a laser.
6. Study of Faraday rotation.
7. Study of Electro-optic Effect.
8. To determine the specific rotation of scan sugar using polarimeter.
9. To determine characteristics of LEDs and Photo- detect

Online Resources:

- Photonics Online Online resource for photonics and optoElectronics concepts and articles
- MIT OpenCourseWare Online course materials and lectures on photonics and optoElectronics

Core XXIII **Sensors and Actuators**

Course Outcomes:

Upon successful completion of the course, the student is able to

- Apply the fundamental physical and technical base of sensors and actuators,
- Analyse various premises, approaches, procedures and results related to sensors and actuators
- Analyse basic laws and phenomena that define behaviour of sensors and actuators.
- Apply the Smart Sensor Interface in various applications
- Develop the application of sensors and actuators

Unit 1:

Sensors: Difference between sensor, transmitter and transducer - Primary measuring elements - selection and characteristics: Range; resolution, Sensitivity, error, repeatability, linearity and accuracy, impedance, backlash, Response time, Dead band. Signal transmission Types of signal: Pneumatic signal; Hydraulic signal; Electronic Signal. Principle of operation, construction details, characteristics and applications of potentiometer, Proving Rings, Strain Gauges, Resistance thermometer, Thermistor, Hot-wire anemometer, Resistance Hygrometer, Photo-resistive sensor.

Unit 2:

Inductive and Capacitive Transducer: Inductive transducers: - Principle of operation, construction details, characteristics and applications of LVDT, Induction potentiometer, variable reluctance transducer, synchros, microsyn. Capacitive transducers: - Principle of operation, construction details, characteristics of Capacitive transducers – different types & signal conditioning- Applications:- capacitor microphone, capacitive pressure sensor, proximity sensor.

Unit 3:

Definition, types and selection of Actuators; linear; rotary; Logical and Continuous Actuators, Pneumatic actuator- Electro-Pneumatic actuator; cylinder, rotary actuators, Mechanical actuating system: Hydraulic actuator - Control valves; Construction, Characteristics and Types, Selection criteria. Electrical actuating systems: Solid-state switches, Solenoids, Electric Motors- Principle of operation and its application: D.C motors - AC motors - Single phase & 3 Phase Induction Motor; Synchronous Motor; Stepper motors - Piezoelectric Actuator.

Unit 4:

Micro Sensors and Micro Actuators: Principles and examples and micro sensors, Force and pressure micro sensors, position and speed micro sensors, acceleration micro sensors, chemical sensors, biosensors, temperature micro sensors and flow micro sensors. Micro Actuators: Actuation principle, shape memory effects-one way, two way and pseudo elasticity. Types of micro actuators- Electrostatic, Magnetic, Fluidic, Inverse piezo effect, other principles.

Suggested References:

- ✓ *Patranabis.D, "Sensors and Transducers", Wheeler publisher, 1994.*
- ✓ *Sergej Fatikow and Ulrich Rembold, " Microsystem Technology and Microbotics", First edition, Springer –Verlag NEwyork, Inc, 1997.*
- ✓ *Jacob Fraden, "Hand Book of Modern Sensors: Physics, Designs and Application" Fourth edition, Springer, 2010.*
- ✓ *Robert H Bishop, "The Mechatronics Hand Book", CRC Press, 2002.*
- ✓ *Thomas. G. Bekwith and Lewis Buck.N, Mechanical Measurements, Oxford and IBH publishing Co. Pvt. Ltd.,*
- ✓ *Massood Tabib and Azar, "Microactuators Electrical, Magnetic, thermal, optical, mechanical, chemical and smart structures", First edition, Kluwer academic publishers, Springer, 1997.*
- ✓ *Manfred Kohl, "Shape Memory Actuators", first edition, Springer.*