# CURRICULUM & SYLLABI
# B.Tech. ELECTRONICS AND COMMUNICATION ENGINEERING
# (VLSI Design and Technology)

**Effective from AY: 2024-25**




## NATIONAL INSTITUTE OF TECHNOLOGY WARANGAL

## WARANGAL, TELANGANA

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## Vision and Mission of the Institute
## National Institute of Technology Warangal

### VISION

Towards a Global Knowledge Hub, striving continuously in pursuit of excellence induction, Research, Entrepreneurship and Technological services to the society.

### MISSION

- Imparting total quality education to develop innovative, entrepreneurial and ethical future professionals fit for globally competitive environment.
- Allowing stake holders to share our reservoir of experience in education and knowledge for mutual enrichment in the field of technical education.
- Fostering product-oriented research for establishing a self-sustaining and wealth creating Center to serve the societal needs.

## Vision and Mission of the Department
## Electronics and Communication Engineering

### VISION

Create an educational environment to mould the students to meet the challenges of modern Electronics and Communication industry through state-of-the-art technical knowledge and innovative experimental approaches.

### MISSION

- To create learning, development and testing environment to meet ever challenging needs of the electronics and communication industries.
- To establish entrepreneurial environment and industry interaction for mutual benefit.
- To become a global training hub for generating human resources in the fields of chip design, communications and embedded systems.
- To associate with internationally reputed Institutions for academic excellence and collaborative research.

## Program: B.Tech. EC (VLSI DT)

### Program Educational Objectives

| | |
|---|---|
| **PEO-1** | Analyze, plan and apply the acquired knowledge in basic sciences and mathematics in solving indigenously the IC requirements of the mankind with technical, economic, environmental and social contexts. |
| **PEO-2** | Design, build and test analog and digital electronic systems for given specifications |
| **PEO-3** | Architect miniaturized, efficient, high speed Integrated Circuits meeting modern communication system challenges. |
| **PEO-4** | Work in a team using technical know-how, common tools and environments to achieve project objectives. |
| **PEO-5** | Communicate effectively, demonstrate leadership qualities and exhibit professional conduct in their career. |
| **PEO-6** | Engage in lifelong learning, career enhancement and adapt to changing professional and societal needs. |

### Program Articulation Matrix

| PEO / Mission Statements | PEO-1 | PEO-2 | PEO-3 | PEO-4 | PEO-5 | PEO-6 |
|---|---|---|---|---|---|---|
| To create learning, development and testing environment to meet ever challenging needs of the electronic industry | 3 | 3 | 2 | 1 | 1 | 3 |
| To create entrepreneurial environment and industry interaction for mutual benefit | 1 | 2 | 1 | 3 | 3 | 2 |
| To become a global partner in training human resources in the fields of chip design, instrumentation and networking | 1 | 2 | 1 | 3 | 3 | 2 |
| To associate with internationally reputed Institutions for academic excellence and collaborative research | 1 | 2 | 2 | 3 | 1 | 1 |

**1 - Slightly; 2 - Moderately; 3 - Substantially**

## Program: B.Tech. EC (VLSI DT)

## Program Outcomes

| | |
|---|---|
| **PO-1** | **Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and IC design and technology concepts towards modelling and prototyping Integrated systems. |
| **PO-2** | **Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. |
| **PO-3** | **Design/development of solutions:** Design methodology to offer hardware solutions to public health, safety and agriculture, consumer electronics along with cultural, societal, and environmental considerations. |
| **PO-4** | **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions. |
| **PO-5** | **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations. |
| **PO-6** | **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice. |
| **PO-7** | **Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development. |
| **PO-8** | **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice. |
| **PO-9** | **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings |
| **PO-10** | **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehended write effective reports and design documentation, make effective presentations, and give and receive clear instructions. |
| **PO-11** | **Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply the set one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments. |
| **PO-12** | **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change. |

## Program Specific Outcomes

| | |
|---|---|
| **PSO-1** | Analyze and design Integrated Circuits & electronic systems to enhance the quality of human life. |
| **PSO-2** | Develop innovative and environment-conscious technologies to sustain human life. |

# CURRICULUM
# B.Tech. EC (VLSI DT)

## 1st Semester

| S.No. | Code | Course Title | L-T-P | Credits |
|---|---|---|---|---|
| 1 | MA1161 | Linear Algebra, Calculus and Ordinary Differential Equations | 3-0-0 | 3 |
| 2 | PY1161 | Engineering Physics | 3-0-2 | 4 |
| 3 | HS1161 | English for Technical Communication | 2-0-2 | 3 |
| 4 | MA1163 | Computer Programming | 3-0-2 | 4 |
| 5 | BT1161 | Biology for Engineers | 2-0-0 | 2 |
| 6 | EC1101 | Programming Languages Lab | 0-1-2 | 2 |
| 7 | IC1101 | EAA-I (Games & Sports/ Yoga wellness) | 0-0-0 | 0 |
| | | | **Total Credits** | **18** |

## 2nd Semester

| S.No. | Code | Course Title | L-T-P | Credits |
|---|---|---|---|---|
| 1 | MA1162 | Integral Calculus, Vector Calculus and Laplace Transforms | 3-0-0 | 3 |
| 2 | CY1161 | Engineering Chemistry | 3-0-2 | 4 |
| 3 | EE1163 | Network Analysis | 3-0-0 | 3 |
| 4 | CS1162 | Data Structures and Practice | 3-0-2 | 4 |
| 5 | EC2102 | Design Thinking | 0-1-4 | 3 |
| 6 | EC2104 | Solid State Electronic Devices | 3-0-0 | 3 |
| 7 | EC2106 | Electronic Devices Lab | 0-1-2 | 2 |
| 8 | IC1102 | EAA-II (Games & Sports / Yoga & Wellness) | 0-0-0 | 0 |
| | | | **Total Credits** | **22** |

## 3rd Semester

| S.No. | Code | Course Title | L-T-P | Credits |
|---|---|---|---|---|
| 1 | MA1265 | Complex Variables and Special Functions | 3-0-0 | 3 |
| 2 | EC1203 | Signals and Systems | 3-0-2 | 4 |
| 3 | EC1205 | Digital Circuit Design | 3-0-0 | 3 |
| 4 | EC2201 | VLSI Technology | 3-0-0 | 3 |
| 5 | EC2203 | Electronic Circuit Design | 3-0-0 | 3 |
| 6 | EC1211 | Digital Circuit Design Lab | 0-1-2 | 2 |
| 7 | EC2205 | Electronic Circuit Design Lab | 0-1-2 | 2 |
| | | | **Total Credits** | **20** |

## 4th Semester

| S.No. | Code | Course Title | L-T-P | Credits |
|---|---|---|---|---|
| 1 | EC1204 | Probability Theory and Stochastic Processes | 3-0-2 | 4 |
| 2 | EC1206 | Electromagnetic Fields and Waves | 3-0-0 | 3 |
| 3 | EC1208 | Linear IC Applications | 3-0-0 | 3 |
| 4 | EC2202 | CMOS Analog IC Design | 3-0-0 | 3 |
| 5 | EC2204 | CMOS Digital IC Design | 3-0-0 | 3 |
| 6 | EC2206 | CMOS Analog IC Design Lab | 0-1-2 | 2 |
| 7 | EC2208 | CMOS Digital IC Design Lab | 0-1-2 | 2 |
| | | | **Total Credits** | **20** |

## 5th Semester

| S.No. | Code | Course Title | L-T-P | Credits |
|---|---|---|---|---|
| 1 | MS1262 | Business Essentials for Engineers | 3-0-0 | 3 |
| 2 | EC1305 | Digital Signal Processing | 3-0-0 | 3 |
| 3 | EC1307 | Microcontrollers | 3-0-0 | 3 |
| 4 | EC2301 | Mixed Signal circuits | 3-0-0 | 3 |
| 5 | EC23XX | Professional Elective – I | 3-0-0 | 3 |
| 6 | EC2381 | Fractal Course – I | 1-0-0 | 0.5 |
| 7 | EC1309 | Microcontrollers Lab | 0-1-2 | 2 |
| 8 | EC2303 | Mixed Signal Circuits Lab | 0-1-2 | 2 |
| | | **Total Credits** | | **19.5** |

## 6th Semester

| S.No. | Code | Course Title | L-T-P | Credits |
|---|---|---|---|---|
| 1 | EC2302 | Verification and Testing | 3-0-0 | 3 |
| 2 | EC2304 | Analog and Digital Communications | 3-0-0 | 3 |
| 3 | EC2306 | Product Development | 0-1-4 | 3 |
| 4 | EC23XX | Professional Elective – II | 3-0-0 | 3 |
| 5 | EC23XX | Professional Elective – III | 3-0-0 | 3 |
| 6 | EC2382 | Fractal Course – II | 1-0-0 | 0.5 |
| 7 | EC1310 | Analog and Digital Communications Lab | 0-1-2 | 2 |
| 8 | EC2308 | Verification and Testing Lab | 0-1-2 | 2 |
| | | **Total Credits** | | **19.5** |

## 7th Semester

| S.No. | Code | Course Title | L-T-P | Credits |
|---|---|---|---|---|
| 1 | EC2401 | Semiconductor Materials Synthesis and Characterization | 3-0-0 | 3 |
| 2 | EC24XX | Professional Elective – IV | 3-0-0 | 3 |
| 3 | EC24XX | Professional Elective – V | 3-0-0 | 3 |
| 4 | XXXXXX | Open Elective – I | 2-0-0 | 2 |
| 5 | EC2403 | Semiconductor Device Characterization Lab | 0-0-2 | 1 |
| 6 | EC2405 | Low Power IC Design Lab | 0-0-2 | 1 |
| 7 | EC2489 | Seminar and Technical Writing | 0-0-0 | 2 |
| 8 | EC2495 | Minor Project | 0-0-0 | 2 |
| 9 | EC2491 | Short-Term Industrial /EPICS/ Research Experience | 0-0-0 | 2 |
| | | | **Total Credits** | **19** |

## 8th Semester

| S.No. | Code | Course Title | L-T-P | Credits |
|---|---|---|---|---|
| 1 | EC24XX | Professional Elective – VI | 3-0-0 | 3 |
| 2 | EC24XX | Professional Elective – VII | 3-0-0 | 3 |
| 3 | EC24XX | Professional Elective – VIII | 3-0-0 | 3 |
| 4 | EC2498 | Major Project | 0-0-0 | 6 |
| | | | **Total Credits** | **15** |

## Professional Elective Courses:

| Professional Elective – I | | |
|---|---|---|
| **S.No.** | **Code** | **Course Title** |
| 1 | EC2321 | Fundamentals of Device Modelling |
| 2 | EC2323 | VLSI Interconnects |
| 3 | EC2325 | Flexible Electronics |
| 4 | EC2327 | Principles of Data Networks |

| Professional Elective – II | | |
|---|---|---|
| **S.No.** | **Code** | **Course Title** |
| 1 | EC1322 | Introduction to Artificial Intelligence and Machine Learning |
| 2 | EC1324 | Embedded and Real Time Operating Systems |
| 3 | EC2322 | Low Power VLSI |
| 4 | EC2324 | Devices for Microwave Engineering |

| Professional Elective – III | | |
|---|---|---|
| **S.No.** | **Code** | **Course Title** |
| 1 | EC1328 | Internet of Things |
| 2 | EC2326 | Introduction to FPGA Design |
| 3 | EC2328 | Antennas |
| 4 | EE1262 | Control Systems Engineering |

| Professional Elective – IV | | |
|---|---|---|
| **S.No.** | **Code** | **Course Title** |
| 1 | EC1421 | Digital Image Processing and Computer Vision |
| 2 | EC2421 | Nanoelectronics |
| 3 | EC2423 | Electronics System Packaging |
| 4 | EC2425 | Heterojunction Device Physics |

| Professional Elective – V | | |
|---|---|---|
| **S.No.** | **Code** | **Course Title** |
| 1 | EC1427 | Computer Architecture and Organization |
| 2 | EC1429 | Cryptography and Network Security |
| 3 | EC2427 | Introduction to ASIC Design |
| 4 | EC2429 | RF Microelectronics |

| Professional Elective – VI | | |
|---|---|---|
| **S.No.** | **Code** | **Course Title** |
| 1 | EC1424 | Wireless Communications - 5G Use Cases |
| 2 | EC2422 | Reliability of VLSI Systems |
| 3 | EC2424 | High Speed Interfacing Circuits |
| 4 | EC2426 | Introduction to Quantum Computing |

| Professional Elective – VII | | |
|---|---|---|
| **S.No.** | **Code** | **Course Title** |
| 1 | EC1430 | Optimization Techniques |
| 2 | EC2428 | CAD for IC Design |
| 3 | EC2430 | MEMS & NEMS |
| 4 | EC2432 | Introduction to Power Management IC Design |

| Professional Elective – VIII | | |
|---|---|---|
| **S.No.** | **Code** | **Course Title** |
| 1 | EC1436 | Cloud based Technologies |
| 2 | EC1442 | IPR and Cyber Laws |
| 3 | EC2434 | Multicore Computer Architecture – Storage and Interconnects |
| 4 | EC2436 | On Chip Sensors and Interfacing Circuits |

## Basic Science Courses

| S.No. | Code | Course Title | L-T-P | Credits |
|---|---|---|---|---|
| 1 | PH1161 | Applied Physics | 3-0-2 | 4 |
| 2 | CY1161 | Engineering Chemistry | 3-0-2 | 4 |
| 3 | MA1161 | Linear Algebra, Calculus and Ordinary Differential Equations | 3-0-0 | 3 |
| 4 | MA1162 | Laplace Transforms, Integral and Vector Calculus | 3-0-0 | 3 |
| 5 | MA1265 | Complex Variables and Special Functions | 3-0-0 | 3 |
| | | **Total Credits** | | **17** |

## Engineering Science Courses

| S.No. | Code | Course Title | L-T-P | Credits |
|---|---|---|---|---|
| 1 | BT1161 | Biology for Engineers | 2-0-0 | 2 |
| 2 | EE1163 | Network Analysis | 3-0-0 | 3 |
| 3 | CS1162 | Data Structures and Practice | 3-0-2 | 4 |
| 4 | MA1163 | Computer Programming | 3-0-2 | 4 |
| 5 | EC1101 | Programming Languages Lab | 0-1-2 | 2 |
| 6 | EC2102 | Designing Thinking | 0-1-4 | 3 |
| | | **Total Credits** | | **18** |

## Humanities and Social Science Courses

| S.No. | Code | Course Title | L-T-P | Credits |
|---|---|---|---|---|
| 1 | IC1101 | EAA-1(Games and sports/Yoga and wellness) | 0-0-0 | 0 |
| 2 | HS1161 | English for Technical Communication | 2-0-2 | 3 |
| 3 | IC1102 | EAA-2(Games and sports/Yoga and wellness) | 0-0-0 | 0 |
| 4 | MS1262 | Business Essentials for Engineers | 3-0-0 | 3 |
| | | **Total Credits** | | **6** |

## The Overall Credit Structure

| Course Category | Credits |
|---|---|
| Basic Science | 17 |
| Engineering Science | 18 |
| Humanities and Social Sciences | 6 |
| Program Core | 86 |
| Professional Elective | 24 |
| Open Elective | 2 |
| **Total Graded Credit Requirement** | **153** |

# SYLLABI
# B.Tech. EC (VLSI DT)

# 1st Semester

**MA1161** **3-0-0 (3)**

# Linear Algebra, Calculus and Ordinary Differential Equations

**Pre-requisites**: **None**

**Course Outcomes**:

| | |
|---|---|
| **CO-1** | Understand to solve the consistent system of linear equations |
| **CO-2** | Apply orthogonal transformations to a quadratic form |
| **CO-3** | Determine the series expansion of a given function |
| **CO-4** | Explore the properties of functions of several variables |
| **CO-5** | Solve arbitrary order linear differential equations |

**Course Articulation Matrix:**

| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PO-11 | PO-12 | PSO-1 | PSO-2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO-1 | 3 | 3 | 1 | 2 | 1 | – | – | – | – | – | – | – | 1 | 1 |
| CO-2 | 3 | 3 | 1 | 2 | 1 | – | – | – | – | – | – | – | - | - |
| CO-3 | 3 | 3 | 1 | 2 | 1 | – | – | – | – | – | – | – | 1 | - |
| CO-4 | 3 | 3 | 1 | 2 | 1 | – | – | – | – | – | – | – | - | - |
| CO-5 | 3 | 3 | 1 | 2 | 1 | – | – | – | – | – | – | – | 2 | 1 |

**1 - Slightly;** **2 - Moderately;** **3 - Substantially**

## Syllabus:

**Linear Algebra**: Vector space, Subspace, Examples, Linear span, Linear independence and dependence, Basis, Dimension, Extension of a basis of a subspace, Intersection and sum of two subspace, Examples. Linear transformation, Kernel and Range of a linear map, Rank-Nullity Theorem (without proof). Rank of a matrix, Row, and column spaces, Solvability of the system of linear equations, Inner product spaces, Orthogonal basis, Gram-Schmidt orthogonalization process. Eigenvalues, Eigenvectors, and properties Caley-Hamilton Theorem (without proof) and applications, diagonalization of a matrix, diagonalization by similarity, and orthogonal transformations.

**Differential Calculus**: Taylor's theorem with remainders; Taylor's and Maclaurin's expansions;Functions of several variables – continuity, differentiability, partial derivatives, Euler's theorem, change of variables, Jacobians, Functional dependence; Maxima andminima of functions of several variables (2 and 3 variables) - Lagrange's method of multipliers.

**Ordinary Differential Equations**: First order differential equations - Basic definitions, Geometric interpretation of solutions of first-order ODE $y' = f(x, y)$, Exact differential equations, Integrating factors, Linear equation, Reducible to linear form: Bernoulli's equations; Orthogonal trajectories; Higher order linear differential equations with constant coefficients - Cauchy-Euler and Legendre's differential equations, Method of variation of parameters - System of linear differential equations; Applications to physical problems.

**Learning Resources:**

Text Books::

1. Howard Anton and Chris Rorres, Elementary Linear Algebra with Supplementary Applications, John Wiley & Sons, 2014, Eleventh Edition.
2. George B. Thomas and Ross L. Finney, Calculus and Analytic Geometry, Pearson, 2020, Ninth Edition.
3. Erwin Kreyszig, Advanced Engineering Mathematics, John Wiley and Sons, 2015, Eighth Edition.

Reference Books:

1. Dennis G. Zill, Advanced Engineering Mathematics, Jones & Bartlett Learning, 2018, Sixth Edition.
2. R. K. Jain and S. R. K. Iyengar, Advanced Engineering Mathematics, Narosa Publishing House, 2016, Fifth Edition.

**PY1161** **3-0-2 (4)**

# Engineering Physics

**Pre-Requisites:** **None**

## Course Outcomes:

| | |
|---|---|
| **CO-1** | Examine the concepts of Interference, diffraction, polarization to solve engineering problems |
| **CO-2** | Assess the technological applications of lasers and optical fibers |
| **CO-3** | Apply the quantum mechanical principles for solving engineering problems |
| **CO-4** | Understand the basics of nanomaterials and their engineering applications |
| **CO-5** | Demonstrate the production, detection and applications of ultrasonics |

## Course Articulation Matrix:

| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PO-11 | PO-12 | PSO-1 | PSO-2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO-1 | 3 | 3 | 1 | 1 | – | – | – | – | – | – | – | – | 3 | 1 |
| CO-2 | 3 | 3 | 1 | 1 | – | – | – | – | – | – | – | – | 3 | 1 |
| CO-3 | 3 | 3 | 2 | 1 | – | – | – | – | – | – | – | – | 3 | 1 |
| CO-4 | 3 | 3 | 2 | 1 | – | – | – | – | – | – | – | – | 3 | 1 |
| CO-5 | 3 | 3 | 2 | 1 | – | – | – | – | – | – | – | – | 3 | 1 |

**1 - Slightly;** **2 - Moderately;** **3 - Substantially**

## Syllabus:

**Interference:** Principle of Superposition, Coherence and Coherent Sources, Production of Coherent Light, Young's Double Slit Experiment, Concept of interference, Newton's Rings, working of Michelson Interferometer, Fabry-Perot Interferometer, and its application as wavelength filter.

**Diffraction:** Definition and types of Diffractions, Huygen's Principle and types of wave fronts, types of Diffraction, Single Slit Diffraction, Double Slit Diffraction, Diffraction Grating, Derivation of Resolving Power and Dispersive Power, Rayleigh's Criterion and applications.

**Polarization:** Introduction to Polarization, Production of Polarized Light by Reflection and Refraction, Phenomenon of Double Refraction, Construction and Working of Nicol's Prism, Half-Wave and Quarter Waveplates, Representation of Different Polarized Lights, Optical Activity, Practical Applications of Polarized Light, Construction and Working of Laurent's Half Shade Polarimeter and Engineering Applications.

**Lasers & Optical Fibers:** Basic theory of Laser, Fundamentals of lasers, Einstein Coefficients, Characteristics of Laser Pumping Mechanisms; Basic Components of Laser System, 2-Level, 3-Level and 4-Level Systems, Construction and working of He-Ne, Nd-YAG, and semiconductor diode Lasers and Engineering Applications of Lasers. Basic Principle of Optical Fiber, Derivation-Numerical Aperture and Acceptance Angle, Types of Optical Fibers (Step and Graded Index, Single Mode and Multimode), Applications in Communications and Sensors.

**Quantum Mechanics:** Concepts and experiments that led to the discovery of Quantum Nature, de Broglie hypothesis of matter waves, Heisenberg uncertainty principle, Schrodinger time independent and time

dependent wave equations, the free particle problem, Particle in an infinite and finite potential well, Quantum mechanical tunnelling and applications.

**Nanomaterials:** Introduction and importance of Nanomaterials, classification (0D, 1D, 2D and 3D) of

nanomaterials, properties of nanomaterials, carbon-based nanomaterials, synthesis of nanomaterials, top-down and bottom-up approaches, characterization of nanomaterials, Engineering Applications of Nanomaterials.

**Ultrasonics:** Production, detection, and applications of ultrasonics

## List of Experiments:

1. Determination of Wavelength of Sodium light using Newton's Rings.
2. Determination of Wavelength of He-Ne laser - Metal Scale.
3. Measurement of Width of a narrow slit using He- Ne Laser.
4. Determination of Specific rotation of Cane sugar by Laurent Half-shade Polarimeter.
5. Determination of Numerical aperture, loss, Acceptance angle of optical fiber.
6. Determination of plank constant by photo electric effect.
7. Determination of I – V characteristics of photo diode.
8. Diffraction grating by normal incidence method.
9. Determination of capacitance by using R-C circuit.
10. Determination of resonating frequency and bandwidth by LCR circuit
11. Strain Gauge
12. Dielectric constant measurements
13. Determination of carrier concentration, charge by using Hall effect experiment
14. Study of I-V characteristics of Solar Cell
15. Determination of velocity of ultrasonic waves and adiabatic compressibility of liquids using ultrasonic interferometer.

## Learning Resources:

Text Books:


1. Halliday Resnic and Walker, Fundamentals of Physics, John Wiley, 2011, Ninth Edition.
2. Arthur Beiser, Shobhit Mahajan, S. Rai Choudhury, Concepts of Modern Physics, McGraw Hill Publications, 2009, Sixth edition.
3. Shatendra Sharma, Jyotnsa Sharma, Engineering Physics, Pearson Education,2018.
4. Sulabha K. Kulkarnl , Nanotechnology: principles and practices. Springer publications, 2018, 3 Ed.
5. G.L. Squire, Practical Physics, Cambridge University press, 2001, fourth edition.


Reference Books:


1. Ajoy K. Ghatak, Optics by Tata McGraw Hill, 2017, Sixth Edition.
2. Jeff Hecht, Understanding Lasers an Entry-Level Guide, Wiley Publications, 2018, Fourth edition.
3. M.N. Avadhanulu, P.G. Khirsagar, A Textbook of Engineering Physics 2011, 9th edition.
4. Hugh D. Young,Roger A. Freedman, University Physics with modern physics by Pearson Education,2014.
5. B. Rogers, J Adams and S. Pennathur, Nanotechnology the whole story, CRC Press, 2013.
6. Dr.S.K. Gupta, Engineering Physics Practical Krishna Prakashan Publications, 2010, ninth edition.


Other Suggested Readings:

1. https://nptel.ac.in/courses/122/107/122107035/

**HS1161** **2-0-2:(3)**

# English for Technical Communication

**Pre-Requisites:** **None**

## Course Outcomes:

| | |
|---|---|
| **CO-1** | Understand and apply principles of technical communication to interact effectively in diverse environments. |
| **CO-2** | Analyze complex technical documents to extract and synthesize key information. |
| **CO-3** | Employ reported speech, active and passive voice in engineering and scientific contexts to compile technical reports. |
| **CO-4** | Demonstrate use of English speech sounds, stress, and intonation in day-to-day situations, conversations, and interactions. |
| **CO-5** | Interpret technical data presented in the form of graphs, pie charts, and diagrams. |
| **CO-6** | Critique and provide constructive feedback on peer communication performances and written works. |

## Course Articulation Matrix:

| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PO-11 | PO-12 | PSO-1 | PSO-2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO-1 | 3 | 3 | 2 | 1 | 1 | | | | | | | 1 | 2 | 1 |
| CO-2 | 3 | 3 | 2 | 1 | 1 | | | | | | | 1 | 2 | 1 |
| CO-3 | 3 | 3 | 2 | 1 | 1 | | | | | | | 1 | 2 | 1 |
| CO-4 | 3 | 3 | 2 | 1 | 1 | | | | | | | 1 | 2 | 1 |
| CO-5 | 3 | 3 | 2 | 1 | 1 | | | | | | | 1 | 2 | 1 |
| CO-6 | 3 | 3 | 2 | 1 | 1 | | | | | | | 1 | 2 | 1 |

**1 - Slightly;** **2 - Moderately;** **3 - Substantially**

## Syllabus:

**Grammar Principles & Effective Sentence Construction**: Correction of Sentences and Concord, - Vocabulary Building, - Synonyms and Antonyms, - Idioms and Phrasal Verbs: Patterns of Use and Suggestions for Effective Employment in Varied Contexts, - Technical Vocabulary (Jargons and Registers),- Strategies for Bringing Variety and Clarity in Sentences, - Removing Ambiguity, - Editing Long Sentences for Brevity and Clarity, - Reported Speech, - Contexts for Use of Reported Speech, - Impact on Audiences and Readers, - Active and Passive Voice, - Reasons for Preference for Passive Voice in Scientific English

**Writing- Paragraph & Letter**: Definition of Paragraph and Types, - Features of a Good Paragraph, - Unity of Theme, - Coherence, - Linking Devices, - Direction, - Patterns of Development**.** - Importance in the Context of Other Channels of Communication, - Qualities of Effective Letters, - Types of Letters, - Official

Letters, - Letters for Various Purposes, - Letters of Application for Jobs, - Cover Letter and Resume Types, - Letters for Internship/Fellowship, - Writing Statements of Purpose (SOPs), - Examples and Exercises

**Reading Techniques**: Definition and Importance, - Skills and Sub-Skills of Reading, - Skimming and Scanning: Uses and Purposes, Examples and Exercises, - Reading Comprehension, - Reading Silently and with Understanding, - Process of Comprehension, - Types of Comprehension Questions

**Technical Writing:** Principles of a Technical Report, - Know Your Audience, Purpose, and Length of Report, - Understand the Cornerstones of a Presentation, - Define Various Purposes of Presentations and Plan the Correct Structure, - Writing Clear Sentences and Paragraphs, - Removing Jargon, Redundancy, and Wordiness, - Kinds of Graphics and Their Messages, - Suitability for Placement in Graphic Representation, - Introduction to Basic Concepts in Research, - Abstract, Keywords, Methodology, Hypothesis, Plagiarism, Critical Reading, - Abstract Writing, - How to Read Scientific Articles, - Basics of Writing a Research Project Proposal, - Preparation and Presentation of Project Reports

**Reviews:** Oral and Written Review of a Chosen Novel/Play/Movie, - Review of Scientific Articles and Science Fiction, - Focus on Appropriate Vocabulary and Structure, - Use of Special Vocabulary and Idioms

## Language laboratory

**1. English Sound System** -vowels, consonants, Diphthongs, phonetic symbols- using dictionary to decode phonetic transcription-- Received Pronunciation, its value and relevance- transcription.

**2. Stress and Intonation** –word and sentence stress - their role and importance in spoken English- Intonation in spoken English -definition, -use of intonation in daily life-exercises

**3. Introducing oneself in formal and social contexts**- Role plays. - their uses in developing fluency and communication in general.

4. **Oral presentation** - definition- occasions- structure- qualities of a good presentation with emphasis on body language and use of visual aids.
5. **Listening Comprehension**- Challenges in listening, good listening traits, some standard listening tests- practice and exercises.
6. **Debate/ Group Discussions**-concepts, types, Do's and don'ts- intensive practice, Guided writing practice with examples, drafting – the mindset to avoid writer's block, checking your own reports and presentations, Giving and receiving constructive feedback.

## Learning Resources:

Text Books:

1. English for Engineers and Technologists (Combined edition, Vol. 1 and 2) Orient Blackswan, 2010.
2. Ashraf, M Rizvi. Effective Technical Communication. Tata McGraw-Hill, 2006

Reference Books:

1. Meenakshi Raman and Sangeetha Sharma. Technical Communication: Principles and Practice, Oxford University Press, 2011, 2nd Edition.
2. Tan, Zhongchao. *Academic Writing for Engineering Publications: A Guide for Non-native English Speakers*. Springer, 2022.

Other Suggested Readings:

Software:

1. Clear Pronunciation – Part-1 *Learn to Speak English.*
2. Clear Pronunciation – Part-2 *Speak Clearly with Confidence*
3. Study Skills
4. English Pronunciation

**MA1163** **3-0-2: (4)**

# Computer Programming

**Pre-Requisites:** **None**

## Course Outcomes:

| | |
|---|---|
| **CO-1** | Design algorithms for solving simple mathematical problems including computing, searching and sorting |
| **CO-2** | Compare and contrast algorithms in terms of space and time complexity to solve simple mathematical problems |
| **CO-3** | Explore the internals of computing systems to suitably develop efficient algorithms |
| **CO-4** | Examine the suitability of data types and structures to solve specific problems |
| **CO-5** | Apply control structures to develop modular programs to solve mathematical problems |
| **CO-6** | Apply object-oriented features in developing programs to solve real world problems |

## Course Articulation Matrix:

| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PO-11 | PO-12 | PSO-1 | PSO-2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO-1 | 3 | 3 | 3 | 3 | 2 | 2 | - | - | 2 | - | - | 1 | - | - |
| CO-2 | 3 | 3 | 2 | 2 | 2 | 2 | - | 2 | 2 | - | - | 1 | - | - |
| CO-3 | 3 | 3 | 2 | 2 | 2 | - | - | 2 | 2 | - | - | 1 | - | - |
| CO-4 | 2 | 3 | 2 | 1 | 2 | 2 | - | - | 2 | - | - | 1 | - | - |
| CO-5 | 2 | 3 | 2 | 2 | 2 | 2 | - | - | 2 | - | - | 1 | - | - |
| CO-6 | 2 | 3 | 2 | 2 | 2 | 2 | - | - | 2 | - | - | 1 | - | - |

**1 - Slightly;** **2 - Moderately;** **3 - Substantially**

## Syllabus:

**Fundamentals of Computers**: Historical perspective, Early computers, Components of a computers, Problems, Flowcharts, Memory, Variables, Values, Instructions, Programs.

**Problem solving techniques**: Algorithmic approach, characteristics of algorithm, Problem solving strategies: Top-down approach, Bottom-up approach, Time and space complexities of algorithms.

**Number systems and data representation**: Basics of C++, Basic data types, Numbers, Digit separation, Reverse order, writing in words, Development of Elementary School Arithmetic Testing System, Problems on Date and factorials, Solutions using flow of control constructs

**Conditional statements**: If-else, Switch-case constructs, Loops - while, do-while, for.

**Functions**: Modular approach for solving real time problems, user defined functions, library functions, parameter passing - call by value, call by reference, return values, Recursion,

**Introduction to Pointers and Arrays**: Sorting and searching algorithms, Large integer arithmetic, Single and Multi-Dimensional Arrays, passing arrays as parameters to functions, Magic square and

matrix operations using Pointers and Dynamic Arrays, Multidimensional Dynamic Arrays String processing, File operations.

**Structures and Classes**: Declaration, member variables, member functions, access modifiers, function over loading, Problems on Complex numbers, Date, Time, Large Numbers.

## PSCP LAB:

1. Programs on conditional control constructs.
2. Programs on loops (while, do-while, for).
3. Programs using user defined functions and library functions.
4. Programs on arrays, matrices (single and multi-dimensional arrays).
5. Programs using pointers (int pointers, char pointers).
6. Programs on structures.
7. Programs on classes and objects.

## Learning Resources:

Text Books:

1. Walter Savitch, Problem Solving with C++, Pearson, 2014, Tenth Edition.
2. Cay Horstmann Big C++, Wiley, 2009, Second Edition.

Reference Books:

1. R.G. Dromey, How to Solve it by Computer, Pearson, 2008.

Other Suggested Readings:

1. https://nptel.ac.in/courses/106/105/106105151/
2. https://onlinecourses.nptel.ac.in/noc21_cs38/preview

**BT1161** **2-0-0 (2)**

# Biology for Engineers

**Pre-Requisites:** **None**

## Course Outcomes:

| | |
|---|---|
| **CO-1** | Realize the significance of biomolecules for sustaining life |
| **CO-2** | Identify the difference between unicellular to multi-cellular organisms |
| **CO-3** | Understand heredity, variation and central dogma of life |
| **CO-4** | Apply the concepts of biology for engineering the cell |

## Course Articulation Matrix:

| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PO-11 | PO-12 | PSO-1 | PSO-2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO-1 | 3 | 2 | 2 | – | – | 2 | 2 | – | – | 2 | – | 3 | 3 | 3 |
| CO-2 | 3 | 2 | 2 | – | – | 2 | – | – | – | – | – | 3 | 3 | 3 |
| CO-3 | 3 | 2 | 2 | – | – | 2 | – | – | – | – | – | 3 | 3 | 3 |
| CO-4 | 3 | 3 | 2 | 2 | 1 | 2 | 2 | 1 | – | 2 | – | 3 | 3 | 3 |

**1 - Slightly;** **2 - Moderately;** **3 - Substantially**

## Syllabus:

**Molecules of Life**: Chemical basis of life, **P**roteins, Nucleic acids, Carbohydrates, Lipids, Membranes and First cell, Inside the cell**,** Cell cycle and Division.

**Information processing in living system:** Central dogma, Concept of Gene, Genetic code, Transcription, Translation, Biological signal transduction, Quorum sensing and Biofilm formation.

**Biomolecular machines and motors:** Cytoskeletal motor proteins, ATP synthase, Cell motility.

**Applied Biotechnology:** Biocomputing, Synthetic biology, Biosensors, Biomedical instrumentation in disease diagnosis, Biomimicry, Biomechanics, Biomaterials, Nanobiotechnology, Industrial and Environmental Biotechnology.

## Learning Resources:

### Text Books:

1. Quillin, Allison Scott Freeman, Kim Quillin and Lizabeth Allison, Biological Science, Pearson Education India, 2016
2. Reinhard Renneberg, Viola Berkling and Vanya Loroch, Biotechnology for Beginners, Academic Press, 2017.

**EC1101** **0-1-2 (2)**

# Programming Languages Lab

**Pre-Requisites:** None

## Course Outcomes:

| | |
|---|---|
| **CO-1** | Develop the application specific codes using python |
| **CO-2** | Understand Strings, Lists, Tuples and Dictionaries in Python |
| **CO-3** | Verify programs using modular approach, file I/O, Python standard library |
| **CO-4** | Implement Digital Systems using Python |

## Course Articulation Matrix:

| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PO-11 | PO-12 | PSO-1 | PSO-2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO-1 | 1 | 1 | 1 | – | – | – | – | – | – | – | – | 1 | – | – |
| CO-2 | 1 | – | 1 | – | – | – | – | – | – | – | – | 1 | – | – |
| CO-3 | – | 2 | 1 | – | 1 | – | – | – | – | – | 1 | 1 | – | – |
| CO-4 | – | – | 2 | – | 2 | – | – | – | – | – | – | 1 | 3 | 3 |

**1 - Slightly;** **2 - Moderately;** **3 - Substantially**

## Syllabus:

**Expressions, Data types, Variables, Flow Control concepts, While Loops, For Loops Functions:** Built-in functions, Writing own functions, Global and local scopes, Error handling Lists, For loops with lists, multiple assignment and augmented operators, List methods Dictionary Datatype and Data structures, string syntax, string methods, String formatting

**Regular expressions:** Basics, Groups, Character classes, Repetition in Regex patterns, Regex method Files Reading and writing, copying and moving, deleting, Directory tree

**Debugging:** raise and assert statements, logging, debugger

**Web scraping:** Web browser, downloading with web requests, Parsing HTML Reading and editing of spreadsheets, PDFs and Word documents Numpy, Pandas, Data visualization libraries, Jupyter Notebook, Python IDEs

**Exercise 1 Basics**

Running instructions in Interactive interpreter and a Python Script.

Write a program to purposefully raise Indentation Error and correct it.

**Exercise 2 Operations**

Write a program to compute GCD of two numbers by taking input from the user.

Write a program add.py that takes 2 numbers as command line arguments and prints its sum.

**Exercise - 3 Control Flow**

Write a Program for checking whether the given number is even number or not.

Write a program using for loop that loops over a sequence.

Python Program to Print the Fibonacci sequence using while loop.

Python program to print all prime numbers in a given interval (use break).

**Exercise – 4 Lists**

Find mean, median, mode for the given set of numbers in a list. Write a program to convert a list and tuple into arrays.

Write a program to find common values between two arrays.

**Exercise – 5 Dictionary**

Write a program to count the numbers of characters in the string and store them in a dictionary data Structure.

Write a program combined lists into a dictionary.

**Exercise – 6 Strings**

Write a program to check whether a string starts with specified characters.

Write a program to check whether a string is palindrome or not.

**Exercise -7 Strings Continued**

Python program to split and join a string.

Python Program to Sort Words in Alphabetic Order.

**Exercise -8 Files**

Write a program to print each line of a file in reverse order.

Write a program to compute the number of characters, words and lines in a file.

Write a program to count frequency of characters in a given file.

**Exercise - 9 Functions**

Simple Calculator program by making use of functions.

Find the factorial of a number using recursion.

Write a function dups to find all duplicates in the list.

Write a function unique to find all the unique elements of a list.

**Exercise - 10 Functions - Problem Solving**

Write a function cumulative_ product to compute cumulative product of a list of numbers.

Write a function reverse to print the given list in the reverse order.

Write function to compute GCD, LCM of two numbers.

**Exercise- 11 Multi-D Lists**

Write a program that defines a matrix and prints.

Write a program to perform addition of two square matrices.

Write a program to perform multiplication of two square matrices

**Exercise - 12 - Modules**

Install NumPy package with pip and explore it.

**Exercise - 13**

Write a program to implement Digital Logic Gates – AND, OR, NOT, EX-OR.

Write a program to implement Half Adder, Full Adder, and Parallel Adder.

**Learning Resources:**

**Reference Books:**

1. Vamsi Kuruma, Python Programming: A Modern Approach, Pearson, 2018.
2. Mark Lutz, Learning Python, O' Reilly, 2013, 5thEdition.
3. A. B. Downey, Think Python, How to Think Like a Computer Scientist, O'Reilly, 2015, 2e.
4. Z. Shaw, LEARN PYTHON 3 THE HARD WAY, Addison-Wesley, 2017.

**Other Suggested Readings:**

1. Online training tutorials on Python with online compiler.
2. https://onlinecourses.nptel.ac.in/noc24_cs57/preview
3. https://onlinecourses.swayam2.ac.in/cec24_cs01/preview

# 2nd Semester

**MA1162** **3-0-0 (3)**

# Integral Calculus, Vector Calculus and Laplace Transforms

**Pre-requisites:** **MA1161**

## Course Outcomes:

| | |
|---|---|
| **CO-1** | Analyze improper integrals for extracting certain properties of beta and gamma integrals. |
| **CO-2** | Evaluate multiple integrals in different coordinate systems. |
| **CO-3** | Apply the concepts of gradient, divergence and curl of scalar and vector point functions to formulate engineering problems. |
| **CO-4** | Convert line integrals into area integrals and surface integrals into volume integrals. |
| **CO-5** | Apply Laplace transforms to solve physical problems arising in engineering. |

## Course Articulation Matrix:

| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PO-11 | PO-12 | PSO-1 | PSO-2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO-1 | 3 | 3 | 1 | 2 | 1 | – | – | – | – | – | – | – | 1 | 2 |
| CO-2 | 3 | 3 | 1 | 2 | 1 | – | – | – | – | – | – | – | 1 | 2 |
| CO-3 | 3 | 3 | 1 | 2 | 1 | – | – | – | – | – | – | – | 1 | 2 |
| CO-4 | 3 | 3 | 1 | 2 | 1 | – | – | – | – | – | – | – | 1 | 2 |
| CO-5 | 3 | 3 | 1 | 2 | 1 | – | – | – | – | – | – | – | 1 | 2 |

**1 - Slightly;** **2 - Moderately;** **3 - Substantially**

## Syllabus:

**Integral Calculus**: Improper integrals; Beta and Gamma functions, and their properties; Differentiation under integral sign, Evaluation of double and triple integrals; Areas and Volumes, change of order of integration; Change of variables in double and triple integrals.

**Vector Calculus**: Scalar and vector fields; Vector differentiation; Level surfaces; Directional derivative; Gradient of a scalar field; Divergence and curl of a vector field; Laplacian operator; Parametrization of curves and surfaces; Line, surface and volume integrals; Green's theorem in a plane; Stoke's theorem; Gauss divergence theorem.

**Laplace Transforms**: Laplace transforms; Inverse Laplace transforms; Properties of Laplace transforms; Laplace transforms of unit step, impulse and periodic functions; Convolution theorem; Applications of Laplace transforms - solving certain initial value problems - solving system of linear differential equations - finding responses of systems to various inputs viz. sinusoidal inputs acting over a time interval, rectangular waves, impulses.

## Learning Resources:

Text Books:

1. George B. Thomas and Ross L. Finney, Calculus and Analytic Geometry, Pearson, 2020, Ninth Edition
2. Dennis G. Zill, Advanced Engineering Mathematics, Jones & Bartlett Learning, 2018, Sixth Edition

Reference Books:

1. Maurice D. Weir, Joel Hass and Christopher Heil, Thomas' Calculus: Early Transcendentals, Pearson, 2014, Thirteenth Edition.
2. Erwin Kreyszig, Advanced Engineering Mathematics, John Wiley and Sons, 2015, Eighth Edition.
3. R. K. Jain and S. R. K. Iyengar, Advanced Engineering Mathematics, Narosa Publishing House, 2016, Fifth Edition.

**CY1161** **3-0-2 (4)**

# Engineering Chemistry

**Pre-Requisites:** **None**

**Course Outcomes:**

| | |
|---|---|
| **CO-1** | Understand the basic concepts of chemistry relevant to materials. |
| **CO-2** | Apply electrochemical concepts for energy harvesting, conversion and storage. |
| **CO-3** | Analyze the properties of materials for various applications. |
| **CO-4** | Comprehend the concepts of instrumentation principles, Spectroscopy and procedures involved in characterization of materials |
| **CO-5** | To analyze the metal contents from the ores by understanding the redox process |
| **CO-6** | To determine the rate of corrosion by a redox reaction and understand the concept of adsorption |

**Course Articulation Matrix:**

| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PO-11 | PO-12 | PSO-1 | PSO-2 | PSO-3 | PSO-4 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO-1 | 3 | - | - | - | - | - | - | - | - | - | - | 2 | 3 | - | – | – |
| CO-2 | 3 | - | - | - | - | - | - | - | - | - | 2 | 2 | 3 | - | – | – |
| CO-3 | 3 | 2 | - | - | - | - | - | - | - | - | 2 | 2 | 3 | 2 | – | – |
| CO-4 | 3 | - | - | - | - | - | - | - | - | - | 2 | 2 | 3 | - | – | – |
| CO-5 | 3 | 3 | 3 | - | 2 | - | 2 | - | - | - | 1 | 1 | 3 | 3 | – | – |
| CO-6 | 3 | 3 | 3 | - | 2 | 2 | - | - | - | 1 | 1 | - | 3 | 3 | – | – |

**1 - Slightly;** **2 - Moderately;** **3 - Substantially**

## Syllabus:

**Chemical Kinetics and Thermodynamics**: Order of a Reaction, Theories of Reaction Rates. Homogeneous and Heterogeneous Catalysis. Thermodynamic variables, Laws of Thermodynamics, Thermodynamic Relationships and Applications.

**Electrochemistry and Energy Systems:** Introduction to Electrochemistry, Nernst's law and its applications. Batteries, fuel cell and photo-electrochemical systems. Corrosion and its prevention. **Transition Metal Chemistry and Organometallic Chemistry:** Bonding in transition metal complexes; Crystal field and MO Theories, Jahn-Teller effect. Properties of Coordination complexes; Metal Carbonyls, EAN and 18-electron rule, Ligands and hapticity; Type of reactions: Oxidative addition, Reductive elimination, Migratory insertion, Hydrogenation, Hydro formylation, Monsanto process and Wacker process.

**Engineering Materials:** Inorganic and Organic Semiconductors, Magnetic materials, Liquid crystals, Superconductors, Photo conducting Materials and conducting polymers. **Chromatographic and Spectroscopic Methods:** Liquid Chromatographic and Gas Chromatographic methods. UV-VIS, spectroscopy, Infrared spectroscopy, NMR spectroscopy.

## List of Experiments:

1. Standardization $KMnO_4$ solution
2. Estimation of metal content in an ore
3. Estimation of Calcium in milk powder by complexometry
4. Extraction and identification of DNA from green peas/onions
5. Estimation of iodine in iodized common salt
6. Blue printing of an object by photochemical reaction
7. Kinetics of acid hydrolysis of methyl acetate
8. Determination of acid strength in citrus fruit
9. Verification of Beer-Lambert Law and estimation of concentration of food color
10. Evaluation of $E^o$ values of $Zn|Zn^{2+}$ and $Cu|Cu^{2+}$ Electrodes and measure the emf by constructing the Daniel cell
11. Estimation of phosphoric acid in soft drinks by pH metry
12. Separation of natural pigments from mixture using paper chromatography
13. Determination of efficiency of a corrosion inhibitor
14. Verification of Freundlich adsorption isotherm
15. Preparation of a polymer and its analysis
16. Estimation of active pharmaceutical ingredient in a drug

### Learning Resources:

Text Books:

1.Shashi Chawla, A Text Book of Engineering Chemistry, Danpathrao & Co. Publications, 2007, 6th India reprint edition

2. Ashutosh Kar, Text Book of Engineering Chemistry, ED-Tech Publications, 2018

3. William Kemp, Organic Spectroscopy, Macmillan Education, Limited, 2017

4. Introductory Chemistry laboratory manual: Concepts and Critical Thinking, Charles Corwin, Pearson Education, 2012.

5. Investigating Chemistry: Laboratory Manual, David Collins, Freeman & Co., 2006.

Reference Books:

1. Michael F. Ashb, David R.H. Jones, Engineering Materials, Elsevier Science, 2012

2. V. Raghava, Material Science and Engineering, PHI Learning, 2015

3. J.M. Martin, Materials for Engineering, Elsevier Science, 20006

4. Peter Atkins, Julio de Paula, James Keeler, Physical Chemistry, Oxford University Press, 2018.

**EE1163** **3-0-0 (3)**

# Network Analysis

**Pre-Requisites:** **None**

## Course Outcomes:

| | |
|---|---|
| **CO-1** | Simplify DC networks and analyze them using loop and node equations and determine the dual of a given network |
| **CO-2** | Analyze magnetic circuits, and electric circuits with sinusoidal excitation along with the phenomenon of resonance |
| **CO-3** | Formulate the dynamic equations of electric circuits using differential equations and simplify their solutions using Laplace. |
| **CO-4** | Simplify the analysis of electric circuits using network theorems and Two port Networks. |

## Course Articulation Matrix:

| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PO-11 | PO-12 | PSO-1 | PSO-2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO-1 | 3 | 3 | 3 | 3 | 3 | 2 | 1 | 1 | 1 | 1 | 1 | 3 | -- | -- |
| CO-2 | 3 | 3 | 3 | 3 | 3 | 2 | 1 | 1 | 1 | 1 | 1 | 3 | -- | -- |
| CO-3 | 3 | 3 | 3 | 3 | 3 | 2 | 1 | 1 | 1 | 1 | 1 | 3 | -- | -- |
| CO-4 | 3 | 3 | 3 | 3 | 3 | 2 | 1 | 1 | 1 | 1 | 1 | 3 | -- | -- |

**1 - Slightly;** **2 - Moderately;** **3 - Substantially**

## Syllabus:

**Circuit Elements and Relations:** Types of circuit components, Types of Sources and Source Transformations, Star-delta transformation, KVL and KCL with dependent and independent Sources, DC circuit analysis, Formation of loop and node equations. Graph of a network- incidence matrix, Dual networks.

**Magnetic Circuits**: Concept of MMF, flux and magnetic reluctance, self and mutual inductances, Dot convention, coefficient of coupling and coupled circuits.

**Steady-state Analysis of Circuits for Sinusoidal Excitations:** Concept of phasor, Single phase Series, Parallel, Series Parallel circuits, Concept of power factor, Solution of AC networks using mesh and nodal analysis, Phasor diagrams. Resonance, Series and Parallel resonance, Bandwidth, Q-factor and selectivity.

**Time Domain Analysis:** Solution of network equations in time domain, Classical differential- equations approach, Initial conditions & evaluation, applications to simple RLC circuits only.

**Applications of Laplace Transforms in Circuit Theory:** Laplace transforms of various signals of excitation, Laplace transformed networks.

**Network Theorems:** Superposition theorem, Thévenin's theorem, Norton's theorem, Maximum power transfer theorem, Millman's theorem, Tellegen's theorem.

**Two-port parameters:** Relationship of two port variables, Short circuit admittance parameters, open circuit impedance parameters, Transmission parameters, Hybrid parameters, Interrelationships, parallel connections of two port networks.

**Learning Resources:**

Text Books:

1. M. E. VanValken Burg, Network Analysis, PHI, 2015, 3 Edition.
2. William H. Hayt, Jack Kemmerly, Steven M. Durbin, Engineering Circuit Analysis, Tata McGraw-Hill, 2013, 8th Edition.

Reference Books:

1. M. L. Soni and J.C. Gupta, A Course in Electrical Circuit Analysis, Dhanpat Rai & Co. (P), 2001.
2. G.K Mittal & Ravi Mittal, Network Analysis, Khanna Publications, 2003, 14th Edition.
3. Gopal G Bhise, Prem R Chadha &Durgesh C. Kulshreshtha Gopal, Engineering Network Analysis and Filter Design, Umesh Publications, 2012.
4. S.R. Paranjothi, Electric Circuit Analysis, New Age International Pub.,2002.
5. De Carlo & Lin, Linear circuit Analysis, Oxford University Press, 2010, 2nd Edition.

Other Suggested Readings:

1. https://nptel.ac.in/courses/108/104/108104139/
2. https://nptel.ac.in/courses/108/102/108102097/

**CS1162** **3-0-2 (4)**

# Data Structures and Practice

**Prerequisites**: **MA1163**

## Course Outcomes:

| | |
|---|---|
| **CO-1** | Understand the basic techniques of algorithm analysis and assess how the choice of data structures impact the performance of programs. |
| **CO-2** | Solve problems using data structures such as linear lists, stacks, queues, hash tables, binary trees, heaps, binary search trees, AVL trees and writing programs for these solutions. |
| **CO-3** | Implement graphs as adjacency matrix, adjacency list, Searching technique - Breadth First Search and Depth First Search. |
| **CO-4** | Analyze, evaluate and choose appropriate data structures and algorithms for a specific application. |

## Course Articulation Matrix:

| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PO-11 | PO-12 | PSO-1 | PSO-2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO-1 | 3 | 2 | 2 | 2 | - | - | - | - | 2 | - | - | 1 | 1 | 1 |
| CO-2 | 3 | 2 | 2 | 2 | - | - | - | - | 2 | - | - | 2 | 2 | 2 |
| CO-3 | 2 | 2 | 2 | 2 | - | - | - | - | 2 | - | - | 1 | 2 | 2 |
| CO-4 | 3 | 2 | 2 | 2 | - | - | - | - | 2 | - | - | 2 | 2 | 2 |

**1 - Slightly;** **2 - Moderately;** **3 - Substantially**

## Syllabus:

**Introduction to Data Structures**: Asymptotic Notations, Theorems and Examples based on Asymptotic Notations, Stack Data Structure and its Applications, Queue Data Structure and its Applications, Linked Lists, Trees and tree traversals, Dynamic Sets and Operations on Dynamic Sets, Binary Search Tree and its Operations, Heap Data Structure

Priority Queue, AVL Trees., Direct Addressing; Introduction to Hashing, Collision Resolution by Chaining, Collision Resolution by Open Addressing, Lower Bound for Comparison based Sorting Algorithms, Insertion Sort, Merge Sort, Quick Sort.

Heap Sort and Counting Sort, Radix Sort, Introduction to Graphs and Representation of Graphs, Depth First Search (DFS), Breadth First Search (BFS), Applications: BFS and DFS.

**Algorithms:** Prim's Algorithm for finding Minimum Spanning Tree (MST), Kruskal's Algorithm for finding MST, Dijkstra's Algorithm for Single Source Shortest Paths Floydd-Warshall Algorithm for All-Pairs Shortest Path Problem

### Laboratory Experiments:

1. Write a program to implement stack using arrays.
2. Write a program to evaluate a given postfix expression using stacks.
3. Write a program to convert a given infix expression to postfix form using stacks.
4. Write a program to implement circular queue using arrays.
5. Write a program to implement double ended queue (de queue) using arrays.

6. Write a program to implement a stack using two queues such that the *push* operation runs in constant time and the *pop* operation runs in linear time.
7. Write a program to implement a stack using two queues such that the *push* operation runs in linear time and the *pop* operation runs in constant time.
8. Write a program to implement a queue using two stacks such that the *enqueue* operation runs in constant time and the *dequeue operation* runs in linear time.
9. Write a program to implement a queue using two stacks such that the *enqueue* operation runs in linear time and the *dequeue* operation runs in constant time.
10. Write programs to implement the following data structures:

(a) Single linked list
(b) Double linked list

11. Write a program to implement a stack using a linked list such that the *push* and *pop* operations
12. Write a program to implement a queue using a linked list such that the *enqueue* and *dequeue* operations
13. Write a program to create a binary search tree (BST) by considering the keys in given order and perform the following operations on it.

(a) Minimum key
(b) Maximum key
(c) Search for a given key
(d) Find predecessor of anode
(e) Find successor of anode
(f) delete a node with given key

14. Write a program to construct an AVL tree for the given set of keys. Also write function for deleting a key from the given AVL tree.
15. Write a program to implement hashing with (a) Separate Chaining and (b) Open addressing methods.

**Learning Resources:**

Text Books:

1. Thomas H. Cormen, Charles E Leiserson, Ronald L. Rivest and Clifford Stein, I*ntroduction to Algorithms*, PHI, 2009, 2nd Edition.
2. Mark Allen Weiss, *Data Structures and Algorithm Analysis in C*++, Pearson Education, 2006, Third Edition.

Reference Books:

1. Ellis Horowitz, Sartaj Sahni and Sanguthevar Rajasekaran, *Fundamentals of Computer Algorithms*, Universities Press, 2011, 2nd Edition.
2. Michael T.Goodrich and Roberto Tamassia, *Algorithm Design: Foundations, Analysis and Internet Examples*, Wiley India, 2006, 2nd Edition.

Other suggested Readings:

1. https://nptel.ac.in/courses/106/106/106106130/
2. https://nptel.ac.in/courses/106/106/106106145/
3. https://nptel.ac.in/courses/106/102/106102064

**EC2102** **0-1-4 (3)**

# Design Thinking

**Pre-Requisites:** **None**

## Course Outcomes:

| | |
|---|---|
| **CO1** | Identify design principles from an engineering perspective |
| **CO2** | Cultivate sensitivity towards design aspects of Activities, Environments, Interactions, Objects, and Users (A-E-I-O-U) in daily life |
| **CO3** | Validate problem statements through user empathization with societal and environmental consciousness |
| **CO4** | Devise visual design and documentation to communicate more effectively |
| **CO5** | Develop project management skills in a multidisciplinary environment |

## Course Articulation Matrix:

| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PO-11 | PO-12 | PSO-1 | PSO-2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO-1 | 1 | 1 | 2 | 2 | 1 | 3 | | | | | | | | |
| CO-2 | 1 | 1 | 1 | 2 | 2 | 1 | 2 | 1 | | 1 | 1 | 1 | 2 | 1 |
| CO-3 | 2 | 2 | 3 | 3 | 1 | 2 | 3 | 1 | 1 | 1 | 1 | 1 | 1 | 3 |
| CO-4 | 2 | 2 | 2 | 2 | 1 | 2 | | | 2 | 3 | 2 | 1 | | 1 |
| CO-5 | 2 | 1 | 1 | | | 1 | | | | | 3 | 1 | | 1 |

**1 - Slightly;** **2 - Moderately;** **3 - Substantially**

## Syllabus:

**MODULE-1: Design Overview and Motivation**
Design is Everywhere – Various perspectives including history; Design Vocabulary; Design in Indian Context; Art and Design; Importance of Design in Career

**MODULE-2: Understanding Design**
Design Engineering vs. Engineering Design; Good and Bad Design — Case Studies, Introduction to the Design Double Diamond: Discover-Define-Develop-Deliver; Importance of user-centricity for design

**MODULE-3: Doing Design: Discover Phase**
Looking for problems: SDGs; Identifying Stakeholders and Defining User Personas; User Empathisation and Tools; Data collection from users and for users: Surveys, Questionnaires, Statistics, Interactions
Need Analysis: Types of Users, Types of Needs; Market Size; Value Proposition to the Users; Identifying Addressable Needs and Touchpoints; Data Validation; Structuring, Need Statements

**MODULE-4: Designing Customer Service Experience**
Enhancing Customer Experience in Services through Innovation and Design Thinking; Service Development Process and Case Studies; Service Experience Cycle and Case Studies

**MODULE-5: Communication Skills for Design**
Communicating using various media to express an idea in print, electronic, mobile, web, and social media: Visuals, Text, Voice and Audio, Infographics
General Guidelines for a Good Presentation: Target Audience, Slideshow Templates, Appropriate Visual Elements and Aesthetics, Typography, Presentation Styles,
General Guidelines for a Good Report: Documentation Classification, Standards, Styles, and Templates

**MODULE-6: Sustainable Design Approaches**
Concern for Environment and Sustainability in Design, Case Studies to understand good Design For Environment (DFE) Decisions; Design Considerations in the five stages of the Product Life Cycle

**STUDENTS' RESPONSIBILITIES:**
1. Forming diverse teams of 3–5 members each to work collaboratively throughout the semester.
2. Proactively engaging to observe the objects and interactions in their daily life and society from a design perspective.
3. Identifying general societal and social problems that may be effectively addressed using design thinking principles
4. Presenting and reporting the tasks to the concerned faculty members using their creative communication and people skills.

ACTIVITIES:

1. Introduction and briefing (15 minutes)
2. Ice-breaker activity (20 minutes)
3. Introduction to Design Thinking (20 minutes)
4. Building empathy for the user (1 hour)
5. Define a problem statement (1 hour)
6. Ideation part 1: Generate ideas and potential solutions (1 hour)
    - Presentation (5 minutes): What is ideation?
    - Activity—worst possible idea (10 minutes)
    - Activity—coming up with solutions (10 minutes)
    - Activity—sharing ideas and getting feedback (10 minutes)
    - Activity—refining your solution (10 minutes)
    - Reflection and discussion (5 minutes)
7. Ideation part 2: User journey mapping (1 hour)
    - Presentation (10 minutes): What is a user journey map?
    - Activity—define the activities and steps in the customer's experience (15 minutes)
    - Activity—group the steps into phases (10 minutes)
    - Activity—adding goals and pain-points (15 minutes)
    - Sharing user journey maps, reflection and discussion (10 minutes)
8. Prototype and test ideas (1 hour)
    - Presentation (5 minutes):
    - Activity—create mobile screens (15 minutes)
    - Activity—add functionality to mobile screens (15 minutes)
    - Activity—user testing (15 minutes)
    - Activity—decide on a winning approach (10 minutes):
9. Debrief and outline next steps (15 minutes)

Exercises:

1) The Pin-Up Exercise
2) The Systems Thinking Exercise
3) The 48-Hour Crash Course Exercise
4) The Design with Empathy Exercise
5) The Tinker Toy Exercise
6) The Wallet Exercise

7) The Pitch Competition Exercise
8) “Yes, but” vs. “Yes, and” exercise
9) “Five whys” or “Nine Whys” exercise
10) The “Six Thinking Hats” exercise

**Learning Resources:**

Text Books:


1. Tim Brown, “Change by Design”, Harper Business, 2012 (ISBN: 978-0062337382)
2. Donald A. Norman, “The Design of Everyday Things”, MIT Press, 2013 (ISBN: 978-0262525671)
3. Daniel Ling, “Complete Design Thinking Guide for Successful Professionals”, Create Space Independent Publishing, 2015 (ISBN: 978-1514202739)
4. Design Thinking: A guide to creative problem solving for everyone, Andrew Pressman, Routledge Taylor and Francis group, 2019, 1st edition.
5. Engineering Design, George E. Dieter, Linda C. Schmidt, McGraw-Hill Education, 2019, 5th edition.
6. Product design and development, Ulrich, K., Eppinger, S. and Yang, M., 2020, 7th edition.


Reference Books:


1. Bruno Munari, “Design as Art”, Penguin UK, 2009 (ISBN: 978-0141035819)
2. Tom Kelly, Jonathan Littman, “The Art of Innovation”, HarperCollins Business, 2002 (ISBN: 978-0007102938)
3. Thomas Lockwood, “Design Thinking: Integrating Innovation, Customer Experience, and Brand Value”, Allworth Press, 2009 (ISBN: 978-1581156683)
4. Joost Groot Kromelink, “Responsible Innovation: Ethics, Safety and Technology”,2nd ed., TU Delft, Faculty of Technology, Policy and Management, 2019 (e-Book ISBN: 978-9463662024)
5. Jimmy Jain, “Design Thinking for Startups: A Handbook for Readers and Workbook for Practitioners”, Notion Press, 2018 (ISBN: 978-1642495034)


Other Suggested Readings:

1. https://www.arvindguptatoys.com/
2. https://honeybee.org/
3. https://dschool.stanford.edu/resources/getting-started-with-design-thinking
4. https://designthinking.ideo.com/

**EC2104** **3-0-0 (3)**

# Solid State Electronic Devices

**Pre-Requisites:** **None**

**Course Outcomes:**

| | |
|---|---|
| **CO-1** | Understand the properties of basic semiconductor materials |
| **CO-2** | Analyze the carrier transport mechanism of semiconductor materials |
| **CO-3** | Apply the mechanics of P-N junction towards solid state electronic devices |
| **CO-4** | Study the electrical characteristics of BJT and MOSFETS |

**Course Articulation Matrix:**

| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PO-11 | PO-12 | PSO-1 | PSO-2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO-1 | 2 | 1 | 1 | – | – | – | – | – | 1 | 1 | – | 2 | 1 | 1 |
| CO-2 | 2 | 3 | 1 | 2 | – | – | – | – | 1 | 1 | – | 2 | 2 | 1 |
| CO-3 | 2 | 3 | 3 | 3 | _ | – | – | – | 1 | 1 | – | 2 | 3 | 1 |
| CO-4 | 2 | 2 | 1 | 2 | 3 | – | – | – | 1 | 1 | – | 2 | 2 | 1 |

**1 - Slightly;** **2 - Moderately;** **3 - Substantially**

## Syllabus:

**Introduction to Semiconductor Physics:** Review of Quantum Mechanics: Probability and the Uncertainity principle, de Broglie hypothesis, Tunneling, Electrons in periodic Lattices, Energy bands, Crystal Lattices. Charge carriers in Semiconductors, carrier concentrations, Excess Carriers in Semiconductors, intrinsic and extrinsic semiconductor, E-k diagrams, direct and indirect bandgap semiconductors, elemental and compound semiconductor.

**Carrier transport:** Diffusion current, drift current, hall effect, mobility and resistivity; design of resistors, Generation and recombination of carriers; Poisson and continuity equation.

**PN junction:** Equilibrium conditions, forward and reverse biased junctions; steady state conditions, reverse bias breakdown and transient AC conditions: reverse recovery and capacitance, metal semiconductor junction, Zener diode, Tunnel Diode, IMPATT Diode, Gunn Diode, Narrow base diode.

**BJT:** Structure, minority carrier distributions and terminal currents, operation, I-V characteristics, Ebers-Moll Model, CE, CB, CC Configurations, large and small signal models.

**MOSFET:** The ideal MOS capacitor, C-V characteristics, Threshold voltage, MOSFET-Structure, operation, output and transfer characteristics, Introduction to novel transistors.

**Learning Resources:**

Text Books:

1.B. G. Streetman, and S. K. Banerjee,Solid State Electronic Devices, Pearson, 2018, 7th edition.
2. D. Neamen, and D. Biswas, Semiconductor Physics and Devices, McGraw-Hill Education,2017, 4th Edition.
3. B. Razavi, Fundamentals of Microelectronics, Wiley, 2021, 3rd Edition.
4. R. F. Pierret, Semiconductor Device Fundamentals, Pearson, 2006, 1st Edition.

Reference Books:

1.S. M. Sze and K. N. Kwok, Physics of Semiconductor Devices, John Wiley & Sons, 2006, 3rd edition.
2. Robert L Boylestad and Louis Nashelsky, Electronic Devices and Circuit Theory, Pearson,2018, 11th Edition.
3. Jacob Millman and Christos Halkias, Electronics Devices and Circuits, Tata McGraw Hill,2015, 4th Edition.

**EC2106** **0-1-2 (2)**

# Electronic Devices Lab

**Pre-Requisites:** **EC2104**

**Course Outcomes:**

| | |
|---|---|
| **CO-1** | Identify the electronic components |
| **CO-2** | Understand the working of electronics lab equipment |
| **CO-3** | Plot the characteristics of diodes and transistors to understand their behavior using experiment/simulation |
| **CO-4** | Implement an Do it Yourself (DIY) electronics project |

**Course Articulation Matrix:**

| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PO-11 | PO-12 | PSO-1 | PSO-2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO-1 | 2 | 3 | 2 | - | - | - | - | - | 2 | 1 | - | 2 | 1 | 1 |
| CO-2 | 2 | 3 | 2 | - | - | - | - | - | 2 | 1 | - | 2 | 1 | 1 |
| CO-3 | 2 | 3 | 2 | 2 | - | - | - | - | 2 | 1 | - | 2 | 1 | 1 |
| CO-4 | 2 | 3 | 2 | 2 | 3 | 2 | - | - | 2 | 1 | 2 | 2 | 2 | 2 |

**1 - Slightly;** **2 - Moderately;** **3 - Substantially**

## Syllabus:

### List of Experiments:

1. Study of components (R, L, C, Diodes, Transistors, etc)
2. Study of Instruments (CRO, Signal Generator, DC Power Supply, Voltmeter, Ammeter, DMM etc)
3. SPICE simulations for Diode circuits and BJT/MOSFET characteristics
4. V-I Characteristics of Diodes
5. BJT Characteristics (CE, CB, CC)
6. MOSFET Characteristics (CS, CG, CD)
7. DIY Electronics Project

### Learning Resources:

Text Books:

1. Solid State Electronic Devices, B. G. Streetman, and S. K. Banerjee, Pearson, 7th edition, 2018.
2. Semiconductor Physics and Devices, D. Neamen, and D. Biswas, McGraw-Hill Education, 4th edition, 2017.
3. Fundamentals of Microelectronics, B. Razavi, Wiley, 3rd Edition, 2021.
4. SPICE, G. W. Roberts, A. S. Sedra, Oxford University Press, 2nd Edition, 1997.

Reference Books:

1. Physics of Semiconductor Devices, S. M. Sze and K. N. Kwok, John Wiley & Sons, 3rd edition, 2006.
2. Electronics Devices and Circuits, Jacob Millman and Christos Halkias, Tata McGraw Hill,4th Edition, 2015.
3. Semiconductor Device Fundamentals, R. F. Pierret, Pearson, 1st Edition, 2006.

Other Suggested Readings:

1. https://nptel.ac.in/courses/117106091

# 3rd Semester

**MA1265** **3-0-0 (3)**

# Complex Variables and Special Functions

**Prerequisites:** **None**

**Course Outcomes:**

| | |
|---|---|
| **CO-1** | Evaluate contour integrals of functions of complex variables |
| **CO-2** | Examine improper integrals using complex variables |
| **CO-3** | Determine the series solutions of Legendre and Bessel equations |
| **CO-4** | Assess series solution of ordinary differential equations at a singular point |
| **CO-5** | Construct a function for data using cubic splines |

**Course Articulation Matrix:**

| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PO-11 | PO-12 | PSO-1 | PSO-2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO-1 | 3 | 1 | - | - | - | - | - | - | - | - | - | - | - | - |
| CO-2 | 3 | 1 | - | - | - | - | - | - | - | - | - | - | - | - |
| CO-3 | 3 | 1 | - | - | - | - | - | - | - | - | - | - | - | - |
| CO-4 | 3 | 1 | - | - | - | - | - | - | - | - | - | - | - | - |
| CO-5 | 3 | 1 | - | - | - | - | - | - | - | - | - | - | - | - |

## Syllabus:

Review of complex numbers, nth roots of complex number, Regions in the complex plane, Functions of a complex variable, Limit and continuity, Functions of a complex variable, Limit and continuity, Derivative, CR-equations, analytic functions, Contour integrals, anti-derivatives, Contour integrals, anti-derivatives, Cauchy-Goursat Theorem, Cauchy Integral Formula.

Taylor‘s and Laurent‘s series expansions, Zeros and singularities, Residues, Residue theorem, Evaluation of improper integrals, Mapping by Elementary functions, Linear fractional transformations (Bilinear transformation), conformal mapping, Schwartz Christoffel transformation. Ordinary points, Classification of singular points of an ordinary differential equation Series solutions

Power series method, Legendre equation, Legendre polynomials and their orthogonal property, Generating function, Regular Singular Points, Method of Frobenius.

Bessel equation, Bessel function of first kind, Generating function, orthogonal property of Bessel functions, Sturm-Liouvelle Problems, Splines and cubic spline functions, Properties and applications, Piecewise approximation with M‘s and m‘s

**Learning Resources:**

Text Books:

1. R.V. Churchill, Complex variables and its applications, McGraw Hill, 2017, 8th Edition
2. S.S. Sastry, Introductory methods of Numerical Analysis, PHI, 2012, 5th Edition.
3. W.W. Bell, Special Functions For Scientists and Engineers, Dover Publications, 2004.
4. Erwin Kreyszig: Advanced Engineering Mathematics, John Wiley and Sons, 2010, 10th Edition.

5. B.S. Grewal: Higher Engineering Mathematics, Khanna Publications, 2014, 43th Edition.

Reference Books:

1. Advanced Engineering Mathematics: by C. R. Wylie & L. C. Barrett, McGraw Hill, 6th Edition
2. Advanced Engineering Mathematics: by R. K. Jain & S. R. K Iyengar, Narosa Pub. House, 2019, 6th Edition.
3. Complex variables and Applications: by R. V. Churchill, T. J. Brown & R. F. Verhey, McGraw Hill, 2013, 9 th Edition.

**EC1203** **3-0-2 (4)**

# Signals and Systems

**Pre-Requisites:** **None**

**Course Outcomes:**

| | |
|---|---|
| **CO-1** | Classify the signals as Continuous time and Discrete time |
| **CO-2** | Analyze the spectral characteristics of signals using Fourier analysis. |
| **CO-3** | Classify systems based on their properties and determine the response of LTI system using convolution. |
| **CO-4** | Understand the process of sampling to convert an analog signal into discrete signal and Apply Z- transform of continuous-time and discrete-time signals for stability analysis. |
| **CO-5** | Demonstrate the principles of signals & systems through simulation. |

**Course Articulation Matrix:**

| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PO-11 | PO-12 | PSO-1 | PSO-2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO-1 | 2 | - | - | - | - | - | - | - | - | - | - | - | 2 | - |
| CO-2 | 3 | - | - | - | - | 2 | - | - | - | - | - | 1 | 2 | - |
| CO-3 | 3 | - | - | - | - | - | - | - | - | - | - | - | 2 | - |
| CO-4 | 2 | 3 | - | - | - | - | - | - | - | - | - | - | 2 | - |
| CO-5 | 2 | 3 | - | - | - | 3 | - | - | - | - | - | 1 | 2 | - |

**1 - Slightly;** **2 - Moderately;** **3 - Substantially**

## Syllabus:

**Signals and Systems:** Continuous Time and Discrete Time signals, Exponential and Sinusoidal Signals, Unit Impulse and Unit Step Functions, Continuous and Discrete Time Systems, basic System Properties.

**Linear Time Invariant Systems:** Discrete Time LTI Systems, Continuous Time LTI Systems, properties of LTI Systems, causal LTI Systems Described by Difference equations.

**Fourier Series Representation of Periodic Signals:** Response of LTI systems to Complex Exponentials, Fourier series Representation of CT periodic Signals, properties of CT Fourier Series, Fourier Series representation of DT periodic Signals, properties of DFS, Fourier series and LTI Systems, Filtering, Examples of CT filters, Examples of DT filters.

**Continuous Time Fourier Transform:** Representation of a periodic Signals by continuous FT, FT of periodic signals, convolution and multiplication property of continuous FT, systems characterized by Linear Constant Coefficient Differential Equations.

**Time and Frequency Characterization of Signals and Systems:** Magnitude and phase representation of FT, Magnitude and phase response of LTI systems, Time de main and Frequency domain aspects of ideal and non-ideal filters.

**Discrete Time Fourier Transform (DTFT) and Discrete Fourier Transform (DFT):** Properties of DTFT and DFT, convolution property, multiplication property, Duality, Systems characterized by Linear Constant Coefficient Difference Equations.

**Sampling**: Sampling theorem, Proof of Sampling theorem, Effect of under sampling- Aliasing**,**

**Z-Transforms**: Z-transforms, Region of convergence and its properties, Inverse Z transform, properties of ZT, Analysis and characterization of LTI systems using ZT.

**Lab Experiments**:

1. Introduction to MATLAB
2. Generation of continuous time signals.
3. Basic operations on the signals.
4. Transformation of signals into time and frequency domains.
5. Convolution between signals and sequences
6. WriteaMATLABprogramtoCalculateandplotFourierTransformandZ-Transformofagiven signal.
7. Write a MATLAB program to Verify Sampling theorem.

**Learning Resources:**

Text Books:

1. AV Oppenheim, AS Willsky, S Hamid Nawab, Signals and Systems, PHI, 2000, 2nd edition.
2. Robert A. Gable, Richard A. Roberts, Signals and Linear Systems, John Wiley, 1995, 3rd edition.
3. John G. Proakis, Dimitris G. Manolakis, Digital Signal Processing, Principles, Algorithms, and Applications, PHI, 2007, 4th Edition.

Reference Books:

1. Simon Haykin, Barry van Veen, "Signals and Systems", John Wiley and Sons (Asia) Private Limited, 1998.
2. Robert A. Gabel, Richard A. Roberts, "Signals and Linear Systems", John Wiley and Sons, 1995.

Other Suggested Readings:

1. NPTEL Courses: https://nptel.ac.in/courses/10810410

**EC1205** **3-0-0 (3)**

# Digital Circuit Design

**Pre-Requisites:** **None**

**Course Outcomes:**

| | |
|---|---|
| **CO-1** | Design of combinational and sequential logic circuits and develop Verilog models |
| **CO-2** | Understand characteristics of the TTL/CMOS logic families and realize Boolean equation using CMOS logic |
| **CO-3** | Understand fault detection techniques for digital logic circuits |
| **CO-4** | Understand SRAM/DRAM organization and periphery circuitry, operation of SRAM cell, DRAM cell, DDR2/DDR4 and SD card |

**Course Articulation Matrix:**

| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PO-11 | PO-12 | PSO-1 | PSO-2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO-1 | 2 | 3 | 2 | - | - | - | - | - | - | - | - | 1 | - | - |
| CO-2 | 2 | 3 | - | - | - | - | - | - | - | - | - | 1 | - | - |
| CO-3 | - | 2 | - | - | - | - | - | - | - | - | - | 1 | - | - |
| CO-4 | 2 | 2 | 1 | - | - | - | - | - | 2 | - | - | 1 | - | - |

**1 - Slightly;** **2 - Moderately;** **3 - Substantially**

## Syllabus:

Number Systems and Codes, Representation of unsigned and signed integers, Floating Point representation of real numbers, Laws of Boolean Algebra, Theorems of Boolean Algebra, Realization of functions using logic gates, Canonical forms of Boolean Functions, Minimization of Functions using Karnaugh Maps.

**Combinational circuit design:** Design with basic logic gates, comparators, data selectors, priority encoders, decoders, full adder, serial binary adder, parallel binary adders-ripple-carry adder, carry-look ahead adder; Parallel prefix adders- Carry select Adder, Conditional sum adder, Kogge-stone Adder, Brent-kung adder, Verilog models.

**Sequential circuit design:** Memory elements and their excitation functions SR, JK, T, and D latches and flip-flops, master slave JK flip-flop, edge-triggered flip-flop, synchronous and asynchronous counters, finite-state machine, sequence detector, minimization and transformation of sequential machines, Registers, Verilog models.

**Testing of Combinational circuits:** Fault models, structural testing: path sensitization Logic families: TTL and CMOS Logic circuits, Transfer characteristics, fan-in, fan-out, noise margin, rise time and fall time analysis, realization of Boolean equations using CMOS logic.

**Memory:** Types of memories, MOS SRAM cells, DRAM, SDRAM, DDR SDRAM, DDR2 SDRAM, DDR4 SDRAM, organization of a SRAM, Organization of SDRAM, Periphery circuitry of Memory, Flash memory, SD card.

**Learning Resources:**

Text Books:

1. William J. Dally and John W. Poulton, Digital Systems Engineering, Cambridge University Press, 2008.
2. Schilling, Herbert Taub and Donald, Digital Integrated Electronics, Tata McGraw-Hill, 2008.
3. Jayaram Bhasker, Verilog Primer, Prentice-Hall India, 1998, 3rd edition.
4. Sameer Palnitkar, Verilog HDL: A guide to digital Design and Synthesis, Pearson, 2003, 2nd edition.

Reference Books:

1. John F Wakerly, Digital Design Principles and Practices, Prentice Hall India, 2001, 3rd Edition.
2. Franklin P. Processor, David E. Winkel, The Art of Digital Design: An Introduction to Top-Down Design,PTR Prentice Hall, 1987, 2nd Edition.

**EC2201** **3-0-0 (3)**

# VLSI Technology

**Pre-Requisites:** **None**

**Course Outcomes:**

| | |
|---|---|
| **CO-1** | Explain the unit fabrication process steps |
| **CO-2** | Explain the functions of packaging |
| **CO-3** | Analyze process yield and yield measurement for a process |
| **CO-4** | Propose the process flow for novel MOS devices |
| **CO-5** | Construct the circuit layout using the design rules |

**Course Articulation Matrix:**

| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PO-11 | PO-12 | PSO-1 | PSO-2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO-1 | 2 | 3 | 3 | 2 | 3 | – | – | – | – | – | 1 | 2 | 2 | – |
| CO-2 | 2 | 2 | 1 | 1 | 1 | – | – | – | – | – | 1 | 2 | 2 | – |
| CO-3 | 2 | 2 | 2 | 2 | 1 | – | – | – | – | – | 1 | 2 | 2 | - |
| CO-4 | 3 | 3 | 3 | 3 | 2 | – | – | – | – | – | 1 | 2 | 2 | 1 |
| CO-5 | 2 | 3 | 1 | 2 | 3 | – | – | – | – | – | 1 | 2 | 2 | 1 |

**1 - Slightly;** **2 - Moderately;** **3 - Substantially**

## Syllabus:

**Environment for VLSI Technology:** Clean room and safety requirements. Wafer cleaning processes and wet chemical etching techniques.

**Impurity incorporation**: Solid State diffusion modelling and technology; Ion Implantation modelling, technology and damage annealing; characterization of Impurity profiles.

**Oxidation:** Kinetics of Silicon dioxide growth both for thick, thin and ultrathin films. Oxidation technologies in VLSI and ULSI; Characterization of oxide films; High k and low k dielectrics for ULSI.

**Lithography:** Photolithography, E-beam lithography and newer lithography techniques for VLSI/ULSI; Mask generation.

**Chemical Vapor Deposition techniques**: CVD techniques for deposition of polysilicon, silicon dioxide, silicon nitride and metal films; Epitaxial growth of silicon; modelling and technology.

**Metal film deposition**: Evaporation and sputtering techniques. Failure mechanisms in metal interconnects; multi-level metallization schemes. Plasma and Rapid Thermal Processing: PECVD, Plasma etching and RIE techniques; RTP techniques for annealing, growth and deposition of various films for use in ULSI.

Process integration for NMOS, CMOS and Bipolar circuits; Advanced MOS technologies

**Learning Resources:**

Text Books:

1. Plummer, J.D., Deal, M.D. and Griffin, P.B.Silicon VLSI Technology: Fundamentals, Practice and Modeling, Prentice-Hall, 2000, 3rd Edition.
2. S.K. Gandhi,VLSI Fabrication principles, John Wiley and Sons, NY, 1994.

Reference Books:

1. S.M. Sze,VLSI technology, McGraw-Hill Book company, NY, 1988.

**EC2203** **3-0-0 (3)**

# Electronic Circuit Design

**Pre-Requisites:** **EC2104**

**Course Outcomes:**

| | |
|---|---|
| **CO-1** | Design rectifiers and filters for regulated power supply |
| **CO-2** | Understand biasing concepts of amplifiers |
| **CO-3** | Develop small-signal model for BJTs and MOSFETs |
| **CO-4** | Apply the concepts of feedback for circuit design |
| **CO-5** | Analyze wave shaping and switching circuits |

**Course Articulation Matrix:**

| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PO-11 | PO-12 | PSO-1 | PSO-2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO-1 | 2 | 3 | 3 | 2 | 3 | – | – | – | – | – | 1 | 2 | 2 | – |
| CO-2 | 2 | 2 | 1 | 1 | 1 | – | – | – | – | – | 1 | 2 | 2 | – |
| CO-3 | 2 | 2 | 2 | 2 | 1 | – | – | – | – | – | 1 | 2 | 2 | 1 |
| CO-4 | 3 | 3 | 3 | 3 | 2 | – | – | – | – | – | 1 | 2 | 2 | – |
| CO-5 | 2 | 3 | 1 | 2 | 3 | – | – | – | – | – | 1 | 2 | 2 | - |

**1 - Slightly;** **2 - Moderately;** **3 - Substantially**

## Syllabus:

**Diode Circuits:** Rectifiers, C, L, LC, π filters, clippers, clampers, voltage regulators.

**Amplifier:** Basic concepts of Bipolar/MOS amplification, DC load line, stability, Operating point Analysis and Design, Single stage amplifier topologies Bipolar (CE, CB and CC) and MOS (CS, CG and CD).

**Frequency Response:** Fundamental concepts, Bode rules, Miller theorem, Estimation of voltage gain, input resistance, output resistance. Low and high frequency response of CE/CS, CB/CG and CC/CD stages.

**Feedback:** Concept of feedback, positive & negative feedback, Voltage series, current series, voltage shunt, current shunt, effect of feedback on gain, bandwidth, input/output impedance, calculation with practical circuits, concept of stability.

**Oscillators:** Barkhausen criterion, RC oscillators (phase shift, Wien bridge), LC oscillators (Hartley, Colpitts, Clapp).

**Wave Shaping:** High Pass and Low Pass RC Circuits and their Response for Sinusoidal, Step Voltage, Pulse, Square Wave and Ramp Inputs. RL and RLC Circuits and their response for step input. General features of a time base signal, methods of generating time base waveform, Principles of Bootstrap time base generators.

**Learning Resources:**

Text Books:

1. Adel S. Sedra and Kenneth C. Smith and Arun N. Chandorkar, Microelectronic Circuits: Theory and Applications, Oxford University Press, 2017, 7th Edition.
2. Donald A Neamen, Microelectronics: Circuit Analysis and Design, McGraw Hill, 2021, 4th Edition.
3. Richard C Jaeger and Travis Blalock, Microelectronic Circuit Design, McGraw Hill, 2022, 6th Edition.
4. JacobMillman, Christos Halkias and Chetan D Parikh, Millman's Integrated Electronics, 2nd edition, McGraw Hill, 2017.

Reference Books:

1. P. Horowitz and W. Hill, The Art of Electronics, Cambridge University Press, 1989, 2nd edition.
2. Paul R. Gray and Robert G.Meyer, Analysis and Design of Analog Integrated Circuits, John Wiley, 3rd Edition.

Other Suggested Readings:

1. NPTEL Courses(https://archive.nptel.ac.in/courses/108/105/108105158/)

**EC1211** **0-1-2 (2)**

# Digital Circuit Design Lab

**Pre-Requisites:** **EC1205**

**Course Outcomes:**

| | |
|---|---|
| **CO-1** | Develop data flow, behavioral and structural Verilog models for digital circuits |
| **CO-2** | Compile and Simulate Verilog models of digital circuits using CAD tool |
| **CO-3** | Synthesize subsystems/ modules using CAD tool |
| **CO-4** | Implement digital circuits on FPGA prototype boards |

**Course Articulation Matrix:**

| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PO-11 | PO-12 | PSO-1 | PSO-2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO-1 | - | 2 | 3 | - | - | - | - | - | - | - | - | - | 1 | 2 |
| CO-2 | - | 2 | 3 | - | - | - | - | - | - | - | - | - | 1 | 2 |
| CO-3 | - | 3 | 2 | - | - | - | - | - | - | - | - | - | 1 | 2 |
| CO-4 | - | 3 | 2 | - | - | - | - | - | - | - | - | 2 | 1 | 2 |

**1 - Slightly;** **2 - Moderately;** **3 - Substantially**

## Syllabus:

**LIST OF EXPERIMENTS:**

1. Develop dataflow Verilog models for

   a) 2-to-4decoder

   b) 8-to-3encoder

   c) 4:1 mux

   d) full adder/subtractor

   e) 8-bit parity generator/checker

   f) 8-bit Kogge-stone adder

Develop structural Verilog models for

   a) 16:1 mux realization using 4:1mux

   b) 4-bit ripple carry adder using full adder

   c) 8-bit adder using 4-bit ripple carry adder

   d) 8-bit carry select adder using 4-bit ripple carry adder

   e) 16-bit adder by cascading an 8-bit Kogge-stone adder/Ripple carry adder

   f) 4-bit asynchronous up/down counter

   g) 16-bit Universal shift register

2. Develop Verilog models for implementation of the following modules using top-down design style

   a) Serial Adder

   b) 16-bit Modified Booth ‘s multiplier

   c) 16-bit Vedic multiplier

3. Mini Project

**Learning Resources:**

Text Books:


1. M.Morris Mano and Michel. D. Ciletti, Digital Design with an introduction to HDL, VHDL and Verilog, Pearson education, Sixth edition.
2. R. Anand, Digital System Design Using VHDL, Khanna Book Publishing Company.
3. R. Anand, Digital Electronics, Khanna Book Publishing Company.
4. R.P. Jain, —Modern digital Electronics‖, Tata McGraw Hill, 2009, 4th edition.
5. Douglas Perry, —VHDL‖, Tata McGraw Hill, 2002, 4th edition.


Reference Books:


1. W.H. Gothmann, —Digital Electronics- An introduction to theory and practice‖, PHI,2006, 2nd edition.
2. D.V. Hall, —Digital Circuits and Systems‖, Tata McGraw Hill, 1989.
3. Charles Roth, —Digital System Design using VHDL‖, Tata McGraw Hill, 2012, 2nd edition.

**EC2205** **0-1-2 (2)**

# Electronic Circuit Design Lab

**Pre-Requisites:** **EC2203**

**Course Outcomes:**

| | |
|---|---|
| **CO-1** | Design rectifiers and filters for regulated power supply |
| **CO-2** | Analyze the effect of biasing in amplifier circuits |
| **CO-3** | Deduce the frequency response of single and two stage amplifiers |
| **CO-4** | Verify the impact of feedback on amplifiers and oscillators |
| **CO-5** | Evaluate the response of wave shaping and switching circuits |

**Course Articulation Matrix:**

| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PO-11 | PO-12 | PSO-1 | PSO-2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO-1 | 3 | 2 | 3 | 1 | 3 | – | – | – | 2 | 1 | – | – | 3 | 2 |
| CO-2 | 3 | 3 | 3 | 1 | 3 | – | – | – | 2 | 1 | – | – | 3 | 2 |
| CO-3 | 3 | 2 | 3 | 1 | 3 | – | – | – | 2 | 1 | – | – | 3 | 2 |
| CO-4 | 3 | 2 | 2 | 1 | 3 | – | – | – | 2 | 1 | – | – | 3 | 2 |
| CO-5 | 3 | 2 | 2 | 1 | 3 | – | – | – | 2 | 1 | – | – | 3 | 2 |

**1 - Slightly;** **2 - Moderately;** **3 - Substantially**

## Syllabus:

**LIST OF EXPERIMENTS:**

1. Half Wave and Full Wave Rectifiers
2. Clippers and clampers
3. Zener Diode as Voltage Regulator
4. Biasing Circuits
5. Single stage amplifier/Two stage amplifier
6. Voltage series/shunt feedback amplifier
7. Current series/shunt feedback amplifier
8. RC phase shift oscillator
9. LC oscillator
10. Wave shaping circuits
11. SPICE simulations

**Learning Resources:**

Text Books:

1. Microelectronics Circuit Analysis and Design, Donald Neamen, McGraw Hill, 2010, 4thEdition.
2. Fundamentals of Semiconductor Fabrication, Gary S May ad Simon M Sze, Wiley,2003, 1stEdition.

Reference Books:

1. Donald Neamen, Microelectronics Circuit Analysis and Design, McGraw Hill, 2010, 4 th Edition.
2. Gary S May ad Simon M Sze, Fundamentals of Semiconductor Fabrication, Wiley, 2003, 1st Edition.
3. S M Sze, VLSI Technology, 2003, 2nd Edition.
4. Richard C Jaeger and Travis N Blalock, Microelectronic Circuit Design, McGraw Hill, 2016,5th Edition.
5. Ben Streetman, Solid State Electronic Devices, Pearson, 2015, 7thEdition.

Other Suggested Readings:

NPTEL Courses:

1. https://nptel.ac.in/courses/117/105/117105147/
2. https://nptel.ac.in/courses/117/108/117108038/
3. https://onlinecourses.nptel.ac.in/noc21_ee86/preview

# 4th Semester

**EC1204** **3-0-2 (4)**

# Probability Theory and Stochastic Processes

**Pre-Requisites:** **None**

**Course Outcomes:**

| | |
|---|---|
| **CO-1** | Distinguish between random variable and stochastic processes |
| **CO-2** | Obtain density and distribution functions for derived random variables |
| **CO-3** | Characterize LTI systems driven by a stationary random process using autocorrelation and power spectral density functions. |
| **CO-4** | Model communication system as a stochastic process. |
| **CO-5** | Model the Probability and Stochastic processes and Visualize their principles through simulation |

**Course Articulation Matrix:**

| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PO-11 | PO-12 | PSO-1 | PSO-2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO-1 | 3 | – | – | – | – | – | – | – | – | – | – | – | – | – |
| CO-2 | 3 | 2 | – | – | – | – | – | – | – | – | – | 2 | – | – |
| CO-3 | 3 | 2 | – | – | – | – | – | – | – | – | – | – | – | – |
| CO-4 | 3 | 2 | – | – | – | – | – | – | – | – | – | – | – | – |
| CO-5 | 3 | 2 | – | – | – | – | – | – | – | – | – | – | – | – |

**1 - Slightly;** **2 - Moderately;** **3 - Substantially**

## Syllabus:

**Introduction:** Axioms of Probability, Probability Space, Conditional Probability, Bayes Theorem, Repeated Trails, Bernoulli ‘s Trails.

**Concept of a Random Variable:** Distribution and density functions, Properties of distribution functions, Continuous type random variable, Normal, Exponential, uniform, Binomial, Poisson distributions, Negative binomial distributions. Conditional distributions, Total probability and Bayes theorem.

**Functions of one random variable:** Distribution and Density Functions, Expectation, Variance, Moments, Characteristic functions.

**Two Random Variables**: One Function of Two Random Variables, Two Functions of Two Random Variables, Joint Moments, Joint Characteristic Functions, Conditional Distributions, Conditional Expected Values.

**Stochastic Processes**: Concept of Stationarity, Distribution and Density Functions, Statistical Independence, Auto correlation function and its properties, Cross- correlation Function and its Properties, Covariance functions Time Averages and Ergodicity, Mean Ergodic Process, Discrete Time Processes and Sequences, Power Density Spectrum and its Properties. Linear systems with random inputs.

## Lab Experiments:

1. Write a MATLAB program to find probability of tossing a coin and rolling a die through large no. of experimentation.
2. Generate Uniform, Gaussian and Exponential distributed random data for given mean and variance.
3. Write a MATLAB program to generate M trials of a random experiment having specific number of outcomes with specified probabilities.
4. To find estimated and true mean of Uniform, Gaussian and Exponential distributed data.
5. To find density and distribution function of a function of random variable Y = 2X + 1. Where X is Gaussian R.V.
6. Estimate the mean and variance of Y = 2X + 1, where X is a Gaussian random variable.
7. Plot Joint density and distribution function of sum of two Gaussian random variable (Z = X + Y).
8. Estimate the mean and variance of a R.V. Z = X+Y. Where X and Y are also random variables.
9. Simulation of Central Limit Theorem.
10. Write two MATLAB functions to generate samples of stationary Gaussian processes.
11. Write three MATLAB functions to generate samples of non-stationary Gaussian processes.
12. Verify relations between correlation and power spectral density using MATLAB simulation.

### Learning Resources:

Text Books:

1. P.Z. Peebles.Jr., Probability, Random Variables AND Random Signal Principles, Tata McGraw Hill Education, 2017, 4th Edition.
2. A.Papoulis, Probability, Random variables and Stochastic Processes, McGraw Hill, 2017, 4th Edition.
3. Scott Miller, Donald Childersm, Probability and Random Processes, Elsevier, 2012, 2nd Edition.

Reference Books:

1. Athanasios Papoulis and S., Unnikrishna Pillai. Probability, Random Variables and Stochastic Processes, TMH, 2002,4th Edition.
2. Pradip Kumar Gosh, Theory of Probability and Stochastic Processes, University Press.
3. Henry Stark and John W. Woods, Probability and Random Processes with Application to Signal Processing, PE, 3rd Edition.
4. S.P. Eugene Xavier, Statistical Theory of Communication, 1997, New Age Publications, 1997.

Other Suggested Readings:

1. https://nptel.ac.in/courses/111102111

**EC1206** **3-0-0 (3)**

# Electromagnetic Fields and Waves

**Pre-Requisites:** **None**

**Course Outcomes:**

| | |
|---|---|
| **CO-1** | Solve Maxwell's equations using vector calculus in three standard coordinate systems |
| **CO-2** | Deduce EM wave propagation in free space and in dielectric medium |
| **CO-3** | Analyze electromagnetic wave propagation in guiding structures under various matching conditions |
| **CO-4** | Understand the power flow mechanism in guiding structures and in unbounded medium |

**Course Articulation Matrix:**

| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PO-11 | PO-12 | PSO-1 | PSO-2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO-1 | 3 | – | – | – | – | – | – | – | – | – | – | – | – | – |
| CO-2 | 2 | 2 | – | – | – | 2 | – | – | – | – | – | – | – | – |
| CO-3 | 2 | 2 | – | – | – | – | – | – | – | – | – | – | – | – |
| CO-4 | 3 | – | – | – | – | 2 | – | – | – | – | – | – | – | – |

**1 - Slightly;** **2 - Moderately;** **3 - Substantially**

## Syllabus:

**Static Electric and Magnetic Field Review**: Introduction to coordinate systems, Gauss's law, gradient, electric scalar potential, electric dipole, divergence of flux density, divergence theorem. Characteristics of dielectrics, boundary relations. Poisson's and Laplace Equations, Biot Savart law, Ampere's law, Comparison of divergence and curl, magnetic vector potential

**Maxwell's Equations**: Faraday's Law, Lenz Law. The equation of continuity for time-varying fields, Maxwell's equations in differential, integral, and phasor forms, Conditions at a boundary surface,

**Plane waves**: Wave equations, plane waves in dielectric media, Plane waves in conducting media, polarization, skin effect, reflection of plane waves: Reflection of normally and oblique plane waves from conductors and dielectrics, total reflection. Poynting theorem, power flow for a plane wave, and power loss in a plane conductor

**Guided Waves:** Waves between parallel planes, TE and TM waves, Characteristics of TE and TM waves, TEM waves, Velocities of propagation, Attenuation in parallel plane guides, Wave impedance, Electric field, and current flow within the conductor.

**Wave Guides**: Rectangular wave guides, TE and TM modes in wave guides, Velocity, wavelength, impedance, and attenuation in rectangular waveguides.

**Learning Resources:**

Text Books:

1. E. C. Jordan and K. G. Balmain, Electromagnetic waves and Radiating Systems, Prentice Hall, Inc., Englewood Cliffs, New Jersey, 2015, 2nd Edition.
2. John D.Kraus, Electromagnetics, McGraw Hill Book Co., 1998, 5th Edition.

Reference Books:

1. Nathan Ida, Engineering Electromagnetics –Springer (India) Pvt. Ltd., New Delhi, 2005,2ndEd.
2. William H. Hayt Jr. and John A. Buck, Engineering Electromagnetics –McGrawHill,2017, 8th Ed.
3. Matthew N.O. Sadiku and S.V. Kulkarni, Principles of Electromagnetics –Oxford University Press, Asian Edition, 2015, 6th Ed.

**EC1208** **3-0-0 (3)**

# Linear IC Applications

**Pre-Requisites:** **None**

**Course Outcomes:**

| | |
|---|---|
| **CO-1** | Design op-amp circuits to perform arithmetic operations |
| **CO-2** | Analyze and design linear and non-linear applications using op-amps. |
| **CO-3** | Analyze and design oscillators and filters using functional ICs. |
| **CO-4** | Choose appropriate A/D and D/A converters for signal processing applications. |

**Course Articulation Matrix:**

| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PO-11 | PO-12 | PSO-1 | PSO-2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO-1 | 2 | 3 | 2 | – | – | – | – | – | – | – | – | – | – | – |
| CO-2 | 2 | 3 | 2 | – | – | - | – | – | – | – | – | – | – | – |
| CO-3 | 1 | 2 | 2 | – | – | – | – | – | – | – | – | – | – | – |
| CO-4 | 1 | 2 | – | – | 2 | - | – | – | – | – | – | 2 | – | – |

**1 - Slightly;** **2 - Moderately;** **3 - Substantially**

## Syllabus:

**Introduction to Op Amp:** Introduction to op-amps, ideal Characteristics, Pin configuration of 741 op-amps. Bias, offsets and drift, bandwidth and slew rate. Offset and Frequency compensation. Inverting and non-inverting amplifiers and their analysis, Applications: inverting and non-inverting summers, difference amplifier, differentiator and integrator, solving differential equations.

**Op-Amp Applications**: Instrumentation amplifier, RC-phase shift oscillator, Wein 's bridge oscillator, Log and antilog amplifiers. Analog IC Multipliers and dividers, Comparators, Schmitt triggers, Square wave Generators, Triangular wave- generators. Active Filters, Low pass, High pass, Band pass and Band Reject filters, Butterworth, Chebyshev filters, Different first and second-order filter Topologies,

**Timer**: 555 Timer functional diagram, monostable and astable operation, applications.

**ADCs and DACs:** Weighted resistor DAC, R-2R DAC. IC DAC-08. counter type ADC, successive approximation ADC, Flash ADC, dual slope ADC, conversion times of typical IC ADC

**Other Linear ICs:** Voltage Regulators Voltage Regulator Series op amp regulator, Three terminal IC voltage regulator exercise problems. IC 723 general purpose regulator, Switching Regulator. Phase Locked Loop PLL- basic block diagram and operation, capture range and lock range; IC 565, VCO IC 566.

**Learning Resources:**

Text Books:


1. G B Clayton, Operational Amplifiers, Elsevier science, 2003, 5th Edition.
2. Sergio Franco, Design with Operational Amplifier and Analog Integrated Circuits, TMH, 2017, 4th Edition.
3. Roy Choudary D. and Shail B. Jain, Linear Integrated circuits, New Age International Publishers, 2017, 4th Edition.
4. Ramakant A. Gayakwad, Op-Amps and Linear Integrated Circuits, PHI, 2015, 4th Edition.

Reference Books:

1. R.F. Coughlin & Fredrick F. Driscoll, Operational Amplifiers & Linear Integrated Circuits, PHI, 2000, 6th Edition.
2. Denton J. Daibey, Operational Amplifiers & Linear Integrated Circuits: Theory & Applications, TMH.

**EC2202** **3-0-0 (3)**

# CMOS Analog IC Design

**Pre-Requisites:** **EC2203**

**Course Outcomes:**

| | |
|---|---|
| **CO-1** | Understand the biasing styles and limitations |
| **CO-2** | Design CMOS analog basic building blocks |
| **CO-3** | Evaluate different CMOS amplifier topologies and design for given specifications |
| **CO-4** | Comprehend the stability issues of the systems and design two stage amplifier |

**Course Articulation Matrix:**

| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PO-11 | PO-12 | PSO-1 | PSO-2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO-1 | 2 | 1 | 1 | 1 | _ | – | – | – | – | – | – | – | 2 | – |
| CO-2 | 3 | 3 | 3 | 3 | 3 | – | – | – | – | – | – | – | 2 | 2 |
| CO-3 | 3 | 3 | 2 | 3 | 2 | – | – | – | – | – | – | – | 2 | 2 |
| CO-4 | 2 | 3 | 2 | 3 | 3 | – | – | – | – | – | – | – | 2 | 3 |

**1 - Slightly;** **2 - Moderately;** **3 - Substantially**

## Syllabus:

**Analysis of MOSFET small signal model**: Effect of channel length modulation and back gate effect, evaluation of figure of merit for MOSFET under different biasing conditions.

**Sources and references**: Current sources and sinks, Basic current mirror, cascode current mirror, Wilson and Widlar current mirrors, voltage and current references.

**CMOS amplifiers:** Common source amplifier with different loads, CS stage with negative feedback, source follower, CG stage, Gain boosting techniques, Cascode topology.

**Differential amplifier**: Characterization of differential amplifier, concept of common mode rejection, small signal analysis of differential amplifier, differential amplifier with MOS loads.

**Operational amplifier:** Characteristics of ideal operational amplifier, constituents of op-amp, small signal analysis of 2 stage op-amp, stability challenges and solutions.

**Learning Resources:**

Text Books:

1. Behzad Razavi, Design of Analog CMOS Integrated Circuit, McGraw Hill Education, 2017, 2nd Edition
2. Pr Gray and Rg Meyer, Analysis and Design of Analog Integrated Circuits, Wiley, 2024, 6thEdition.
3. Mohammed Ismail and Terri Fiez, Analog VLSI: Signal and Information Processing, McGraw-Hill, 1994.

Reference Books:

1. Geiger, Allen and Stradder, VLSI Design Techniques for Analog and Digital Circuits, Tata McGraw-Hill Education, 2010.

Other Suggested Readings:

1. NPTEL Courses (https://nptel.ac.in/courses/117101105)

**EC2204** **3-0-0 (3)**

# CMOS Digital IC Design

**Pre-Requisites:** **EC2104**

**Course Outcomes:**

| | |
|---|---|
| **CO-1** | Design CMOS inverters with specified noise margin and propagation delay. |
| **CO-2** | Design an Inverter with different logic styles and analyze the performance |
| **CO-3** | Design building blocks of combinational and sequential circuits using CMOS logic |
| **CO-4** | Design Synchronous Systems meeting timing constraints. |
| **CO-5** | Study various architectures in the organization of volatile and non-volatile memories using 1-bit memory cells along with periphery circuits to improve access time and power consumption. |

**Course Articulation Matrix:**

| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PO-11 | PO-12 | PSO-1 | PSO-2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO-1 | 2 | 1 | 2 | 3 | 2 | - | – | – | – | – | – | – | – | – |
| CO-2 | 2 | 1 | 1 | 1 | 2 | 2 | – | – | – | – | – | – | – | – |
| CO-3 | 2 | 1 | 1 | 2 | 3 | 1 | – | – | – | – | – | – | – | – |
| CO-4 | 1 | 1 | 2 | 2 | 3 | 1 | – | – | – | – | – | – | – | – |
| CO-5 | 1 | 1 | 1 | 2 | 3 | - | – | – | – | – | – | – | – | – |

**1 - Slightly;** **2 - Moderately;** **3 - Substantially**

## Syllabus:

**MOS INVERTERS:** Introduction, Definitions and Properties, Static CMOS Inverter, Static and Dynamic Power Dissipation, CMOS inverter delay time definitions and calculations, FinFET.

**DESIGNING COMBINATIONAL & SEQUENTIAL LOGIC GATES in CMOS:** Static CMOS Design, Dynamic CMOS Design, Static Latches and Registers, Dynamic Latches and Registers, Alternative Register Styles, Nonbistable Sequential Circuits.

**TIMING ISSUES IN DIGITAL CIRCUITS:** Introduction, Synchronous Timing basics, Clock Skew and Jitter, methods to minimize timing issues.

**DESIGNING ARITHMETIC BUILDING BLOCKS:** Introduction, The Adder: Circuit and Logic Design, Multipliers: Shifters, Power Considerations in Datapath Structures.

**DESIGNING MEMORY:** Introduction, Semiconductor Memories - An Introduction, The Memory Core: RAM, ROM, Memory Peripheral Circuitry.

**Advanced Digital IC Design:** Block level design

**Learning Resources:**

Text Books:

1. Jan M Rabaey, Digital Integrated Circuits, Pearson Education, 2003, 2nd Edition.
2. John P Uymera, Introduction to VLSI Circuits and Systems, Wiley, 2002.

Reference Books:

1. Sung-Mo Kang, CMOS Digital Integrated Circuits, McGraw-Hill, 2003, 3rd Edition.

**EC2206** **0-1-2 (2)**

# CMOS Analog IC Design Lab

**Pre-Requisites:** **EC2202**

**Course Outcomes:**

| | |
|---|---|
| **CO-1** | Understand the significance of different biasing styles and apply for analog circuits |
| **CO-2** | Design basic building blocks for analog CMOS circuits |
| **CO-3** | Comprehend the stability issues of the systems and design OP-amp fully compensated against process, supply and temperature variations |
| **CO-4** | Identify suitable topologies of the constituent sub systems and corresponding circuits as per the specifications of the system. |
| **CO-5** | Design Analog integrated circuits with parasitic effects. |

**Course Articulation Matrix:**

| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PO-11 | PO-12 | PSO-1 | PSO-2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO-1 | 3 | 1 | 1 | 1 | 1 | – | – | – | 2 | 1 | – | – | – | – |
| CO-2 | 3 | 2 | 3 | 1 | 3 | – | – | – | 2 | 1 | – | – | – | – |
| CO-3 | 3 | 3 | 3 | 3 | 3 | – | – | – | 2 | 1 | – | – | 2 | – |
| CO-4 | 3 | 3 | 3 | 3 | 3 | – | – | – | 2 | 1 | – | – | 2 | – |
| CO-5 | 3 | 3 | 3 | 3 | 3 | – | – | – | 2 | 1 | – | – | 2 | – |

**1 - Slightly;** **2 - Moderately;** **3 - Substantially**

## Syllabus:

**All circuits till post layout**

Lambda calculation for PMOS & NMOS, Transconductance plots, Single transistor amplifier with different loads,

Current sinks: Basic current sink.

Current sources: Basic current source.

Current mirrors: Basic current mirror, Wilson current mirror

CMOS differential amplifier with current mirror load.

Two stage Operational amplifier.

**Learning Resources:**

Text Books:

1. Behzad Razavi, Design of Analog CMOS Integrated Circuit, McGraw Hill Education, 2017, 2nd Edition.
2. Pr Gray and Rg Meyer, Analysis and Design of Analog Integrated Circuits, Wiley, 2009, 5th Edition.
3. Mohammed Ismail and Terri Fiez, Analog VLSI: Signal and Information Processing, McGraw-Hill, 1994.

Reference Books:

1. Geiger, Allen and Stradder, VLSI Design Techniques for Analog and Digital Circuits, Tata McGraw-Hill Education, 2010.

**EC2208** **0-1-2 (2)**

# CMOS Digital IC Design Lab

**Pre-Requisites:** **EC2204**

**Course Outcomes:**

| | |
|---|---|
| **CO-1** | Design of combinational and sequential circuits using Verilog HDL/ VHDL |
| **CO-2** | Synthesize digital circuit targeting state of the art FPGA |
| **CO-3** | Design combinational and sequential circuits at circuit level using EDA tools |
| **CO-4** | Implement efficient techniques at circuit level for improving power and speed |

**Course Articulation Matrix:**

| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PO-11 | PO-12 | PSO-1 | PSO-2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO-1 | 3 | 3 | 3 | 1 | 3 | – | – | – | 2 | 2 | – | – | 1 | – |
| CO-2 | 3 | 3 | 3 | 2 | 3 | – | – | – | 2 | 2 | – | – | 1 | – |
| CO-3 | 3 | 3 | 3 | 1 | 3 | – | – | – | 2 | 2 | – | – | 1 | – |
| CO-4 | 3 | 3 | 3 | 3 | 3 | – | – | – | 2 | 2 | – | – | 3 | 2 |

**1 - Slightly;** **2 - Moderately;** **3 - Substantially**

## Syllabus:

**Cycle 1**

Design and Simulation of CMOS Inverter to study the static characteristics and transfer Characteristics by varying the design constraints using EDA Tools

Design and Simulation of logic gates using various logic styles and compare the performance

Design a Full Adder cell using CMOS, Pass transitor and transmission gate and simulate to compare the performance using EDA tools

**Cycle 2:**

Design, Develop HDL model, Simulate and Synthesize

32-bit Parallel adder using 8-bit adder module, 32-bit Shift register using 8-bit Shift register module

RTL to GDS-II: Design any System as a case Study

EDA Tools: Mentor Graphics Tools

**Learning Resources:**

Text Books:

1. Samir Palnitkar, Verilog HDL Pearson Education, 2003, 2nd Edition.
2. Douglas Perry, VHDL: Programming by Example, 2017.

# 5th Semester

**MS1262** **3-0-0 (3)**

# Business Essentials for Engineers

**Pre-Requisites:** **None**

## Course Outcomes:

| | |
|---|---|
| **CO-1** | Understand the basic concepts of management and its functions |
| **CO-2** | Apply the functions of management for taking effective decisions |
| **CO-3** | Analyze factors influencing management in competitive business environment |
| **CO-4** | Identify business opportunities and challenges |
| **CO-5** | Integrate functions of management for building a better organization |

## Course Articulation Matrix:

| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PO-11 | PO-12 | PSO-1 | PSO-2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO-1 | – | – | – | – | – | – | – | – | 3 | – | 3 | 3 | – | – |
| CO-2 | – | – | – | – | – | – | – | – | 2 | – | 3 | 3 | – | – |
| CO-3 | – | – | – | – | – | – | – | – | 1 | – | 3 | 3 | – | – |
| CO-4 | – | – | – | – | – | – | – | – | 1 | – | 2 | 2 | – | – |
| CO-5 | – | – | – | – | – | – | – | – | 1 | – | 1 | 2 | – | – |

**1 - Slightly;** **2 - Moderately;** **3 - Substantially**

## Syllabus:

**Introduction:** The evolution of management theory, Business functions and their roles, Organizations and types, Levels of management, Types of markets and pillars of management- planning, organizing, leading and controlling.

**People Management:** Catalysts for organizational performance – Motivation & Leadership, Organization culture & Change, Human resource functions in a dynamic business environment and evolving dynamics in Industrial Relations.

**Marketing Management:** Nature and scope of marketing, Company's orientation towards market place, Importance of marketing concept, Marketing environment, 4p's of marketing, market segmentation, target market selection and positioning.

**Financial Management:** Financial accounting, Financial statements and analysis for decisions, Financial planning, Capital, Working capital, Capital structure and Sources of corporate finance, Investment decisions.

**Project Management:** Project screening and Selection, Techniques, Structuring concepts and Tools (WBS, OBS, and LRC, RACE). Project life cycle analysis. Appraisal of a project, Project Planning: Techniques, CPM, PERT- GAN - Time Cost Trade-off and Crashing Procedure, Project Monitoring: Monitoring Techniques and time control System, EVA Analysis

**Quality & Strategy:** Quality, Principles, Quality Awards, Standards of Quality culture, Quality metrics programs, Strategy, Vision and Mission, Porter's 5–forces, McKinsey's 7S Model, BCG Matrix, Competitive advantage - Value chain analysis & Resource based view.

**Learning Resources:**

**Text Books:**

1. Ronald J. Ebert, Ricky W. Griffin, Business Essentials, Pearson, 2019, 12th Edition
2. Harold Koontz, Heinz Weihrich, Mark V. Cannice, Essentials of Management, McGraw hill, 2020, 11th Edition

**Reference Books:**

1. G. Shainesh Philip Kotler, Kevin lane Keller, Alexander Chernev, Jagdish N. Sheth, Marketing Management, Pearson, 2022, 16th Edition
2. Dessler, G., & Varkkey, B, Human Resource Management, Pearson Education, 2024, 17th Edition
3. Prasanna Chandra, Financial Management: Theory & Practice, Mc Graw Hill, 2022, 11th Edition
4. Poornima M Charantimath, Total Quality Management, Pearson, 2022, 4th Edition
5. IM Pandey, Financial Management, Vikas Publications, 2021, 12th Edition
6. Jack R. Meredith, Mantel, Project Management - A Managerial Approach, John Wiley, 2021,11th Edition

**Other Suggested Readings:**

1. https://nptel.ac.in/courses/110106050
2. https://nptel.ac.in/courses/110105146
3. https://nptel.ac.in/courses/110105069
4. https://nptel.ac.in/courses/110104068
5. https://ocw.mit.edu/courses/15-535-business-analysis-using-financial-statements-spring-2003/
6. https://ocw.mit.edu/courses/15-810-marketing-management-fall-2010/

**EC1305** **3-0-0 (3)**

# Digital Signal Processing

**Pre-Requisites:** **EC1203**

## Course Outcomes:

| | |
|---|---|
| **CO-1** | Able to identify, formulate, and solve engineering problems in the area of signal processing. |
| **CO-2** | Able to implement FFT algorithms for computing the DFT |
| **CO-3** | Able to design and implementation of FIR and IIR filters. |
| **CO-4** | Able to apply down and up sampling techniques in designing of advanced digital signal processing systems. |

## Course Articulation Matrix:

| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PO-11 | PO-12 | PSO-1 | PSO-2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO-1 | 3 | 3 | 1 | 1 | – | – | – | – | – | – | – | – | 3 | 2 |
| CO-2 | 3 | 3 | 2 | 2 | – | – | – | – | – | – | – | – | 2 | 2 |
| CO-3 | 3 | 3 | 3 | 3 | – | – | – | – | – | – | – | 2 | 2 | 2 |
| CO-4 | 3 | 3 | 3 | 3 | – | – | – | – | – | – | – | 2 | 2 | – |

**1 - Slightly;** **2 - Moderately;** **3 - Substantially**

## Syllabus:

**Review of signals and Systems:**

**DISCRETE FOURIER TRANSFORM(DFT):** The DFT & its properties; Inverse DFT, Linear filtering methods based on DFT - Use of DFT in linear filtering, filtering of long data sequences, Efficient computation of DFT algorithms-Radix2 (DIT & DIF), Radix4, Split radix algorithms. Linear filtering approach to computation of DFT-Goertzel algorithm, Chirp z transform, Quantization effects in the computation of DFT - Direct & FFT method.

**DIGITALFILTERS:** Linear phase FIR filter, characteristic response, location of zeros, Design of FIR filter-Windowing, Frequency sampling, Design of IIR filters from Analog Filters-Impulse in variance, Bilinear transformation, Matched z-transform. Quantization of filter coefficients - Sensitivity to Quantization of filter coefficients, Quantization of coefficients in FIR filters, Roundoff effects in digital filters - Limit cycle, scaling to prevent overflow.

**DIGITAL FILTER STRUCTURES:** FIR filters - Direct form, Cascade form, Frequency sampling, Lattice IIR filter - Direct form I, Direct form II cascade form parallel form Lattice &Lattice loader

**MULTIRATE DIGITAL SIGNAL PROCESSING:** Decimation by a factor D, Interpolation by a factor I, Sampling rate conversion by a rational factor I/D, cascade equivalence, Filter design Implementation for sampling rate conversion, Applications: Phase-Shifters, Digital Filter-Banks, Sub band Coding of Speech Signals, Quadrature Mirror Filters, Trans multiplexers, Over Sampling A/D and D/A Conversion.

**DSP PROCESSORS:** TMS C6xxx, Features, Architecture and Applications. Harvard Architecture, pipelining, Multiplier-Accumulator (MAC) Hardware. Architectures of Fixed- and Floating-point DSP processors. Addressing modes, functional modes. Memory architecture, on-chip peripherals of a DSP processor

**Learning Resources:**

Text Books:

1. J.G. Proakis & D.G. Manolakis, Digital Signal Processing - Principles, algorithms & Applications, PHI, 2000. B. Venkataramani, M.Bhaskar, "Digital Signal Processors, Architecture, Programming and Application", Tata McGraw Hill, New Delhi,2003
2. A.V. Oppenheim and Ronald W. Schafer, Discrete Time Signal Processing, PHI,2000, 2nd Edition.
3. S.K. MITRA, Digital Signal Processing – A computer Based Approach, MGH, 2010, 4th Edition.

Reference Books:

1. Multi Rate Systems and Filter Banks – P.P.Vaidyanathan – Pearson Education.
2. Fundamentals of Digital Signal Processing using Matlab – Robert J. Schilling, Sandra L. Harris, Thomson, 2010, 2nd Edition.

**EC1307** **3-0-0 (3)**

# Microcontrollers

**Pre-Requisites:** **EC1205**

## Course Outcomes:

| | |
|---|---|
| **CO-1** | Understand the evolution of microprocessors and microcontrollers and its architectures |
| **CO-2** | Understand the evolution and architectures of ARM processors. |
| **CO-3** | Analyze and understand the instruction set and development tools of ARM |
| **CO-4** | Understand the architectural features of ARM cortex M4 microcontrollers. |
| **CO-5** | Understand the exception, interrupts and interrupt handling schemes |
| **CO-6** | Understand the hardware and interfacing peripheral devices to ARM cortex M4 |

## Course Articulation Matrix:

| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PO-11 | PO-12 | PSO-1 | PSO-2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO-1 | 2 | 3 | - | - | 2 | - | - | - | - | - | 2 | 1 | 1 | 1 |
| CO-2 | - | 3 | - | - | 2 | - | - | - | 1 | - | 2 | 1 | 1 | 1 |
| CO-3 | - | 3 | - | - | - | - | - | - | 1 | - | 2 | 1 | 2 | 2 |
| CO-4 | - | 2 | - | - | 3 | - | - | - | 1 | - | 2 | 1 | 1 | 1 |
| CO-5 | - | 2 | - | | 3 | - | - | - | 1 | - | - | - | 2 | 2 |
| CO-6 | 2 | 2 | 2 | | 3 | - | - | - | 2 | 2 | 2 | 2 | 2 | 2 |

**1 - Slightly;** **2 - Moderately;** **3 - Substantially**

## Syllabus:

**Introduction to Microprocessors and Microcontrollers:** Evolution and introduction of 80X86microprocessor, Architecture of 8086, Memory organization, 8086 system connections and timing. Overview of 8051 microcontroller, Architecture, Instruction set and addressing modes.

**Introduction to ARM Processors:** Introduction to ARM processors, Evolution of ARM processors, pipeline organization, ARM Processor cores and CPU cores. Introduction to ARM Cortex-M Processors, ARM Cortex-M4 processor ‘s architecture, Programmer ‘s model, Special registers, Operation Modes, Debug and Trace features.

**ARM Cortex-M4 programming:** Assembly basics, Instruction set, Data transfer, Data processing, conditional and branch instructions, barrier and saturation operations, Cortex-M4-specific instructions, Thumb2 instructions, Keil Microcontroller Development Kit for ARM, Typical program compilation flow, Sample arithmetic and logical assembly language programs

**ARM cortex-M4 Memory Systems and interrupts:** Overview of memory system features, Memory map, Memory access attributes and permissions, Data alignment and unaligned data access support, Bit-band operations, Overview of exceptions and interrupts, Exception types, Overview of interrupt management, Definitions of priority, Vector table and vector table relocation, Debug and reset sequence, Software interrupts, Exception Handling.

**TivaC Series ARM Cortex-M4 microcontroller and applications**: Detailed block diagram of TM4C123GH6PM controller, Features, Bus interfaces, On-chip memory organization, on-chip peripherals GPIOs, Timers, UART, I2C, SPI, PWM, ADC programming.

**Applications:** Flashing of LEDS, Interfacing stepper motor, Interfacing temperature sensor, Interfacing ADC, Interfacing Real Time Clock, Interfacing of Analog Key pad.

**Learning Resources:**

Text Books:

1. Joseph Yiu, The Definitive Guide to ARM Cortex-M3 and Cortex-M4 Processors, Newnes Publications; Third Edition, 2013.
2. Ata Elahi-Trever Arjeski, —ARM Assembly language with hardware experimentǁ, Springer Int. Publishing, 2015.
3. Steve Furber —ARM system on chip Architectureǁ, Pearson Publications, 2000, Second Edition.
4. D. V. Hall. Microprocessors and Interfacing, TMGH, 2017, Third Edition.
5. Wrox, — Professional Embedded ARM Developmentǁ

Reference Books:

1. William Hohl and Christoper Hinds, —ARM assembly language fundamentals and Techniques, 2015, Second Edition.
2. M.A. Mazidi, J.G. Mazidi, R.D. Mckinlay, —The 8051 Microcontroller and Embedded Systemsǁ, Pearson, 2007, Second Edition.

**EC2301** **3-0-0 (3)**

# Mixed Signal Circuits

**Pre-Requisites:** **EC2202, EC2204**

## Course Outcomes:

| | |
|---|---|
| **CO-1** | Understand the necessity of mixed signal systems |
| **CO-2** | Analyze Op-Amp to meet the mixed signal specifications. |
| **CO-3** | Design CMOS comparators to meet the high-speed requirements of digital circuitry. |
| **CO-4** | Develop efficient data converter circuits for mixed signal systems |

## Course Articulation Matrix:

| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PO-11 | PO-12 | PSO-1 | PSO-2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO-1 | 3 | – | 1 | – | – | – | – | – | – | – | – | – | – | – |
| CO-2 | 3 | 3 | 2 | 2 | 3 | – | – | – | – | – | – | – | – | – |
| CO-3 | 3 | 3 | 3 | 2 | 3 | – | – | – | – | – | – | – | 2 | 1 |
| CO-4 | 3 | 3 | 3 | 3 | 3 | – | – | – | – | – | – | – | 3 | 1 |

**1 - Slightly;** **2 - Moderately;** **3 - Substantially**

## Syllabus:

**Review:** Basic building blocks**,** Process and temperature independent compensation, Challenges in mixed signal circuit design.

**Switched Capacitor Circuits:**

Constituents: Op-Amp, Capacitors, Switches, Non-overlapping Clocks, Basic Operation and Analysis, Resistor Equivalence of a Switched Capacitor, Parasitic-Sensitive Integrator, Parasitic Insensitive Integrators, Signal-Flow-Graph Analysis.

**Performance of Sample-and-Hold Circuits:** Testing Sample and Holds, MOS Sample-and-Hold Basics, Examples of CMOS S/H Circuits, Input-Offset Voltage Errors, Charge-Injection Errors, Making Charge-Injection Signal Independent, Minimizing Errors Due to Charge-Injection

**Comparators**: Characterization of comparator, Design of Linear response comparators, slew-rate limited comparators, Latched Comparators, Latch-Mode Time Constant, Architecture of High-speed comparators.

**Data Converters**: Classification, Ideal D/A Converter, Ideal A/D Converter, Quantization Noise, Deterministic Approach, Stochastic Approach, Signed Codes, Performance Limitations, Resolution, Offset and Gain Error, Accuracy and Linearity Integrating Converters, Design of Successive-Approximation Converters, DAC-Based Successive Approximation, Charge-Redistribution A/D, Principles of Sigma-Delta ADC, Testing of data converters.

## Learning Resources:

Text Books:

1. David A Johns, Ken Martin: Analog IC design, Wiley 2008.
2. Behzard Razavi, “Design of Analog CMOS Integrated Circuits” McGraw Hill Education, 2017, 2nd Edition.

3. R. Jacob Baker “CMOS: Mixed-Signal Circuit Design” IEEE Press Series on Microelectronic Systems, 2008, 2nd Edition.

Reference Books:

1. R Gregorian and G C Temes: Analog MOS integrated circuits for signal processing, Wiley 1986.
2. Roubik Gregorian: Introduction to CMOS Op-amps and comparators, Wiley, 2008.
3. Rui Paulo da Silva Martins, Pui-In Mak, “Analog and Mixed-Signal Circuits in Nanoscale CMOS”, Springer publications, 2024.

Other Suggested Readings:

1. https://youtube.com/playlist?list=PLLDC70psjvq5vtrb0EdII4xIKA15ec-Ij&feature=shared

**EC2381** **1-0-0 (0.5)**

# Fractal Course - I

**Pre-Requisites:** **None**

## Course Outcomes:

| | |
|---|---|
| **CO-1** | Acquire an in-depth understanding of the specific topic covered in the course, which could range from a particular technology, method, or recent advancement in VLSI or Electronics and Communication Engineering. |
| **CO-2** | Develop hands-on skills relevant to the course topic, such as using specific tools, software, or techniques. |
| **CO-3** | Apply learned concepts to solve focused and practical engineering problems related to the course content |
| **CO-4** | Understand the interdisciplinary aspects and applications of the course to solve real-world industrial problems. |

## Course Articulation Matrix:

| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PO-11 | PO-12 | PSO-1 | PSO-2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO-1 | 3 | 3 | 3 | - | - | - | - | - | - | - | - | - | 1 | 2 |
| CO-2 | - | - | - | 2 | 2 | 3 | 3 | - | - | - | - | - | 3 | 3 |
| CO-3 | - | - | 3 | 2 | 2 | - | - | - | - | - | - | - | 3 | 3 |
| CO-4 | - | - | - | - | - | - | - | - | 1 | 3 | - | 2 | - | - |

**1 - Slightly;** **2 - Moderately;** **3 - Substantially**

## Syllabus:

This one-week course aims to bridge the gap between academic learning and industry application / latest research developments, providing students with a comprehensive understanding of the VLSI or Electronics and Communication engineering field and enhancing their readiness for professional careers.

a. **Structure:** Lectures delivered by an expert from the VLSI or Electronics and Communication Engineering Industry / R&D Organization / Academic Institution (SPARK Collaborators / Foreign Subject Experts in GIAN program / Adjunct Professors from Foreign Universities @ NITW).
b. **Content:** Topics covering current practices, case studies, technological advancements, and future trends.
c. **Interactive Sessions:** Q&A sessions, discussions, and case study analyses to foster interaction between students and the subject expert.
d. **Assessment:** the mode of assessment (Participation, a short reflective report / a presentation summarizing key takeaways from the lectures / Objective or descriptive type exam, etc.) will be decided by the subject expert

## Learning Resources:

1. Course material and any learning resources suggested by the experts

**EC1309** **0-1-2 (2)**

# Microcontrollers Lab

**Pre-Requisites:** **EC1307**

**Course Outcomes:**

| | |
|---|---|
| **CO-1** | Understand the hardware and interfacing of peripheral devices to ARM cortex M4 |
| **CO-2** | Write assembly language and C programs for arithmetic operations. |
| **CO-3** | Interface LED, ADC and DAC modules with microprocessor-based system |
| **CO-4** | Interface stepper motor, Keyboard and memory |
| **CO-5** | Interface wi-fi, IIC, SPI, and Bluetooth modules |

**Course Articulation Matrix:**

| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PO-11 | PO-12 | PSO-1 | PSO-2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO-1 | 2 | 3 | - | - | 2 | - | - | - | 2 | 2 | 2 | 1 | 1 | 1 |
| CO-2 | - | 3 | - | - | 2 | - | - | - | 2 | 2 | 2 | 1 | 1 | 1 |
| CO-3 | - | 3 | - | - | - | - | - | - | 2 | 2 | 2 | 1 | 2 | 2 |
| CO-4 | - | 2 | - | - | 3 | - | - | - | 2 | 2 | 2 | 1 | 1 | 1 |
| CO-5 | - | 2 | - | | 3 | - | - | - | 2 | 2 | - | - | 2 | 2 |

**1 - Slightly;** **2 - Moderately;** **3 - Substantially**

## Syllabus:

1. Write a simple program for arithmetic operations – addition,
2. subtraction, multiplication and division of 16 or 32 – bit numbers
3. Flashing of LEDS using Shift Register
4. Interfacing ADC
5. Interfacing DAC
6. Interfacing 7-Segment LED.
7. Interfacing of Analog Key pad.
8. Interrupt using on board push button
9. Interfacing real time clock.
10. Interfacing stepper motor.
11. Interfacing temperature sensor.
12. Interfacing Bluetooth module.
13. Interfacing Real Time Clock
14. Interfacing of micro SD Card.
15. Interfacing Wi-Fi Module
16. Interfacing of IIC and SPI module

**Learning Resources:**

Text Books:

1. Joseph Yiu, The Definitive Guide to ARM Cortex-M3 and Cortex-M4 Processors, Newnes Publications, 2013, Third Edition.

2. Ata Elahi-Trever Arjeski, ARM Assembly language with hardware experiment, Springer Int. Publishing, 2015.

Reference Books:

1. Steve Furber, ARM system on chip Architecture, Pearson Publications, 2000, Second Edition.
2. Douglas. V. Hall and SSSP Rao, Microprocessors and Interfacing, McGraw Hill Education, 2017.
3. James A. Langbridge, Professional Embedded ARM Development, Wrox publication, 2014

**EC2303** **0-1-2 (2)**

# Mixed Signal Circuits Lab

**Pre-Requisites:** **EC2301**

**Course Outcomes:**

| | |
|---|---|
| **CO-1** | Implement discrete time signal processing circuits |
| **CO-2** | Implement layout techniques specific to mixed signal IC design |
| **CO-3** | Design OP-amp for mixed signal environment |
| **CO-4** | Design a high-speed comparator with high resolving capability |
| **CO-5** | Design data converters and RF circuits for mixed signal environment. |

**Course Articulation Matrix:**

| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PO-11 | PO-12 | PSO-1 | PSO-2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO-1 | 1 | 1 | 3 | 1 | 1 | 2 | – | – | – | – | – | – | – | – |
| CO-2 | – | 1 | 3 | 1 | – | 3 | – | – | – | – | – | – | – | – |
| CO-3 | – | – | 2 | 1 | 1 | 1 | – | – | – | – | – | – | – | – |
| CO-4 | – | 1 | 2 | 1 | – | 1 | – | – | – | – | – | – | – | – |
| CO-5 | 1 | 1 | 3 | – | – | 2 | – | – | – | – | – | – | – | – |

**1 - Slightly;** **2 - Moderately;** **3 - Substantially**

## Syllabus:

**Cycle 1:**

1) Fully compensated op-amp with resistor compensation

2) comparator design a. linear Response b. Slew-rate limited

**Cycle 2:**

3) Switched capacitor circuits

i. Parasitic sensitive integrator

ii. Parasitic insensitive integrator

4) Data converters (ADC, DAC for given specifications)

5) Layouts of All the circuits Designed and Simulated

**Learning Resources:**

Text Books:

1.David A johns, Ken Martin, Analog Integrated Circuit Design, Wiley, 2008.
2. R. Gregorian and G.C Ternes, Analog MOS Integrated Circuits for Signal Processing, Wiley, 1986.

Reference Books:

1. Roubik Gregorian, Introduction to CMOS Op Amp and Comparators, Wiley, 1999.
2. Alan Hastlings, The art of Analog Layout, Wiley, 2005.

# 6th Semester

**EC2302** **3-0-0 (3)**

# Verification and Testing

**Pre-Requisites:** **EC2202**

**Course Outcomes:**

| | |
|---|---|
| **CO-1** | Apply scheduling and allocation algorithms for VLSI verification |
| **CO-2** | Develop logic optimization for sequential circuits |
| **CO-3** | Construct binary decision diagram and apply temporal logic |
| **CO-4** | Discuss about built in self-test and its application in modern digital design |
| **CO-5** | Use modern tools for testing and verification |

**Course Articulation Matrix:**

| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PO-11 | PO-12 | PSO-1 | PSO-2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO-1 | 1 | 2 | 2 | 2 | 1 | – | – | – | – | – | – | – | – | – |
| CO-2 | 1 | 3 | 1 | 2 | 2 | – | – | – | – | – | – | – | – | – |
| CO-3 | 2 | 2 | 1 | 2 | 2 | – | – | – | – | – | – | – | – | – |
| CO-4 | 1 | 1 | 1 | 1 | 2 | 2 | – | – | – | – | – | – | – | – |
| CO-5 | 1 | 1 | 1 | 2 | 2 | 2 | – | – | – | – | – | – | – | – |

**1 - Slightly;** **2 - Moderately;** **3 - Substantially**

## Syllabus:

**Introduction:** Introduction to Digital VLSI Design Flow, High Level Design Representation, Transformations for High Level Synthesis.

**Scheduling and Allocation:** Scheduling, Allocation and Binding Problem, Scheduling Algorithms, Binding and Allocation Algorithms, Allocation Techniques: Clique Partitioning, Left-Edge Algorithm, Iterative Refinement.

**Logic Optimization and Synthesis:** Two level Boolean Logic Synthesis, Heuristic Minimization of Two-Level, Finite State Machine Synthesis, Multilevel Implementation.

**Binary Decision Diagram:** Introduction and construction, Ordered Binary Decision Diagram, Operations on Ordered Binary Decision Diagram, Ordered Binary Decision Diagram for Sequential Circuits.

**Temporal Logic:** Introduction and Basic Operations on Temporal Logic, Syntax and Semantics of CLT, Equivalence between CTL Formulas

**Model Checking:** Verification Techniques, Model Checking Algorithm, Symbolic Model Checking

**Introduction to Digital Testing:** Introduction to Digital VLSI Testing, Functional and Fault Simulation and Testability Measures

**Fault Simulation:** Testability Measures (SCOAP)Structural Testing, Fault Equivalence.

**Combinational Circuit Test Pattern Generation:** Introduction to Automatic Test Pattern Generation (ATPG) and ATPG Algebras, D-Algorithm

**Sequential Circuit Testing and Scan Chains:** ATPG for Synchronous Sequential Circuits, Scan Chain based Sequential Circuit Testing

**Built in Self-test (BIST):** Built in Self-Test, Memory Testing

## Learning Resources:

Text Books:

1. M. L. Bushnell and V. D. Agrawal, “Essentials of Electronic Testing”, 3rd Kluwer Academic Publishers, 2002.
2. S. Palnitkar, Verilog HDL: A Guide to Digital Design and Synthesis, Prentice Hall, 2003, 2nd edition.
3. G. De Micheli. Synthesis and optimization of digital circuits, 1994, 1st edition.

Reference Books:

1. M. Huth and M. Ryan, Logic in Computer Science modeling and reasoning about systems, Cambridge University Press, 2004, 2nd Edition.
2. D. D. Gajski, N. D. Dutt, A.C.-H. Wu and S.Y.-L. Lin, High-Level Synthesis: Introduction to Chip and System Design, Springer, 1992, 1stEdition.

Other Suggested Readings:

1. NPTEL Courses (https://nptel.ac.in/courses/106103016).

**EC2304** **3-0-0 (3)**

# Analog and Digital Communications

**Pre-Requisites:** **EC1203**

**Course Outcomes:**

| | |
|---|---|
| **CO-1** | Introduce the principles of continuous wave modulation |
| **CO-2** | Evaluate the performance of modulation and demodulation techniques |
| **CO-3** | Construct the mathematical model for optimum receiver |
| **CO-4** | Study source coding and channel coding techniques |

**Course Articulation Matrix:**

| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PO-11 | PO-12 | PSO-1 | PSO-2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO-1 | 1 | 1 | - | - | 2 | - | 1 | - | – | – | – | – | – | – |
| CO-2 | 2 | 3 | - | - | 1 | 2 | 1 | - | – | – | – | – | – | – |
| CO-3 | 2 | 1 | - | - | 1 | - | 1 | - | – | – | – | – | – | – |
| CO-4 | 2 | 3 | - | - | - | 1 | - | - | – | – | – | – | – | – |

**1 - Slightly;** **2 - Moderately;** **3 - Substantially**

## Syllabus:

**Introduction:** Uncertainty, Information & Entropy, Source coding theorem, Huffman coding, Channel Capacity, Shannon Hartley law.

**Analog Communication:**
**Necessity of Modulation:** Amplitude Modulation (AM), Envelop Detection, Limitations of AM, DSB-SC, SSB, Frequency Division Multiplexing, Angle Modulation, Frequency Modulation, Narrowband FM, Generation of FM, Detection of FM, Noise in AM and FM, Pre-emphasis and Deemphasis.

**Pulse Modulation** —Pulse Amplitude Modulation, Pulse width Modulation, Pulse Position Modulation, Pulse code modulation, TDM, delta modulation., Line coding formats, Nyquist criterion for Zero ISI, Raised cosine filter.

**Digital Communication:** Model of Digital Communication Systems, Gram-Schmidt Orthogonalization, Geometric interpretation of signals, detection of known signals in noise, probability of error, matched filter receiver, correlation receiver

**Digital Modulation Techniques:** Coherent binary modulation techniques (BPSK, BFSK), Coherent quadrature modulation techniques (QPSK), Non-Coherent binary modulation techniques (DPSK), QAM, M-ary modulation techniques, bandwidth efficiency.

**Error control Coding:** Linear block Codes, syndrome decoding, Introduction to Cyclic and convolutional codes.

**Learning Resources:**

Text Books:

1. Simon Haykin, Communication Systems, Wiley India Pvt. Ltd., 2009, 5th Edition.
2. Simon Haykin, An Introduction to Analog and Digital Communications, Wiley India Pvt. Ltd, 2006, 2nd Edition.

Other Suggested Readings:

1.https://nptel.ac.in/courses/117/105/117105143/

2. https://nptel.ac.in/noc/courses/noc17/SEM2/noc17-ec11/

3. https://onlinecourses.nptel.ac.in/noc21_ee74/preview

**EC2306** **0-1-4 (3)**

# Product Development

**Pre-Requisites:** **EC2102**

**Course Outcomes:**

| | |
|---|---|
| **CO-1** | Express Product Design Ideas using 2D or 3D sketches |
| **CO-2** | Model the components with geometric (engineering) specifications and appropriate materials |
| **CO-3** | Develop a prototype of the product |
| **C**O-4 | Evaluate the entire product and the product based on testing with user |
| **C**O-5 | Explore the scope for protecting novelty of the product through patent |

**Course Articulation Matrix:**

| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PO-11 | PO-12 | PSO-1 | PSO-2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO-1 | - | - | 2 | 3 | 3 | 3 | 2 | 2 | 3 | 3 | 2 | 3 | - | - |
| CO-2 | - | - | 2 | 3 | 3 | 3 | 2 | 2 | 3 | 3 | 2 | 3 | - | - |
| CO-3 | - | - | 2 | 3 | 3 | 3 | 2 | 2 | 3 | 3 | 2 | 3 | - | - |
| CO-4 | - | - | 2 | 3 | 3 | 3 | 2 | 2 | 3 | 3 | 2 | 3 | - | - |
| CO-5 | - | - | 2 | 3 | 3 | 3 | 2 | 2 | 3 | 3 | 2 | 3 | - | - |

**1 - Slightly;** **2 - Moderately;** **3 - Substantially**

## Syllabus:

**Design Thinking process for Product Development:** Review of five step design thinking process of Empathize- Define- Ideate- Prototype- Test.

**Project Selection:** Identification of the problem through empathy, formulate and ideate to solve the problem.

**Product Development:**

**Sketching**: 2D and 3D sketching: Students will sketch the concept on drawing sheets/ digital screens. The drawings will contain the specifications of the geometric form.

**3D Modelling**: Develop the 3D model features including free form surfaces, final product design specifications, parametric design.

**Physical Component Development**: Development of components: fabrication of actual components of the product using the materials and tools available in the lab, Iterations.

**Iterative improvement of the product and Report writing**: Development of assemblies/mock-up models/ working models/ prototypes/functional models/products, Testing and design review, Report writing.

**IPR**: Different forms of innovations emanating from the human mind and their protection using different tools of IPR, Basic introduction to Patents, Trademarks, Copyright, Industrial Designs Registrations, Geographical Indications Trade Secrets. Filing of IPR, implications, Ethics and societal implications of Intellectual Property Rights.

**Learning Resources:**

Textbooks:

1. The design studio method: creative problem solving with UX sketching, Sullivan, Brian, Focal Press, 2016.
2. Autodesk Fusion 360 Black Book, Verma G., CADACAMCAE Works, 2021, 2nd edition.
3. Class Junghans and Adam Levy, “Intellectual Property Management: A guide for Scientists, Engineers, Financers and Managers”, Willey (2006)

Other Suggested Reading:

1. Self-Paced Tutorials: https://help.autodesk.com/view/fusion360/ENU/courses/
2. Product Documentation https://help.autodesk.com/view/fusion360/ENU/?guid=GUID1C665B4D-7BF7-4FDF-98B0-AA7EE12B5AC2

**EC2382** **1-0-0 (0.5)**

# Fractal Course - II

## Pre-Requisites: None

## Course Outcomes:

| | |
|---|---|
| **CO-1** | Acquire an in-depth understanding of the specific topic covered in the course, which could range from a particular technology, method, or recent advancement in VLSI or Electronics and Communication Engineering. |
| **CO-2** | Develop hands-on skills relevant to the course topic, such as using specific tools, software, or techniques. |
| **CO-3** | Apply learned concepts to solve focused and practical engineering problems related to the course content |
| **CO-4** | Understand the interdisciplinary aspects and applications of the course to solve real-world industrial problems. |

## Course Articulation Matrix:

| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PO-11 | PO-12 | PSO-1 | PSO-2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO-1 | 3 | 3 | 3 | - | - | - | - | - | - | - | - | - | 1 | 2 |
| CO-2 | - | - | - | 2 | 2 | 3 | 3 | - | - | - | - | - | 3 | 3 |
| CO-3 | - | - | 3 | 2 | 2 | - | - | - | - | - | - | - | 3 | 3 |
| CO-4 | - | - | - | - | - | - | - | - | 1 | 3 | - | 2 | - | - |

**1 - Slightly; 2 - Moderately; 3 - Substantially**

## Syllabus:

This one-week course aims to bridge the gap between academic learning and industry application / latest research developments, providing students with a comprehensive understanding of the VLSI or Electronics and Communication engineering field and enhancing their readiness for professional careers.

a. **Structure:** Lectures delivered by an expert from the VLSI or Electronics and Communication Engineering Industry / R&D Organization / Academic Institution (SPARK Collaborators / Foreign Subject Experts in GIAN program / Adjunct Professors from Foreign Universities @ NITW).
b. **Content:** Topics covering current practices, case studies, technological advancements, and future trends.
c. **Interactive Sessions:** Q&A sessions, discussions, and case study analyses to foster interaction between students and the subject expert.
d. **Assessment:** the mode of assessment (Participation, a short reflective report / a presentation summarizing key takeaways from the lectures / Objective or descriptive type exam, etc.) will be decided by the subject expert

### Learning Resources:

1. Course material and any learning resources suggested by the experts

**EC1310** **0-1-2 (2)**

# Analog and Digital Communications Lab

**Pre-Requisites:** **EC2304**

**Course Outcomes:**

| | |
|---|---|
| **CO-1** | Generate AM and FM signals and evaluate their performance |
| **CO-2** | Perform signal sampling by determining the sampling rates for baseband |
| **CO-3** | signals and reconstruct the signals |
| **CO-4** | Generate digital modulation signals for ASK, PSK and FSK and perform their |

**Course Articulation Matrix:**

| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PO-11 | PO-12 | PSO-1 | PSO-2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO-1 | 2 | - | - | - | 3 | 3 | - | - | - | - | - | - | 2 | 2 |
| CO-2 | 3 | - | - | - | 3 | - | - | - | - | - | - | - | 2 | 2 |
| CO-3 | 1 | - | - | - | 3 | 1 | - | - | - | - | - | - | 2 | 2 |
| CO-4 | 2 | - | - | - | 3 | 2 | - | - | 1 | - | - | - | 2 | 2 |

**1 - Slightly;** **2 - Moderately;** **3 - Substantially**

## Syllabus:

1. DSBSC and AM Transmitter & the corresponding Receiver
2. FM Transmitter & Receiver
3. Analog signal sampling & Reconstruction
4. Frequency Division Multiplexing and Demultiplexing
5. Time Division Multiplexing and Demultiplexing
6. Generation & Detection of PAM/PWM/PPM
7. Generation & Detection of PCM
8. Generation & Detection of DM/SIGMA DELTA/ADM
9. Baseband digital data transmission
10. Generation & Detection of BPSK/DPSK/DEPSK
11. Simulation of digital modulation schemes

**Learning Resources:**

Text Books:

1. Simon Haykin, Communication Systems, Wiley India Pvt. Ltd., 2009, 5th Edition.
2. Simon Haykin, An Introduction to Analog and Digital Communications, Wiley India Pvt. Ltd, 2006, 2nd Edition.

**EC2308** **0-1-2 (2)**

# Verification and Testing Lab

**Pre-Requisites:** **EC2302**

**Course Outcomes:**

| | |
|---|---|
| **CO-1** | Develop packet, class, driver, mail box and score board for DUT |
| **CO-2** | Analyze line, code and functional coverage |
| **CO-3** | Examine the assertions for DUT |
| **CO-4** | Construct binary decision diagram and apply temporal logic |
| **CO-5** | Apply built in self-test in modern digital design |

**Course Articulation Matrix:**

| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PO-11 | PO-12 | PSO-1 | PSO-2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO-1 | 1 | 2 | 2 | 2 | 1 | – | – | – | – | – | – | – | – | – |
| CO-2 | 1 | 3 | 1 | 2 | 2 | – | – | – | – | – | – | – | – | – |
| CO-3 | 2 | 2 | 1 | 2 | 2 | – | – | – | – | – | – | – | – | – |
| CO-4 | 1 | 1 | 1 | 1 | 2 | 2 | – | – | – | – | – | – | – | – |
| CO-5 | 1 | 1 | 1 | 2 | 2 | 2 | – | – | – | – | – | – | – | – |

**1 - Slightly;** **2 - Moderately;** **3 - Substantially**

## Syllabus:

1. Introduction to test bench architecture.
2. Development of an exhaustive test bench for the 1-bit full adder.
3. Development of exhaustive test bench for 16X1 Multiplexer using file reading writing features.
4. Development of layered testbench components for functional verification of an 8-bit full adder.
5. Development of layered testbench components for functional verification of 8-bit ALU.
6. Development of layered testbench components for functional verification of synchronous FIFO.
7. Development of layered testbench components for functional verification of Round Robin Arbiter.
8. Design for Test and Automatic Test pattern Generation for a 4-bit counter.
9. Design for Test and Automatic Test pattern Generation for a 4-bit counter.
10. Perform the logic equivalence (formal verification).

**Learning Resources:**

Text Books:

1. M. L. Bushnell and V. D. Agrawal, “Essentials of Electronic Testing” ,3rd Kluwer Academic Publishers, 2002.
2. S. Palnitkar, Verilog HDL: A Guide to Digital Design and Synthesis, Prentice Hall, 2003, 2nd edition.
3. G. De Micheli. Synthesis and optimization of digital circuits, 1994, 1st edition.

Reference Books:

1. M. Huth and M. Ryan, Logic in Computer Science modeling and reasoning about systems, Cambridge University Press, 2004, 2nd Edition.

2. D. D. Gajski, N. D. Dutt, A.C.-H. Wu and S.Y.-L. Lin, High-Level Synthesis: Introduction to Chip and System Design, Springer, 1992, 1st edition.

Other Suggested Readings:

1. NPTEL Courses (https://nptel.ac.in/courses/106103016).

# 7th Semester

**EC2401** **3-0-0 (3)**

# Semiconductor Materials Synthesis and characterization

**Pre-Requisites:** **None**

**Course Outcomes:**

| | |
|---|---|
| **CO-1** | Develop bulk and thin films using synthesis techniques |
| **CO-2** | Interpret electron and X-ray diffraction data |
| **CO-3** | Select an imaging mode of SEM/TEM for a specific analysis |
| **CO-4** | Select a Thermal analysis technique for material analysis |

**Course Articulation Matrix:**

| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PO-11 | PO-12 | PSO-1 | PSO-2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO-1 | 2 | 3 | 3 | 2 | 3 | 2 | 2 | 2 | 1 | 2 | 1 | 1 | 2 | 2 |
| CO-2 | 2 | 2 | – | 1 | 3 | 1 | – | – | 1 | 1 | 1 | 1 | 1 | – |
| CO-3 | 3 | 2 | – | 2 | 3 | 1 | – | – | 1 | 1 | – | 1 | 1 | – |
| CO-4 | 3 | 2 | – | 2 | 3 | 1 | – | – | 1 | 1 | – | 1 | 1 | – |

**1 - Slightly;** **2 - Moderately;** **3 - Substantially**

## Syllabus:

**Processing techniques**: bulk crystal growth, thin films, Combustion Synthesis, Spray Pyrolysis, Electrospinning, Hydrothermal
**Fundamentals of Crystallography**: Lattice Geometry, The Weiss Zone Law, Symmetry Elements, Translational Symmetry, Rotational Symmetry, Reflection Symmetry, Restrictions on Symmetry Elements, Possible Combinations of Rotational Symmetries, Crystal Systems, Space Lattices (Bravais Lattices).

**X-ray Diffraction:** Reciprocal Lattice, Stereographic projection, Basics of X-rays, X-ray diffraction and methods, X-ray techniques: X-ray diffraction- Generation and characteristics of x-ray, Lattice planes and Bragg's law, Theory of diffraction, determination of particle size and micro/macro strains, reciprocal lattice, electron diffraction, energy loss spectroscopy, SAXS, XRF, in-situ methods in XRD.

**Optical Microscopy:** (working principle and data interpretation), Introduction to Electron microscopy (SEM, TEM, EDX, WDS, EPMA) – Working principle and electron matter interaction.
**Characterization:** Working principle and analysis for Mechanical Characterization (Hardness, tensile test), Thermal analysis (e.g., DTA, DSC, TGA, DMA).

**Synthesis of Nanomaterials:** CVD, Nucleation and Growth, ALD, Epitaxy, MBE. Compound semiconductor hetero-structure growth and characterization: Quantum wells and Thickness measurement techniques: Contact - step height, Optical - reflectance and ellipsometry. AFM. Characterization techniques for nanomaterials: FTIR, XRD, AFM, SEM, TEM, EDAX etc. Applications and interpretation of results. Emerging nano materials: Nanotubes, nanorods and other nano structures, LB technique, soft lithography etc. Microwave-assisted synthesis, Self-assembly etc.

**Learning Resources:**

Text Books:

1. Annelise Kopp Alves, Carlos P. Bergmann, Felipe Amorim Berutti, “Novel Synthesis and Characterization of Nanostructured Materials”, Springer Berlin, 2013.
2. Anthony Kelly and Kevin M. Knowles, Crystallography and Crystal Defects.
3. B. D. Cullity and S. R. stock, Elements of X-ray Diffraction;
4. Goldstein et al, Solar-Grade Scanning electron microscopy and x-ray microanalysis.
5. D.B. Williams and C.B. Carter, Transmission Electron Microscopy - A Textbook for Materials Science.

Reference Books:

1. Douglas B. Murphy, Fundamentals of light microscopy and electronic imaging’, Wiley-Liss, Inc. USA, 2001.
2. Editors C. Richard Brundle, Charles A. Evans, Jr., Shaun Wilson, Butterworth-Heinemann, Encyclopedia of Materials Characterization, Surfaces, Interfaces, Thin Films,’ Boston, US.
3. B.D. Cullity and S.R. Stock, Elements of X-ray diffraction’ Prentice Hall, Inc. USA, 2001,
4. Transmission electron microscopy” D.B. Williams and C. Barry Carter, 4 volumes, Springer, The USA,1996.

**EC2403** **0-0-2 (1)**

# Semiconductor Device Characterization Lab

**Pre-Requisites:** **EC2201**

## Course Outcomes:

| | |
|---|---|
| **CO-1** | Understand the material and electrical parameters of intrinsic and extrinsic semiconductor materials. |
| **CO-2** | Understand the basic characteristics of MOS transistor. |
| **CO-3** | Apply MOS understanding to use advance design TCAD tool to describe the basic characteristics of BJT and MOS transistors. |
| **CO-4** | To use advance design TCAD tool to analyze the characteristics of the inverter. |

## Course Articulation Matrix:

| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PO-11 | PO-12 | PSO-1 | PSO-2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO-1 | 2 | 2 | – | 1 | 3 | 1 | – | – | 1 | 1 | 1 | 1 | 1 | – |
| CO-2 | 2 | 2 | – | 1 | 3 | 1 | – | – | 1 | 1 | 1 | 1 | 1 | – |
| CO-3 | 3 | 2 | – | 2 | 3 | 1 | – | – | 1 | 1 | – | 1 | 1 | – |
| CO-4 | 2 | 3 | 3 | 2 | 3 | 2 | 2 | 2 | 1 | 2 | 1 | 1 | 2 | 2 |

**1 - Slightly;** **2 - Moderately;** **3 - Substantially**

## Syllabus:

1. Overview of Sentarus TCAD software
2. GUI of 2-D PN junction Diode, BJT
3. GUI of 2-D NMOS and PMOS
4. PN DIODE characterization using Sdevice
5. NMOS and PMOS Characterization using Sdevice
6. CMOS Characterization
7. NMOS and PMOS with multigate

## Learning Resources:

Text Books:

1. Anthony Kelly and Kevin M. Knowles Crystallography and Crystal Defects.
2. B. D. Cullity and S. R. stock, Elements of X-ray Diffraction.
3. Solar-Grade Scanning electron microscopy and x-ray microanalysis; Goldstein et al.
4. D.B. Williams and C.B. Carter, Transmission Electron Microscopy - A Textbook for Materials Science.

Reference Books:

1. Douglas B. Murphy, Fundamentals of light microscopy and electronic imaging' Wiley-Liss, Inc. USA, 2001.
2. Editors C. Richard Brundle, Charles A. Evans, Jr., Shaun Wilson, Butterworth-Heinemann, Encyclopedia of Materials Characterization, Surfaces, Interfaces, Thin Films,' Boston, US.
3. B.D. Cullity and S.R. Stock, Elements of X-ray diffraction', Prentice Hall, Inc. USA, 2001.
4. D.B. Williams and C. Barry Carter, Transmission electron microscopy", 4 volumes, Springer, 1996. The USA.

**EC2405** **0-0-2 (1)**

# Low Power IC Design Lab

**Pre-Requisites:** **None**

**Course Outcomes:**

| | |
|---|---|
| **CO-1** | Low power design techniques at different levels of a System design flow |
| **CO-2** | Design a 32-bit pipelined MIPS processor with a specific instruction set depending the application employing low power techniques at architectural level |
| **CO-3** | Implement the 32-bit pipelined MIPS processor using standard cell based semicustom design methodology. |
| **CO-4** | Analyze the performance of a system and employ various techniques to meet the required power and tine budget. |

**Course Articulation Matrix:**

| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PO-11 | PO-12 | PSO-1 | PSO-2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO-1 | 2 | 1 | - | 1 | 2 | 1 | – | – | – | – | – | – | – | – |
| CO-2 | 2 | 1 | - | 2 | 1 | 1 | – | – | – | – | – | – | – | – |
| CO-3 | 2 | - | 2 | 1 | 1 | - | – | – | – | – | – | – | – | – |
| CO-4 | 2 | - | - | 2 | 3 | 2 | – | – | – | – | – | – | – | – |

**1 - Slightly;** **2 - Moderately;** **3 - Substantially**

## Syllabus:

Implement a high speed and low power 32-bit adder using 8-bit adder module.

Implement a 32-bit MIPS processor by employing low power techniques in the design of Datapath and control units

Perform the functional simulation, Static Timing Analysis and post synthesis timing verification and RTL to GDS-II

EDA Tools: Synopsis Tools

**Learning Resources:**

Text Books:

1. Kiat Seng Yeo and Kaushik Roy, Low- Voltage, Low-Power VLSI Subsystems, Tata Mc Graw Hill Edition, 2009.
2. Soudris D, Piguet C and Goutis C, Designing CMOS Circuits for Low Power, Kluwer Academic Publishers, 2002

Reference Books:

1. Jan Rabaey, Low Power Design Essentials, Springer.
2. Samir Palnitkar, Verilog HDL, Pearson Education, 2003, 2nd Edition.

**EC2489** **0-0-0 (2)**

# Seminar and Technical Writing

**Pre-Requisites:** **None**

**Course Outcomes:**

| | |
|---|---|
| **CO-1** | Consolidate ideas based on expert talks attended |
| **CO-2** | Prepare a well-organized report employing elements of critical thinking and technical writing |
| **CO-3** | Demonstrate the ability to describe, interpret and analyze the subject matter and develop competence in presenting |

**Course Articulation Matrix:**

| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PO-11 | PO-12 | PSO-1 | PSO-2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO-1 | 2 | | 2 | | | 3 | 3 | | 2 | 3 | | 3 | | |
| CO-2 | 2 | | 2 | | | 3 | 3 | | 2 | 3 | | 3 | | |
| CO-3 | 2 | | 2 | | | 3 | 3 | | 2 | 3 | | 3 | | |

**1 - Slightly; 2 - Moderately; 3 - Substantially**

**Description:**

In Seminar and Technical Writing, every student is expected to prepare a well-organized report based on one / all of the following:

- by attending at least 5 expert lectures/ invited talks/ Seminar/ Popular lectures etc. organized by the institute/any of the departments, ideally in a specific domain or with the same theme.
- prepare a business or marketing plan based on patent search

The student is expected to consolidate the ideas from these lectures/patent searches and may even include material from other sources to strengthen the content of the report. The student should prepare a well-organized report based on the above and present it to the panel constituted by the department, for evaluation.

**Evaluation Criteria:**

The student will be evaluated by the panel based on the below criteria.

| Criteria | Description | Weightages |
|---|---|---|
| I | Clarity on the topic | |
| II | List of lectures attended | |
| III | Report | |
| IV | Presentation | |
| V | Response to questions | |

## Evaluation Criteria-CO Mapping

| CO / Criteria | CO1 | CO2 | CO3 |
|---|---|---|---|
| I | X | | |
| II | X | | |
| III | | X | |
| IV | | | X |
| V | | | X |

**EC2495** **0-0-0 (2)**

# Minor Project

**Pre-Requisites:** **None**

**Course Outcomes:**

| | |
|---|---|
| **CO-1** | Apply engineering principles to real-world projects |
| **CO-2** | Plan and monitor project tasks individually or as a team |
| **CO-3** | Demonstrate practical experience in project execution |
| **CO-4** | Communicate project findings clearly through reports and presentations |

**Course Articulation Matrix:**

| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PO-11 | PO-12 | PSO-1 | PSO-2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO-1 | 3 | 3 | 3 | 3 | 3 | | | | 2 | 1 | | 3 | | |
| CO-2 | 2 | 2 | 2 | 2 | 2 | | | | 3 | 2 | 3 | 3 | | |
| CO-3 | 2 | 2 | 2 | 2 | 2 | | | | 3 | 2 | 3 | 3 | | |
| CO-4 | 1 | 1 | 1 | 1 | 1 | | | | 3 | 3 | | | | |

**1 - Slightly;** **2 - Moderately;** **3 - Substantially**

**Description:**

Students are expected to choose real world or relevant problems and apply the engineering principles learned, to solve the problem through building prototypes or simulations or writing codes or establishing processes/synthesis/correlations etc. The department constituted panel can decide the suitability and worthiness of the project

**Evaluation Criteria:**

The student will be evaluated by the panel based on the below criteria. Weightage for each criterion will be determined by the panel and will be informed to the students.

| Criteria | Description | Weightages |
|---|---|---|
| I | Identification of Problem Domain | |
| II | Study of Existing Systems and establishing clear objectives | |
| III | Planning of project and work distribution within the team | |
| IV | Proper Documentation and Technical Writing | |
| V | Presentation and Response to questions | |

## Evaluation Criteria-CO Mapping

| CO / Criteria | CO1 | CO2 | CO3 | CO4 |
|---|---|---|---|---|
| I | X | | | |
| II | X | | | |
| III | | X | X | |
| IV | | | | X |
| V | | | | X |

**EC2491** **0-0-0 (2)**

# Short-Term Industrial /EPICS/Research Experience

**Pre-Requisites:** **None**

**Course Outcomes:**

| | |
|---|---|
| **CO-1** | Apply engineering principles to real-world problems, gaining practical experience |
| **CO-2** | Plan, manage and execute the work with ethical consideration |
| **CO-3** | Review the social and environmental impact of the work |
| **CO-4** | Communicate the learnings through report and presentation |

**Course Articulation Matrix:**

| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PO-11 | PO-12 | PSO-1 | PSO-2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO-1 | 3 | 3 | 3 | 3 | 3 | | | | | | | 3 | | |
| CO-2 | 2 | 2 | 2 | 2 | 2 | | | 3 | 3 | | 3 | 3 | | |
| CO-3 | | | | | | 3 | 3 | | | | | 3 | | |
| CO-4 | | | | | | | | | | 3 | | 3 | | |

**1 - Slightly;** **2 - Moderately;** **3 - Substantially**

**Description:**

Every student has to undergo either a Summer Internship / EPICS / Research project. The summer internship may be undergone in an Industry/Research organization or any premier academic Institution, including NIT Warangal for 6-8 weeks. The EPICS/research project shall be registered under the guidance of any faculty member in the institute. The student is required to submit a report and present the work before an evaluation committee, nominated by the Head of the Department.

**Evaluation Criteria:**

The student will be evaluated by the panel based on the below criteria. Weightage for each criterion will be determined by the panel and will be informed to the students.

| Criteria | Description | Weightages |
|---|---|---|
| I | Relevance of the area of work | |
| II | Performance of the Task | |
| III | Crucial learnings from the work | |
| IV | Report Preparation | |
| V | Presentation and Response to questions | |

**Evaluation Criteria-CO Mapping**

| CO / Criteria | CO1 | CO2 | CO3 | CO4 |
|---|---|---|---|---|
| I | X | | | |
| II | | X | | |
| III | | | X | |
| IV | | | | X |
| V | | | | X |

# 8th Semester

**EC2498** **0-0-0 (6)**

# Major Project

**Pre-Requisites:** **None**

**Course Outcomes:**

| | |
|---|---|
| **CO-1** | Identify a domain specific and contemporary topic |
| **CO-2** | Review literature to identify gaps and define objectives & scope of the work. |
| **CO-3** | Develop a prototype/model, experimental set-up or software systems to meet the objectives |
| **CO-4** | Analyze the results to draw valid conclusions |

**Course Articulation Matrix:**

| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PO-11 | PO-12 | PSO-1 | PSO-2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO-1 | 3 | 2 | | | 2 | 1 | | 1 | 3 | 1 | 1 | 2 | | |
| CO-2 | 2 | 2 | | | 1 | 2 | 1 | 1 | 2 | 2 | | 3 | | |
| CO-3 | 2 | 2 | 3 | 3 | 3 | 2 | 2 | 2 | 2 | 1 | 3 | 2 | | |
| CO-4 | 2 | 2 | | 3 | 3 | | | | 2 | 2 | | 3 | | |

**1 - Slightly;** **2 - Moderately;** **3 - Substantially**

**Description:**

Students are expected to choose real-world contemporary problem and apply the engineering principles learned, to solve the problem through building prototypes or simulations or writing codes or establishing processes/synthesis/correlations etc. The department constituted panel will decide the suitability and worthiness of the project

The students are required to submit a report showing that plagiarism is within 30%. The B.Tech. Project work will be evaluated for 100 marks, with the following weightages**:**

| **Component** | **Weightage** |
|---|---|
| Periodic evaluation by Guide | 40 marks |
| Mid-term review | 20 marks |
| End Semester viva-voce examination | 40 marks |
| **Total** | 100 marks |

**Evaluation Criteria:**

The student will be evaluated by the panel based on the below criteria. Weightage for each criterion will be determined by the panel and will be informed to the students**.**

| **Criteria** | **Description** | **Weightages** |
|---|---|---|
| I | Selection of topic | |
| II | Literature Survey | |
| III | Objectives and Solution Methodology | |
| IV | Performance of the Task and clarity on the work | |
| V | Report Preparation | |
| VI | Presentation and Response to questions | |

**Evaluation Criteria-CO Mapping**

| CO / Criteria | CO1 | CO2 | CO3 | CO4 |
|---|---|---|---|---|
| I | X | | | |
| II | | X | | |
| III | | X | | |
| IV | | | X | |
| V | | | | X |
| VI | | | | X |

Refer to B.Tech. – Regulations for any further information regarding Mid-term review, End Sem evaluation, Template for report preparation and plagiarism.

# Professional Electives

# Professional Elective - I

**EC2321** **3-0-0 (3)**

# Fundamentals of Device Modelling

**Pre-Requisites:** **EC2104**

**Course Outcomes:**

| | |
|---|---|
| **CO-1** | Explain the equations, approximations and techniques available for deriving a model |
| **CO-2** | List mathematical functions representing various non-linear shapes. |
| **CO-3** | Understand the physics of a new device and conversion of this understanding into equations |
| **CO-4** | Simulate characteristics of a simple device using MATLAB, SPICE or other tools. |

**Course Articulation Matrix:**

| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PO-11 | PO-12 | PSO-1 | PSO-2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO-1 | 3 | 2 | 1 | 2 | 2 | 1 | – | – | 2 | 1 | – | 1 | 2 | – |
| CO-2 | 3 | 2 | 1 | 2 | 2 | – | – | – | 2 | 1 | – | 1 | 2 | – |
| CO-3 | 3 | 2 | 2 | 3 | 2 | – | – | – | 2 | 2 | – | 2 | 3 | – |
| CO-4 | 3 | 2 | 2 | 2 | 3 | 1 | 1 | 1 | 3 | 2 | 1 | 2 | 3 | 2 |

**1 - Slightly;** **2 - Moderately;** **3 - Substantially**

## Syllabus:

**Introduction**: Semi-classical Bulk Transport: Qualitative Model, EM field and Transport Equations

**Drift-Diffusion Transport Model**: Equations, Boundary Conditions, Mobility and Generation / Recombination, Characteristic times and lengths, Energy band diagrams.

**Device Model**: Types of Device Models, Steps of Deriving a device model, P-N junction, MOSFET Model: Structure and Characteristics. DC model of a large uniformly doped bulk MOSFET: Qualitative Theory, Equations, Boundary Conditions and Approximations, Surface Potential based and Threshold based solutions for drain current, Testing, Improvement and Parameter Extraction.

**Other Effects:** Series resistance, non-uniform doping and small geometry effects.

**Introduction to CAD** based software and Modeling of MOSFET and few novel devices.

**Learning Resources:**

Text Books:

1. C. Snowden, “Semiconductor Device Modeling”, World Scientific, 2011.
2. Y. Tsividis and C. McAndrew, “MOSFET modeling for Circuit Simulation”, Oxford University Press, 2011.

Reference Books:

1. Narain Arora, “MOSFET Models for VLSI Circuit Simulation: Theory and Practice”, Springer Vienna, 1st Edition, 2012.
2. Research papers on modeling.

Other Suggested Readings:

1. NPTEL Course (https://archive.nptel.ac.in/courses/117/106/117106033/)

**EC2323** **3-0-0 (3)**

# VLSI Interconnects

**Pre-Requisites:** **EE1163**

**Course Outcomes:**

| | |
|---|---|
| **CO-1** | Get an insight on transmission line parameters of VLSI interconnects |
| **CO-2** | Understand the novel solutions on future VLSI Interconnects |
| **CO-3** | Analyze the effect of crosstalk and parasitic in VLSI interconnects |
| **CO-4** | Analyze the performance of various VLSI interconnects |

**Course Articulation Matrix:**

| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PO-11 | PO-12 | PSO-1 | PSO-2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO-1 | 2 | 1 | – | 1 | 3 | – | – | – | – | – | – | – | – | – |
| CO-2 | 3 | 1 | 3 | – | – | – | – | – | – | – | – | – | 1 | – |
| CO-3 | 3 | 3 | 2 | 3 | 3 | – | – | – | – | – | – | – | – | – |
| CO-4 | 3 | 3 | 3 | 2 | 3 | – | – | – | – | – | – | – | 2 | – |

**1 - Slightly;** **2 - Moderately;** **3 - Substantially**

## Syllabus:

**Introduction to VLSI Interconnect:**. Distributed RC interconnect model, Elmore delay, Elmore delay in interconnects, Elmore delay in RC tree and branched interconnects.

Equivalent circuit of RC interconnect, Scaling Effects, Delay mitigation in RC interconnects, RC interconnect simulation session, Inductive effects in interconnects.

**Distributed RLC Interconnect model** (Frequency domain analysis), Transmission line equations. When to consider the inductive effects? The transfer function of an interconnect, Time-domain response of a lumped model RLC circuit.

**Equivalent Elmore model** for RLC interconnects (Distributed model), Two-pole model of RLC interconnects from ABCD parameters. Simulation of RLC interconnects. Origin of the skin effect, Effective resistance at high frequencies.

Equivalent circuit to simulate skin effect, Power dissipation due to interconnects, Optimum interconnect width for minimizing total power dissipation. Heating effects and thermal modelling,

Compact Thermal modeling with equivalent electrical circuit.

Electromigration in interconnects, Mitigation of electromigration. Capacitive coupling in interconnects. Cross-talk and timing jitters in two identical interconnects. Effects of cross-talk and timing jitters. Techniques for mitigation of cross-talk, Analysis of coupled interconnects, Simulation of RC coupled interconnects, Extraction of capacitance, Extraction of inductance, Estimation of interconnect parameters from S parameters, Future VLSI Interconnects.

**Learning Resources:**

Text Books:

1. Ashok K. Goel, High-SpeedVLSIInterconnects,2007.
2. Y.S.Diamand, Advanced Nanoscale ULSI Interconnects: Fundamentals and Applications,2009.

Reference Books:

1. H.S Philip Wong and Deji Akinwande, Carbon nanotube and Graphene Device Physics,2011.
2. Related research papers.

Other Suggested Readings:

1. NPTEL Courses (https://nptel.ac.in/courses/108105187)

**EC2325** **3-0-0 (3)**

# Flexible Electronics

**Pre-Requisites:** **None**

**Course Outcomes:**

| | |
|---|---|
| **CO-1** | Identify the advantages, drawbacks, performances, complementarity, and uniqueness of large-area manufacturing versus silicon technology. |
| **CO-2** | Integrate the operation principles, architectures, and processing of main devices and systems fabricated for flexible electronics. |
| **CO-3** | Predict system integration issues and propose methods for integration and encapsulation of printed devices and systems. |
| **CO-4** | Learn about structure and properties of materials for flexible electronics |

**Course Articulation Matrix:**

| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PO-11 | PO-12 | PSO-1 | PSO-2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO-1 | 2 | - | – | – | – | – | – | – | – | – | – | – | – | – |
| CO-2 | 2 | 2 | 2 | 2 | 3 | – | – | – | – | – | – | – | 1 | – |
| CO-3 | 3 | 2 | 2 | 3 | 3 | – | – | – | – | – | – | – | 1 | – |
| CO-4 | 2 | – | – | – | – | – | – | – | – | – | – | – | – | – |

**1 - Slightly;** **2 - Moderately;** **3 - Substantially**

## Syllabus:

**Introduction to Flexible and Printed Electronics:** Evolution of Flexible Electronics, review of cutting-edge research on electronics that can be flexible, plastic, stretchable, conformable or printed. Electronic materials, components, and systems, applications for IoT.

**Materials, Processing, and Manufacturing:** Various semiconductors, dielectric, and conducting materials, Organic semiconductors, from chemical bonds to bands, Charge injection and transport, Examples of printable functional materials, Thin-film Deposition and Processing Methods for Flexible Devices, Solution-based Patterning Processes; Ink-jet printing, gravure, and other processes, surface energy effects, multilayer patterning.

**Flexible Thin-Film Transistors and Circuits:** Thin-Film Transistor; Device structure and performance, Electrical characteristics, parameter extraction, characterization methods for rigid and flexible devices, electrical stability, printed transistors; organic/polymer, metal-oxide, electrolyte gated, Case studies; sub micrometer OTFTs and gravure printed OTFTs, From transistors to circuits. **Circuits on flexible and non-silicon substrates, Contacts, and Interfaces to Organic and Inorganic Electronic Devices:** Schottky contacts, defects, carrier recombination, the effect of applied mechanical strain.

**Other Flexible Devices and System Integration:** Organic Light Emitting Diodes, Organic Solar Cells, thin flexible OLED displays, OLED lighting, smart wallpaper, sensors, logic, and memory, RFID tags, Latest applications of printed electronics, Encapsulation, roll to roll printing processes, Integration Issues, and Designs for the Future.

**Learning Resources:**

Text Books:

1. G. Nisto, D. Lupo, S. Ganz, Organic and Printed Electronics Fundamental and Applications, CRC press, 2016.
2. M. M. Hussain and N. El-Atab, Handbook of Flexible and Suitable Electronics, CRC press, 2020.
3. Sarbicsoloman, 3D Bioprinting Revolution, Khanna Publishing House, 2020.

Reference Books:

1. Mario Caironi and Yong Yuong Nob, Large Area and Flexible Electronics, Wiley VCH, 2015.
2. Wong, Williams S, and Alberto Salleo, “Flexible Electronics: materials and applications”, vol 11, Springer, 2009.

**EC2327** **3-0-0 (3)**

# Principles of Data Networks

**Pre-Requisites:** **EC1204**

## Course Outcomes:

| | |
|---|---|
| **CO-1** | Identify and explain the fundamental concepts of network architecture, protocols and internetworking principles. |
| **CO-2** | Design a data communication link considering fundamental concepts of stop & wait, go-back-n and selective repeat link layer concepts and framing. |
| **CO-3** | Design and build Local Area Networks considering the shared medium choices for high-speed LANs or Wireless LANs. |
| **CO-4** | Understand the concepts of Wide Area Networks, such as switching, routing, congestion, and network management. |
| **CO-5** | Understand the concepts of media access control, IP addressing, packet forwarding, and process-to-process communication. |
| **CO-6** | Design networks with good quality-of-service and security. |

## Course Articulation Matrix:

| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PO-11 | PO-12 | PSO-1 | PSO-2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO-1 | 3 | 3 | – | – | – | – | – | – | – | – | – | – | 2 | – |
| CO-2 | 2 | 3 | 3 | 2 | 1 | – | – | – | – | – | – | – | 2 | 2 |
| CO-3 | 3 | 3 | 3 | – | 3 | – | – | – | – | – | – | – | 2 | 2 |
| CO-4 | 1 | 2 | – | 2 | – | – | – | – | – | – | – | – | 2 | – |
| CO-5 | 1 | 2 | 2 | 3 | 3 | 3 | – | – | – | – | – | 3 | 3 | 3 |
| CO-6 | 3 | 2 | 3 | 3 | 3 | 3 | 3 | – | – | – | – | 3 | 3 | 3 |

**1 - Slightly;** **2 - Moderately;** **3 - Substantially**

## Syllabus:

**Introduction:**

Basics of Data Communications for networking; Packet switching, Store-&-Forward operation; Layered network architecture.

**Data Link layer**

Framing; error control, error detection, Internet Checksum and Cyclic Redundancy Codes for error detection; Flow control, ARQ strategies and their performance analysis using different distributions; HDLC protocol. Media Access Control (MAC): MAC for wired and wireless Local Area Networks (LAN), Pure and Slotted ALOHA, CSMA, IEEE802.3; ETHERNET, Fast ETHERNET, Gigabit ETHERNET; IEEE 802.11 WiFi MAC protocol.

**Network Layer:**

Routing algorithms, Link State and Distance Vector routing; Internet routing, RIP, OSPF, BGP; IPv4 protocol, packet format, addressing, subnetting, CIDR, ARP, RARP, fragmentation and reassembly; DHCP, NAT; IPv6summary.

**Transport Layer:**

UDP, segment structure and operation; TCP, segment structure and operation. Reliable stream service, congestion control and connection management.

**Network Security:**

Security Requirements and Attacks, Confidentiality with Conventional Encryption, Message Authentication and Hash Functions, Public-Key Encryption and Digital Signatures, Secure Socket Layer, IP Security.

**Selected Application layer Protocols:**

Web and HTTP, electronic mail (SMTP), file transfer protocol (FTP), Domain Name Service (DNS).

**Learning Resources:**

Text Books:

1. D. Bertsekas and R. Gallagar, Data Networks, PHI,1992, 2/e.
2. J.F. Kurose and K. W. Ross: Computer Networking, A Top-Down Approach, Pearson/Addison Wesley,2016, 7/e.
3. BEHROUZ A. FOROUZAN, Data Communications and Networking, Tata McGraw-Hill, New Delhi,2006, 4th Edition.

Reference Books:

1. DOUGLAS E COMER, Computer Networks and Internet, Pearson Education Asia,2000.
2. Leon-Garcia and I. Widjaja: Communication Networks; McGraw Hill,2017, 2/e.
3. S. Tanenbaum, Computer Networks, PHI,2013, 5/e.
4. W. Stallings, Data and Computer Communication, Prentice-Hall,2017, 10/e.

# Professional Elective - II

**EC1322** **3-0-0 (3)**

# Introduction to Artificial Intelligence and Machine Learning

**Pre-Requisites:** **None**

**Course Outcomes:**

| | |
|---|---|
| **CO-1** | Understand the key concepts of Artificial intelligence |
| **CO-2** | Design and implement machine learning solutions to classification, regression, and clustering problems |
| **CO-3** | Understand and implement the Artificial Neural Networks |
| **CO-4** | Evaluate and interpret the results of the algorithms |
| **CO-5** | Analyze working of convolutional neural networks |

**Course Articulation Matrix:**

| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PO-11 | PO-12 | PSO-1 | PSO-2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO-1 | 3 | – | – | – | – | – | – | – | 2 | – | 3 | 2 | – | – |
| CO-2 | 3 | 2 | – | 2 | 3 | – | – | – | 2 | – | 3 | 2 | 2 | – |
| CO-3 | 3 | 1 | – | – | – | – | – | – | 2 | – | 3 | 2 | – | – |
| CO-4 | 3 | 3 | 2 | 3 | 3 | – | – | – | 2 | – | 3 | 2 | 2 | – |
| CO-5 | 3 | 3 | 2 | 3 | 3 | – | – | – | 2 | – | 3 | 2 | 2 | – |

**1 - Slightly;** **2 - Moderately;** **3 - Substantially**

## Syllabus:

**Introduction to AI:** Introduction, history, intelligent systems, foundations of AI, applications, development of AI languages, current trends.

**Supervised Machine Learning:** Basics of linear regression, its assumptions, limitations and industry applications. Least square based and Gradient Descent Based Regression, Multiple linear regression, Polynomial regression, Logistic regression

**Artificial Neural Networks:** Biological neurons and artificial neurons. Model of an ANN. Activation functions used in ANNs. Typical classes of network architectures. Mathematical Foundations and Learning mechanisms, Feed forward ANN: Structures of Multi-layer feedforward networks. Back propagation algorithm. Back propagation – training and convergence. Functional approximation with back propagation.

**Unsupervised Machine Learning:** Different clustering methods (Distance, Density, Hierarchical) , Iterative distance-based clustering; K-Means Clustering Algorithm and Image Quantization, basics of Principal Component Analysis

**Introduction to Deep learning:** Analyze the key computations underlying deep learning, Convolutional Neural Network, Building blocks of CNN- Convolutional layers, pooling layers dense layers.

**Learning Resources:**

Text Books:

1. Christopher Bishop, Pattern Recognition and Machine Learning, Springer, 2010.
2. Gareth James, Daniela Witten, Trevor Hastie, Robert Tibshiran, Introduction to Statistical Learning, Springer, 2017.

Reference Books:

1. Ian Goodfelllow, Yoshua Benjio, Aaron Courville, Deep Learning, The MIT Press,2016.
2. Richard O. Duda, Peter E. Hart, David G. Stork, Pattern Classification, John Wiley & Sons Inc. 2003, Second Edition.

**EC1324** **3-0-0 (3)**

# Embedded and Real Time Operating Systems

**Pre-Requisites:** **EC1205**

## Course Outcomes:

| | |
|---|---|
| **CO-1** | Identify the applications, Design metrics and challenges of Embedded system |
| **CO-2** | Design, implement and test an embedded system. |
| **CO-3** | Write the programs for embedded system. |
| **CO-4** | Describe the various components and operating systems used in real-time Embedded systems. |
| **CO-5** | Identify Fundamental Issues, Computation models in Hardware-software co- design, and Hardware Software Trade-offs. |

## Course Articulation Matrix:

| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PO-11 | PO-12 | PSO-1 | PSO-2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO-1 | - | 2 | - | - | - | - | - | - | - | - | _ | 1 | 2 | 2 |
| CO-2 | 2 | 3 | 2 | 2 | - | - | - | - | - | - | _ | 1 | 2 | 2 |
| CO-3 | 2 | 3 | - | 2 | - | - | - | - | - | - | _ | 1 | 2 | 2 |
| CO-4 | - | 2 | - | 2 | - | - | - | - | - | - | _ | 1 | 2 | - |
| CO-5 | - | 2 | 2 | - | - | - | - | - | - | - | _ | 1 | 2 | 2 |

**1 - Slightly;** **2 - Moderately;** **3 - Substantially**

## Syllabus:

**Introduction to Embedded Systems:** Embedded systems Overview, Embedded Systems Vs General Computing Systems, History of Embedded Systems, Classification, Major Application Areas, Purpose of Embedded Systems, Characteristics of embedded computing applications, Design Challenges, Common Design Metrics

**Embedded System Development:** Core of the Embedded System: General Purpose and Domain Specific Processors, ASICs, PLDs, Commercial Off the Shelf Components (COTS). Memory: ROM, RAM, Memory according to the type of Interface, Memory Shadowing, Memory selection for Embedded Systems, Sensors and Actuators, Reset Circuit, Brown-out Protection Circuit, Oscillator Unit, Real Time Clock, Watchdog Timer Communication Interface: Onboard and External Communication Interfaces

**Embedded system Program:** Embedded Firmware, ARM processor Architecture, pipeline, registers, instructions, thumb mode, exceptions Embedded Firmware Design Approaches and Development Languages.

**Real-Time Operating Systems:** Architecture of the kernel, Tasks and Task Scheduler, Scheduling algorithms, Interrupt Service Routines, Semaphores, Mutex, Mailboxes, Message queues, Event Registers, Pipes, Signals, Timers, Memory management, Priority Inversion problem. Overview of off-the shelf operating systems-MicroC/OS II, Vxworks, RT Linux.

**Overview of Hardware – Software co design**

Fundamental Issues in Hardware-Software co-design, Computation models in Embedded system design, Introduction to Unified Modeling Language (UML), Hardware Software Trade-offs

**Learning Resources:**

Text Books:

1. Introduction to Embedded Systems -Shibu K.V, McGrawHill
2. Embedded Systems Design –Santanu Chattopadhyay, PHI, 2nd Edition, 2013
3. Embedded System Design -Frank Vahid, Tony Givargis, JohnWiley.

Reference Books:

1. Embedded/Real-Time Systems: Concepts Design and Programming, K.V.K.K. Prasad Dreamtech,2005.
2. An Embedded Software Primer -David E. Simon, Pearson Education.

**EC2322** **3-0-0 (3)**

# Low Power VLSI

**Pre-Requisites:** **EC2204**

**Course Outcomes:**

| | |
|---|---|
| **CO-1** | Analyze different types of power consumption in a given CMOS VLSI Circuit. |
| **CO-2** | Study different sources of leakage power in a DSM VLSI Circuit. |
| **CO-3** | Choose the types of SRAMs/ DRAMs for the given Low power applications. |
| **CO-4** | Design low power arithmetic circuits and systems. |

**Course Articulation Matrix:**

| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PO-11 | PO-12 | PSO-1 | PSO-2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO-1 | 1 | 1 | 1 | 1 | 1 | 1 | – | – | – | – | – | – | – | – |
| CO-2 | 1 | 1 | 1 | 1 | 2 | 1 | – | – | – | – | – | – | – | – |
| CO-3 | 1 | 2 | 2 | 2 | 3 | 2 | – | – | – | – | – | – | – | – |
| CO-4 | 2 | 2 | 2 | 3 | 2 | 3 | – | – | – | – | – | – | – | – |

**1 - Slightly;** **2 - Moderately;** **3 - Substantially**

## Syllabus:

**Low Power CMOS VLSI design**: Sources of Power Dissipation in MOS devices and their reduction techniques, Static, dynamic and short circuit power dissipation.

**Circuit Techniques for Low Power Design**: Design for Low Power, transistor stacking, Multiple Vth techniques, Dynamic Vth techniques Standard Adder Cells, review of low power adders architectures and performance comparison. Review of low power multiplier architectures and their performance comparison. Sources of power dissipation in SRAMs, Low power SRAM circuit techniques, Sources of power dissipation in DRAMs, Low power DRAM circuit techniques

**Architectural Techniques for Low Power**: Parameters effecting power dissipation, Variable frequency, Dynamic voltage Scaling, Dynamic Voltage and Frequency Scaling, Reduced VDD.

**Low Power Implementation Techniques**: Library Selection, Clock Gating, Timing Impact due to Clock gating.

**Learning Resources:**

Text Books:

1. Kiat Seng Yeo and Kaushik Roy, Low- Voltage, Low-Power VLSI Subsystems, McGraw Hill, 2009.
2. Soudris D, Piguet C and Goutis C, Designing CMOS Circuits for Low Power, Kluwer Academic Publishers, 2002.

Reference Books:

1. Jan Rabaey, Low Power Design Essentials, Springer

**EC2324** **3-0-0 (3)**

# Devices for Microwave Engineering

**Pre-Requisites:** **EC2104**

**Course Outcomes:**

| | |
|---|---|
| **CO-1** | Understand the requirements of RF devices for IC designing. |
| **CO-2** | Apply the principles of heterojunctions physics for RF technology. |
| **CO-3** | Develop a solid understanding of Bipolar RF devices, S-parameters, smith charts, and the principles of impedance matching and RF device packaging. |
| **CO-4** | Acquire technical expertise in the operation, characteristics and applications of Gun diodes and IMPATT devices. |

**Course Articulation Matrix:**

| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PO-11 | PO-12 | PSO-1 | PSO-2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO-1 | 2 | 1 | 1 | – | – | – | – | – | 1 | 1 | – | 2 | 1 | 1 |
| CO-2 | 2 | 3 | 1 | 2 | – | – | – | – | 1 | 1 | – | 2 | 2 | 1 |
| CO-3 | 3 | 3 | 3 | 3 | _ | – | – | – | 1 | 1 | – | 2 | 3 | 1 |
| CO-4 | 2 | 2 | 1 | 2 | 3 | – | – | – | 1 | 1 | – | 2 | 2 | 1 |

**1 - Slightly;** **2 - Moderately;** **3 - Substantially**

## Syllabus:

**Introduction to the course:** perspective & historical overview, Applications of various RF devices today

Basics of heterojunctions and heterostructure physics, Basics of III-nitrides and polarization Schottky multipliers & varactors

**Transferred Electron Devices:** Gunn Diode, Avalanche Transit Devices: IMPATT

III-V MESFET: physics and transport, I-V, load line, transconductance, fabrication. Intro to JFOM.

III-V HEMT/MODFET – physics, modulation doping & the formation of 2DEG, breakdown, gain, traps, dispersion. p-HEMT, recess gate, field-plate, power cell, multi-finger devices, fabrication.

GaN HEMTs – benefits of WBG, various aspects of GaN RF HEMT such as substrate, processing, dispersion & virtual gate, leakage, stack design, compensation doping.

Basics of RF CMOS; LDMOS – device physics, transport, breakdown, On resistance, snapback.

LDMOS - layout & design, bond pad manifold, frequency aspects, the concept of RESURF.

Bipolar devices for RF: working of HBT, Early Effect, Kirk Effect, Gain, Common Emitter & Common Base mode, small-signal model.

**Bipolar devices:** base design, collector design, emitter ballast, SiGe bipolar, FET vs bipolar for RF, fabrication

Microwave concepts for devices and packaging: S-parameters & 2-port analysis, concept of impedance, Intro to Smith chart, de-embedding parasitics, derivation of cut-off frequencies and MAG/MSG,

Transmission lines & waveguides, concept of impedance matching, Basics of RF device packaging and thermal management.

**Learning Resources:**

Text Books:

1. Umesh Mishra &Jasprit Singh, Semiconductor Device Physics and Design, Springer, 2014.
2. John Walker, Handbook of RF and Microwave Power Amplifiers, Cambridge University Press, 2011.

Reference Books:

1. Tobias Eribacher, Lateral Power Transistors in Integrated Circuits, Springer, 2014.
2. S. M. Sze and Kwok k. Ng, Physics of Semiconductor Devices, Wiley, 2015.

Other Suggested Readings:

1. NPTEL videos (https://nptel.ac.in/courses/108108377)

# Professional Elective - III

**EC1328** **3-0-0 (3)**

# Internet of Things

**Pre-Requisites:** **None**

**Course Outcomes:**

| | |
|---|---|
| **CO-1** | Understand IOT design requirements |
| **CO-2** | Compare various technologies and protocols |
| **CO-3** | Study storage and intelligent analytics |
| **CO-4** | Application of IOT in smart cities |
| **CO-5** | Design and experiment various use cases |

**Course Articulation Matrix:**

| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PO-11 | PO-12 | PSO-1 | PSO-2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO-1 | 3 | - | - | - | - | - | - | - | - | - | - | - | 2 | 2 |
| CO-2 | - | 3 | - | - | - | - | - | - | - | - | - | - | 2 | 2 |
| CO-3 | 2 | - | - | - | - | - | - | 3 | - | - | - | - | 2 | 2 |
| CO-4 | - | 2 | - | - | - | - | - | 3 | - | - | - | - | 2 | 2 |
| CO-5 | - | - | 1 | - | - | - | 3 | - | - | - | - | - | 2 | 2 |

**1 - Slightly;** **2 - Moderately;** **3 - Substantially**

## Syllabus:

**Introduction to IOT:** IoT and the connected world, Architecture of IoT, Security issues, Opportunities for IoT.

**The Web of Things:** Linked data, Enterprise data, Importance of security, privacy, and authenticity, Industry standards, Web of Things layer as the driver for IoT systems

**Lessons from the Internet:** Relevance of Internet to network of Things, network management, security, mobility and longevity.

**Technologies:** Wireless protocols, Connectivity options.

**Data storage and analysis:** Managing high rate sensor data, Processing data streams, Data consistency in an intermittently connected or disconnected environment, Identifying outliers and anomalies.

**Use cases:** Smart Buildings, Smart health, Home automation, Location tracking

**Smart Cities:** Collection of information including opportunistic sensing, crowd sensing, and ad-hoc sensing Response of the system including analytics and optimization, distributed action, people as intelligent actuators, the risk for cyber-attacks in centralized and distributed systems

Text Books:

1. Adrian McEwen, Hakim Cassimally, Designing the Internet of Things, Wiley, 2013.
2. Naveen Balani, Enterprise IoT, Create Space Independent Publishing Platform, 2016.

**EC2326** **3-0-0 (3)**

# Introduction to FPGA Design

**Pre-Requisites:** **EC1205**

**Course Outcomes:**

| | |
|---|---|
| **CO-1** | Understand FPGA design flow. |
| **CO-2** | Identify the building blocks of commercially available FPGA/CPLDs. |
| **CO-3** | Develop VHDL/Verilog models and synthesize targeting for & series FPGA Devices. |
| **CO-4** | Design an SoC targeting Zynq 7000 series device. |

**Course Articulation Matrix:**

| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PO-11 | PO-12 | PSO-1 | PSO-2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO-1 | 3 | – | – | – | 1 | – | – | – | – | – | – | – | – | – |
| CO-2 | 2 | – | 1 | – | 2 | – | – | – | – | – | – | – | – | – |
| CO-3 | 2 | 2 | 2 | 1 | 3 | – | – | – | – | – | – | – | 2 | – |
| CO-4 | 3 | 2 | 3 | 3 | 3 | – | – | – | – | – | – | – | 2 | – |

**1 - Slightly;** **2 - Moderately;** **3 - Substantially**

## Syllabus:

**INTRODUCTION TO FPGAs:** Evolution of programmable devices, FPGA Design flow, Applications of FPGA, Review of building blocks of Xilinx FPGA devices XC3000, XC4000: LUT, dedicated carry logic, I/O Block and Programmable Interconnect.

**Xilinx FPGAs:** Programming Technologies, features of commercially available Xilinx FPGAs: Xilinx 7 Series devices, Xilinx Ultra scale devices.

**Xilinx Zynq 7000 series devices:** Features and different technologies employed in developing these Architectures Building blocks of 7 Series FPGAs: different resources for mapping the functionality modelled using HDL Configurable Logic blocks, Block RAM, DSP blocks, Input-output blocks, High speed transceivers, Routing structures, Clock resources.

**Building blocks of Ultra scale FPGAs**: Configurable Logic blocks, Input-output blocks, Ultra Scale architecture configuration.

**Building blocks of Xilinx Zynq 7000 series devices:** Application Processor Unit (APU), cache, External Memory Interfaces, I/O Peripherals and Interfaces, Interconnect, Configurable Logic blocks, Programmable I/O Blocks, JTAG Boundary-Scan, Serial Transceivers, PCI Express® Block, Two 12-Bit Analog-to-Digital Converters.

**DEISGN EXAMPLES USING Xilinx FPGA:** 32-bitAdder architectures, multiplier Architectures,32-bit MIPS processor with a few DSP and Multimedia Instructions

**Learning Resources:**

Text Books:

1. John V. Old Field, Richrad C. Dorf, Field Programmable Gate Arrays, Wiley, 2008.

2. Stephen D. Brown, Robert J. Francis, Jonathan Rose, Zvonko G. Vranesic, Field Programmable Gate Arrays, Springer, 1992, 2nd Edition.

Reference Books:

1. DatasheetsofArtix-7, Kintex-7, Virtex-7

**EC2328** **3-0-0 (3)**

# Antennas

**Pre-Requisites:** **None**

**Course Outcomes:**

| | |
|---|---|
| **CO-1** | Provide an understanding of antenna radiating principle and discuss the fundamental characteristics and parameters of antennas. |
| **CO-2** | Develop the performance characteristics of antennas arrays, its operating principles, methods and concepts to design. |
| **CO-3** | Simulation and Measurement of antenna parameters. |
| **CO-4** | Understand the behavior of nature on EM wave propagation. |

**Course Articulation Matrix:**

| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PO-11 | PO-12 | PSO-1 | PSO-2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO-1 | 3 | | | | | | 2 | | | | | | 2 | |
| CO-2 | | 2 | | | | 1 | 1 | | | | | | 2 | 2 |
| CO-3 | | | 2 | | | 1 | | | | | | | 2 | 2 |
| CO-4 | 3 | 1 | 1 | 1 | 1 | | | | | | | | 2 | |

**1 - Slightly;** **2 - Moderately;** **3 - Substantially**

**Syllabus:**

**Antenna Fundamentals:** Introduction to antennas & their significance, Scalar electric potential, magnetic vector potential, radiation from an alternating current element, Induction field, radiation field, power radiated by a current element, Radiation mechanism of the infinitesimal dipole, power and its radiation resistance. Definition of an electric dipole, Power radiation and its radiation resistance of dipole, half-wave dipole, monopole and a quarter-wave monopole, Isotropic radiator, Radiation resistance of aerials and loop, related problems.

**Antenna Parameters:** Radiation pattern**,** power pattern, field pattern, Radiation intensity, beam width, field region, radiation power density, Directivity and gain, bandwidth, polarization, co polarization and cross-polarization level, input impedance, efficiency, antenna effective length and area**,** antenna temperature**,** scattering loss, network theorem, application of network theorem to antennas. Friss Transmission formula**,** Radar range equation.

**Design of Arrays:** Linear Array-Two element array, N-element linear array- broadside array, End fire array, Directivity, radiation pattern. Pattern multiplication, Effect of earth on vertical pattern mutual impedance effects. Non-uniform excitation- Binomial, Chebyshev distribution, Planar array – Array factor, Circular array - array factor, Directivity (Qualitative study), related problems.

**Practical Antennas:** Resonant & non-resonant antennas, Travelling wave antenna, V antenna, Rhombic antenna, Folded dipole & Yagi-Uda antenna, Corner reflector, Parabolic reflector antenna, Horn antenna Microstrip patch Antennas.

**Antenna Measurements:** Radiation pattern measurements, Measurement of gain, Polarization measurements.

## Learning Resources:

### Text Books:

1. E.C. Jordan & K.G. Balmain, Electromagnetic waves & Radiating Systems, PHI, 2007.
2. Antenna Theory: Analysis and Design – Constantine A. Balanis, John Wiley & Sons, 2009, 3 rd Ed.

### Reference Books:

1. John D. Kraus, Antennas, McGraw Hill, 1988, 2nd Edition.
2. R.E. Collins, Antennas and Radio Propagation, Singapore: McGraw Hill, 1985.
3. R.S.Elliot, “Antenna Theory and Design”, IEEE Press, John Wiley, 2005.

### Other Suggested Readings:

1. https://nptel.ac.in/courses/108/105/108105114/
2. https://nptel.ac.in/courses/108/101/108101092/
3. https://nptel.ac.in/courses/117/107/117107035/

**EE1262** **3-0-0 (3)**

# Control Systems Engineering

**Pre-Requisites: MA1161, MA1162**

## Course Outcomes:

| | |
|---|---|
| **CO-1** | Analyze electromechanical systems using mathematical modelling. |
| **CO-2** | Determine Transient and Steady State behavior of systems using standard test signals. |
| **CO-3** | Analyze linear and non-linear systems for steady state errors, absolute stability and relative stability. |
| **CO-4** | Design a stable control system satisfying requirements of stability and reduced steady state error. |

## Course Articulation Matrix:

| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PO-11 | PO-12 | PSO-1 | PSO-2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO-1 | 3 | 2 | 1 | 1 | 2 | 1 | 2 | 1 | 2 | 3 | 1 | 1 | -- | -- |
| CO-2 | 3 | 2 | 1 | 2 | 1 | 1 | 1 | 1 | 2 | 3 | 1 | 1 | -- | -- |
| CO-3 | 3 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 3 | 1 | 1 | -- | -- |
| CO-4 | 2 | 3 | 2 | 1 | 1 | 2 | 2 | 1 | 2 | 3 | 1 | 1 | -- | -- |

**1 - Slightly; 2 - Moderately; 3 - Substantially**

## Syllabus:

**Introduction**: Concepts of Control Systems- Open Loop and closed loop control systems and their differences- Different examples of control systems- Classification of control systems, Feed-Back Characteristics, Effects of feedback. Mathematical models – Differential equations, Impulse Response and transfer functions.

**Transfer Function Representation**: Block diagram representation of systems considering electrical systems as examples -Block diagram algebra – Representation by Signal flow graph - Reduction using mason's gain formula.

**Time Response Analysis**: Standard test signals - Time response of first order systems – Characteristic Equation of Feedback control systems, Transient response of second order systems - Time domain specifications – Steady state response - Steady state errors and error constants – Effects of proportional derivative, proportional integral systems.

**Stability Analysis in S-Domain**: The concept of stability – Routh's stability criterion – qualitative stability and conditional stability – limitations of Routh's stability.

**Root Locus Technique**: The root locus concept - construction of root loci-effects of adding poles and zeros to G(s) H(s) on the root loci.

**Frequency Response Analysis**: Introduction, Frequency domain specifications-Bode Diagrams-Determination of Frequency domain specifications and Phase margin and Gain Margin-Stability Analysis

from Bode Plots. Polar Plots, Nyquist Plots Stability Analysis. Compensation techniques – Lag, Lead, and Lead-Lag Controllers design in frequency Domain, PID Controllers.

**State Space Analysis of Continuous Systems**: Concepts of state, state variables and state model, derivation of state models from block diagrams, Diagonalization- Solving the Time invariant state Equations- State Transition Matrix and it's Properties – Concepts of Controllability and Observability.

**Learning Resources:**

Text Books:

1. Norman S. Nise, Control Systems Engineering, Willey Publications, 2019, 7th Edition.
2. I.J. Nagarath, M. Gopal, Control Systems Engineering, New Age Pub. Co, 2017, 6th Edition.
3. Katsuhiko Ogata, Modern Control Engineering, Pearson Education India, 2015, 5th Edition.

Reference Books:

1. G. Franklin, J. Powell, A. Emami-Naeini, Feedback control of dynamic systems, 2018, 8th Edition.
2. Richard C. Dorf, Robert H. Bishop, Modern Control Systems, Prentice Hall, 2015, 13th Edition.
3. B.C.Kuo, Automatic Control Systems, Wiley, 2014, 9th Edition.

Other Suggested Readings:

1. https://www.controleng.com/
2. https://nptel.ac.in/courses/108/102/108102043/

# Professional Elective - IV

**EC1421** **3-0-0 (3)**

# Digital Image Processing and Computer Vision

**Pre-Requisites:** **None**

**Course Outcomes:**

| | |
|---|---|
| **CO-1** | Development of algorithms and techniques to analyze and interpret the visible world. |
| **CO-2** | Apply feature extraction and segmentation methods for computer processing. |
| **CO-3** | Implement pattern recognition algorithms for real world problems |
| **CO-4** | Design of detection and recognition algorithms for various computer vision like face/biometric etc. problems |

**Course Articulation Matrix:**

| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PO-11 | PO-12 | PSO-1 | PSO-2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO-1 | 2 | 3 | - | 3 | 2 | - | - | 1 | - | - | - | - | 2 | 2 |
| CO-2 | 3 | 3 | 3 | 2 | 2 | 2 | - | 2 | - | - | - | - | 2 | 2 |
| CO-3 | 3 | 3 | 3 | 3 | 3 | - | - | - | 2 | - | - | - | 2 | 2 |
| CO-4 | 2 | 3 | 2 | 2 | 2 | 2 | - | 2 | 2 | - | - | - | 2 | 2 |

**1 - Slightly;** **2 - Moderately;** **3 - Substantially**

## Syllabus:

**Digital Image Formation and Low-level processing:** Overview and State-of-the-art, Fundamentals of Image Formation, Types of Image processing, Transformation: Orthogonal, Euclidean, Affine, Projective, etc; Image Transform like DFT, DCT etc., face/biometric etc. Convolution and Image Filtering, Image Enhancement and Various Techniques, Image Restoration and various techniques, Histogram Processing and Morphological Operations and its types.

**Feature Extraction:** Edges - Canny, LOG, DOG; Line detectors (Hough Transform), Corners- Harris and Hessian Affine, Orientation Histogram, SIFT, SURF, HOG, GLOH, Scale-Space Analysis- Image Pyramids and Gaussian derivative, Gabor Filters and DWT.

**Image Segmentation:** Region Growing, Edge Based approaches to segmentation, Graph- Cut, Mean-Shift, MRFs, Texture Segmentation; Object detection.

**Pattern Analysis**: Clustering: K-Means, K-Medoids, Mixture of Gaussians, Classification: Discriminant Function, Supervised, Un-supervised, Semi-supervised; Classifiers: Bayes, KNN.

**Motion Analysis:** Background Subtraction and Modeling, Optical Flow, KLT, Spatio-Temporal Analysis, Dynamic Stereo; Motion parameter estimation. Use Cases on Finger print recognition, Face detection and recognition, Object tracking, medical Diagnosis etc

**Learning Resources:**

Text Books:

1. Richard Szeliski, Computer Vision: Algorithms and Applications, Springer-Verlag London Limited, 2011.
2. D. A. Forsyth, J. Ponce, Computer Vision: A Modern Approach, PHI Learning, 2009.
3. R.C. Gonzalez and R.E. Woods, Digital Image Processing, Pearson Education, 2017, 4thEdition.
4. Jayaraman, S., Esakkirajan, S. and Veerakumar, T.,Digital image processing (Vol. 7014). New Delhi: Tata McGraw Hill Education, 2009.

Reference Books:

1. Milan Soanka, Vaclav Hlavac and Roger Boyle, Digital Image Processing and Computer Vision, Cengage Learning, 2014.

Other Suggested Readings:

1. NPTEL Courses (https://nptel.ac.in/courses/108/103/108103174/)

**EC2421** **3-0-0 (3)**

# Nanoelectronics

**Pre-Requisites: EC2104, EC2201**

**Course Outcomes:**

| | |
|---|---|
| **CO-1** | Understand the physics and materials for Nanoelectronics |
| **CO-2** | Understand the scaling issues |
| **CO-3** | Explain the need for non-classical and non-silicon-based devices |
| **CO-4** | Analyze the performance of novel devices |

**Course Articulation Matrix:**

| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PO-11 | PO-12 | PSO-1 | PSO-2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO-1 | 3 | – | – | – | – | – | – | – | – | – | – | – | – | – |
| CO-2 | 3 | – | 1 | – | – | – | – | – | – | – | – | – | – | – |
| CO-3 | 3 | – | 1 | 1 | – | – | – | – | – | – | – | – | – | – |
| CO-4 | 3 | 3 | 3 | 3 | 3 | – | – | – | – | – | – | – | 1 | – |

**1 - Slightly; 2 - Moderately; 3 - Substantially**

## Syllabus:

**Overview:** Nanodevices, Nano materials, Nano characterization, Definition of Technology node, Basic CMOS Process flow, MOS Scaling theory, Issues in scaling MOS transistors: short channel effects, Description of a typical 65 nm CMOS technology. Requirements for Nonclassical MOS transistor, MOS capacitor, Role of interface quality and related process techniques, Gate oxide thickness scaling trend, SiO2 vs High-k gate dielectrics. Integration issues of high-k Interface states, bulk charge, band offset, stability, reliability – Qbd high field, possible candidates, CV and IV techniques.

**Metal gate transistor:** Motivation, requirements, Integration Issues, Transport in Nano MOSFET, velocity saturation, ballistic transport, injection velocity, velocity overshoot. SOI - PDSOI and FDSOI, Ultrathin body SOI – double gate transistors, integration issues, Vertical transistors - FinFET and Surround gate FET, Metal source/drain junctions – Properties of Schottky junctions on Silicon, Germanium, and compound semiconductors-Work function pinning.

**Germanium Nano MOSFETs:** strain, quantization, Advantages of Germanium over Silicon, PMOS versus NMOS. Compound semiconductors – material properties, MESFETs Compound semiconductors MOSFETs in the context of channel quantization and strain, Heterostructure MOSFETs exploiting novel materials, strain, quantization.

**Learning Resources:**

Text Books:

1. Y. Taur and T. Ning, “Fundamentals of Modern VLSI devices” Cambridge University Press.
2. Nicollian and J. R. Brews “MOS (Metal Oxide Semiconductor) Physics and Technology” Wiley Publishers

Reference Books:

1. Brundle, C. Richard, Evans, Charles A. Jr.; Wilson, Shaun “Encyclopedia of Materials Characterization”, Elsevier.
2. Supriyo Datta, Lessons from Nanoelectronics A new Prospective on transport – Part A: Basic Concepts, World Scientific, 2017.

**EC2423** **3-0-0 (3)**

# Electronics System Packaging

**Pre-Requisites:** **EC2201**

## Course Outcomes:

| | |
|---|---|
| **CO-1** | Understand the role of packaging in the computer, telecommunication, automotive, medical and consumer electronics industry |
| **CO-2** | Learn the fundamentals of electrical packaging design, design for reliability, thermal management |
| **CO-3** | Analyze the performance of various TSVs for 3-D ICs |
| **CO-4** | Identify the packaging materials with their appropriate properties |

## Course Articulation Matrix:

| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PO-11 | PO-12 | PSO-1 | PSO-2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO-1 | 2 | 1 | 3 | | | 2 | 2 | | | | 1 | 2 | 2 | |
| CO-2 | 3 | 3 | 3 | 2 | | 2 | 1 | | | | 1 | 2 | 2 | |
| CO-3 | 3 | 3 | 3 | 3 | 3 | | | | | | 1 | 2 | 2 | 1 |
| CO-4 | 3 | 3 | 3 | 3 | | 2 | 1 | | | | 1 | 2 | 2 | 1 |

**1 - Slightly;** **2 - Moderately;** **3 - Substantially**

## Syllabus:

**Overview of electronic systems packaging:** Products and levels of packaging, Packaging aspects of handheld products.

**Semiconductor Packaging Overview:** Basics of Semiconductor and Process flowchart; Packaging evolution, Chip connection choices, Wire bonding, TAB and flipchip, Need for packaging & Single chip packages or modules (SCM), Commonly used packages and advanced packages, Materials in packages, Multichip modules (MCM)-type, System-in- package (SIP).

**Electrical Design considerations in systems packaging:** Resistive Parasitic, Capacitive and Inductive Parasitic, Layout guidelines and the Reflection problem, Interconnection, CAD for Printed Wiring Boards: Components of a CAD package and its highlights, Design Flow considerations; Beginning a circuit design with schematic work and component layout, Demo and examples of layout and routing; Technology file generation from CAD; DFM checklist and design rules; Design for Reliability.

**Printed Wiring Board Technologies:** Fabrication Process, Printing technologies for PWBs, PWB etching, Resist stripping, Screen-printing technology, Through-hole manufacture process steps, Panel and pattern plating methods, Solder mask for PWBs, Multilayer PWBs;

**Introduction to micro-via:** Micro-via technology, and Sequential build-up technology process flow for high-density interconnects, Conventional Vs HDI technologies; Flexible circuits.

**Surface Mount Technology:** SMD benefits; Design issues; soldering methods, soldering properties, and defects, failure analysis, Lead free soldering, Environmental considerations, Thermal design consideration in system packaging.

**Learning Resources:**

Text Books:

1. Rao R. Tummala, Fundamentals of Microsystems Packaging, McGraw Hill, NY, 2001.
2. William D. Brown, Advanced Electronic Packaging, IEEE Press, 1999.

Reference Books:

1. Bosshart, Printed Circuit Boards Design and Technology, TataMcGraw Hill, 1988.
2. Blackwell (Ed), The electronic packaging handbook, CRC Press, 2000.

Other Suggested Readings:

1. NPTEL Courses (https://archive.nptel.ac.in/courses/108/108/108108031/)

**EC2425** **3-0-0 (3)**

# Heterojunction Device Physics

**Pre-Requisites:** **EC2104**

**Course Outcomes:**

| | |
|---|---|
| **CO-1** | Understand the band structure of heterojunction devices |
| **CO-2** | Analyze the electrical behavior of 2D heterojunctions |
| **CO-3** | Understand the density of states in different dimensional structures like 0D, 1D, 2D and 3D |
| **CO-4** | Analyze the transport mechanisms in heterojunction devices |

**Course Articulation Matrix:**

| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PO-11 | PO-12 | PSO-1 | PSO-2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO-1 | 1 | 1 | – | – | – | – | – | – | 2 | 1 | – | 1 | 2 | – |
| CO-2 | 2 | 2 | – | 1 | 2 | 2 | – | 2 | 2 | 2 | – | 1 | 2 | – |
| CO-3 | 2 | 2 | 2 | 2 | 2 | – | 1 | – | 2 | 2 | – | 1 | 2 | 2 |
| CO-4 | 2 | 2 | – | 2 | – | – | – | – | 2 | 2 | – | 1 | 2 | – |

**1 - Slightly;** **2 - Moderately;** **3 - Substantially**

## Syllabus:

Semiconductor abrupt junctions, Equilibrium conditions, the contact potential, space charge at a semiconductor junction, qualitative description of current flow at a junction, minority, and majority carrier currents, carrier injection, minority carrier distributions, variation of the quasi-Fermi levels with the position, junction current from excess minority carriers, junction breakdown mechanisms, capacitance of p-n junctions.

**Semiconductor heterojunctions:** Types of heterojunctions, energy band diagrams of hetero structures, current-voltage and, capacitance-voltage characteristics of anisotype heterojunctions, hetero junction bipolar transistors, electrical and optical characteristics of LEDs, laser gain semiconductor band system, high electron mobility transistor, hot electron heterojunction transistor.

**2D electron gas and Quantum wells:** 2D electron gas in Si and GaAs MOS structures, effect of applied bias on energy bands of the MOS capacitors, bias dependence of capacitance, free charge carrier transfer. Triangular quantum wells (both finite and infinite), coupled quantum wells, and superlattices, double heterostructure lasers, single quantum well lasers, multiple quantum well lasers. Optical absorption due to electronic transitions in quantum wells.

T**ransport properties of heterostructures and quantum devices**: Effect of electric field parallel and perpendicular to the interfaces, effects of constant magnetic field, Landau levels, magnetoconductivity in a 2D heterostructure. One-D and Zero-D quantum structures.

The density of states in 3D, 2D, 1D and 0D structures, 1D and 0D optical phenomena and optical devices, quantum confined stark effect, quantum well modulators, self-electro-optic effect devices, resonant tunneling devices, the coulomb blockade, single electron transistor.

**Learning Resources:**

Text Books:

1. B. L. Sharma and R. K. Purohit, Semiconductor Heterojunctions, Pergamon press, 2015.
2. A. R. Milnes and D. L. Hnech, Heterojunction and metal semiconductor junctions, Academic Press.

Reference Books:

1. B. G. Streetman Solid state electronic devices, Prentice Hall India Learning Private Limited,2006, 6th Edition.
2. M. Balkanski and R. F. Walls, Semiconductor Physics and applications, Oxford university press, 2000.

# Professional Elective - V

**EC1427** **3-0-0 (3)**

# Computer Architecture and Organization

**Pre-Requisites:** **EC1205**

**Course Outcomes:**

| | |
|---|---|
| **CO-1** | Understand the micro-architectural design of processors |
| **CO-2** | Apply the concept of memory hierarchy for efficient memory design and virtual memory to overcome the memory wall |
| **CO-3** | Analyze performance of different pipelining techniques |
| **CO-4** | Understand the concept of multithreading |

**Course Articulation Matrix:**

| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PO-11 | PO-12 | PSO-1 | PSO-2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO-1 | 2 | 2 | 2 | 1 | 1 | 2 | 2 | 2 | 1 | -- | - | - | 2 | - |
| CO-2 | 3 | 2 | 3 | 2 | 3 | 2 | 2 | 2 | 1 | - | - | - | 2 | 2 |
| CO-3 | 3 | 2 | 2 | _ | 1 | 1 | 2 | 1 | 2 | - | - | - | 2 | 2 |
| CO-4 | 3 | 2 | 2 | _ | 1 | 1 | 2 | 1 | 2 | - | - | - | 2 | 2 |

**1 - Slightly;** **2 - Moderately;** **3 - Substantially**

## Syllabus:

**Instructions & Arithmetic Operations:** Basic computer organization, Components of computer systems, Instructions – operations and operands – representing instructions – Logical operations – control operations – Addressing and addressing modes, ALU - Addition and subtraction – Multiplication – Division – Floating Point operations

**Interfacing: I/O transfer techniques:** Program controlled, Interrupt controlled and DMA; Introduction to computer buses, Peripherals and current trends in architecture.

**Memory Hierarchy:** Advanced Optimizations of Cache Performance, Memory Technology and Optimizations, Virtual Memory and Virtual Machines, The Design of Memory Hierarchy.

**Pipelining:** Introduction to high performance computing, RISC philosophy and overview of pipelined architecture. Performance evaluation of pipelined architecture. Limitations of scalar pipelines, Instruction level parallelism, superscalar pipeline.

**Advanced Data Flow Techniques:** Instruction reuse and value prediction, Memory data flow, Advanced memory data flow architectures, performance evaluation of superscalar architectures.

**Multi-Threading:** Simultaneous multithreaded (SMT) architectures, SMT performance on various designs.

**Learning Resources:**

Text Books:

1. J.L. Hennessy, and D.A. Patterson, Computer Architecture: A quantitative approach, Morgan Kaufman Publication, 2012, Fifth Edition.
2. J.P. Shen and M.H. Lipasti, Modern Processor Design, MC Graw Hill, Crawfordsville, 2005.
3. C. Hamacher, Z. Vranesic and S. Zaky, Computer Organization, McGraw-Hill, 2002, 5th edition.

Reference Books:

1. Andrew S. Tanenbaum, Structured Computer Organization, Prentice Hall,2012,6th edition
2. J.P. Shen and M.H. Lipasti. Modern Processor Design: Fundamentals of Superscalar Processors. McGraw-Hill Publishers, 2005.
3. D.B. Kirk and W.W. Hwu. Programming Massively Parallel Processors. 2nd Edition, Morgan Kauffmann Publishers, 2012.

Other Suggested Readings:

1. NPTEL Courses (https://nptel.ac.in/courses/106106134)

**EC1429** **3-0-0 (3)**

# Cryptography and Network Security

**Pre-Requisites:** **None**

**Course Outcomes:**

| | |
|---|---|
| **CO-1** | Analyze encryption algorithms. |
| **CO-2** | Apply cryptographic algorithms to build secure protocols |
| **CO-3** | Identify system vulnerabilities of communication protocols |
| **CO-4** | Design of secure protocols to solve real world scenario |

**Course Articulation Matrix:**

| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PO-11 | PO-12 | PSO-1 | PSO-2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO-1 | 1 | - | 1 | - | 2 | - | – | – | – | – | – | – | 1 | – |
| CO-2 | 2 | 2 | - | 3 | 3 | 1 | – | – | – | – | – | – | 1 | – |
| CO-3 | - | - | 3 | 1 | 1 | 2 | – | – | – | – | – | – | 1 | – |
| CO-4 | 3 | 1 | 2 | 3 | 3 | 3 | – | – | – | – | – | – | 3 | – |
| CO-5 | 1 | 1 | 2 | 2 | 2 | – | – | – | – | – | – | – | 1 | 3 |

**1 - Slightly;** **2 - Moderately;** **3 - Substantially**

## Syllabus:

**Security Goals and Services:** Definitions – Threat; Vulnerabilities; Attacks – Classifications of attacks; Security services; Security mechanisms.

**Cryptographic algorithms:** Private key algorithms – Classical Encryption techniques; Stream ciphers; Block cipher modes; DES; AES; Random number generators; Public key algorithms - Principles of Public key Cryptography; RSA; Deffie-Hellman; ElGamal; Elliptic Curve Cryptography.

**Security mechanisms:** Key management and Distribution - Certificate authorities; PKI; MAC; Hashing; Digital Signatures-Authentication protocols; Digital Signature Standard;

**Introduction to Network Security:** Network security threats; Vulnerabilities - Denial-of- service/Distributed denial-of-service attacks; Spoofing, Man-in-the-middle, Replay, TCP/Hijacking, Fragmentation attacks, Weak keys, Port scanning, Dumpster diving, Birthday attacks, Password guessing, Eavesdropping, War driving, TCP sequence number attacks.

**Network Defense Tools:** Firewalls- Firewall Properties; Design of firewalls; VPN's; Filtering; Intrusion detection.

**Security protocols:** Network and transport layer security- SSL/TLS, IPsec IKE; IPsec AH, ESP; Application security- Kerberos; S/MIME; PGP.

**Learning Resources:**

Text Books:

1. Charlie Kaufman, Radia Perlman, Mike Speciner, Network Security: Private Communication in a Public World, Prentice Hall, 2002.
2. William Stallings, Cryptography and Network Security, Pearson Education, 2014, 6th edition.

Reference Books:

1. Menezes, P. Van Oorschot, S. Vanstone, Handbook of Applied Cryptography, CRC Press, 2004.

**EC2427** **3-0-0 (3)**

# Introduction to ASIC Design

**Pre-Requisites:** **EC2204**

**Course Outcomes:**

| | |
|---|---|
| **CO-1** | Architect ASIC library design. |
| **CO-2** | Develop programmable ASIC logic cells. |
| **CO-3** | Design I/O cells and interconnects. |
| **CO-4** | Identification of new developments in SOC and low power design. |

**Course Articulation Matrix:**

| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PO-11 | PO-12 | PSO-1 | PSO-2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO-1 | 1 | - | 2 | 1 | 2 | – | – | – | – | – | – | – | – | – |
| CO-2 | 2 | 2 | 3 | 2 | 3 | – | – | – | – | – | – | – | 1 | – |
| CO-3 | 3 | 3 | 3 | 3 | 3 | – | – | – | – | – | – | – | 2 | – |
| CO-4 | 3 | 3 | 3 | 3 | 3 | – | – | – | – | – | – | – | 2 | – |

**1 - Slightly;** **2 - Moderately;** **3 - Substantially**

## Syllabus:

**Programmable ASIC:** CLB, IOB, Memory, DSP Slices and other resources of Xilinx 7 series FPGA devices, features of Ultra scale FPGA devices, Programming technologies Partitioning and Coding Styles: Partitioning for Synthesis, General guidelines, Logic Inference.

**Static Timing Analysis Concepts:** CMOS Logic Design, Modeling of CMOS Cells, Min and Max Timing Paths, Clock Domains, Operating conditions, Timing Verification- Setup Timing Check, Hold Timing Check

**Standard Cell Library:** Pin Capacitance, Timing Modeling, Timing Models - Combinational Cells, Sequential cells

**Power Analysis in ASICs:** Power Computation for Basic Cells and Macros-Leakage Power Computation, Active Power Computation, Power Computation for a Flip-Flop Cell, Power Computation for a Memory Macro.

**Optimizing Designs:** Design Space Exploration, Compilation Strategies, Resolving multiple instance, Optimization Techniques.

**Design Intent for Power Management:** Power Management Requirements, Special Cells for Power Management, Architectural techniques for low power.

**Learning Resources:**

Text Books:

1. Michel John Sebastian Smith, Application Specific Integrated Circuits, Addison Wesley Professional, 2008.
2. Vaibbhav Taraate, ASIC Design and Synthesis: RTL Design using Verilog, Springer, 2021.

Reference Books:

1. Himanshu Bhatnagar, Advanced ASIC Chip Synthesis: Using Synopsys Design Compiler, Kluwer Academic, 2001, 2nd Edition.
2. Khosrow Golshan, Physical Design Essentials: An ASIC Design Implementation Perspective, Springer, 2007.
3. Khosrow Golshan, The Art of Timing Closure: Advanced ASIC Design Implementation, Springer, 2020.

**EC2429** **3-0-0 (3)**

# RF Microelectronics

**Pre-Requisites:** **EC2202**

## Course Outcomes:

| | |
|---|---|
| **CO-1** | Understand the design bottlenecks specific to RF IC design |
| **CO-2** | Identify noise sources and develop noise models for the devices and systems. |
| **CO-3** | Understand various Transmitter and receiver architectures |
| **CO-4** | Design constituent blocks of the RF receiver front end. |

## Course Articulation Matrix:

| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PO-11 | PO-12 | PSO-1 | PSO-2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO-1 | 2 | 1 | 1 | 1 | – | – | – | – | – | – | – | – | – | – |
| CO-2 | 2 | 2 | 3 | 1 | 2 | – | – | – | – | – | – | – | 2 | – |
| CO-3 | 2 | 1 | 1 | 1 | – | – | – | – | – | – | – | – | – | – |
| CO-4 | 2 | 2 | 3 | 2 | 3 | – | – | – | – | – | – | – | 3 | 2 |

**1 - Slightly;** **2 - Moderately;** **3 - Substantially**

## Syllabus:

**Basic concepts of RF IC design:** Design Bottle necks of RF IC design Non-linearity and Time invariance Sensitivity and dynamic range, Passive impedance transformation, RF radio receiver front end non-idealities and design parameters: Effects of nonlinearity, 1 dB compression point, Derivation of required noise figure at receiver front end, Required $IIP_3$ at receiver front end, Partitioning of required NF at receiver front end and $IIP_3$ into individual NF and $IIP_3$.

**Noise:** Noise sources in MOSFETs, Modeling of thermal noise and flicker noise, noise analog integrated circuits.

**Transceiver architectures:** General considerations, receiver architecture, Transmitter Architecture, transceiver performance tests.

**Low Noise Amplifier:** Introduction, General Philosophy, Matching Networks, Comparison of Narrowband and wideband LNA.

Wideband LNA Design: DC Bias, Gain ad Frequency Response, Noise Figure.

Narrowband LNA: Principles, core amplifier design, noise figure, power dissipation.

**Mixers:** Active mixer, modeling mixers, unbalanced mixer circuits, single balanced mixer circuit, Gilbert mixer, conversion gain.

**PLL based frequency synthesizer:** Concepts of PLL, phase detector, charge pump, Frequency Divider, VCO, LC oscillators, Ring oscillator, Phase noise.

**Learning Resources:**

Text Books:

1. Bosco Leung, VLSI for wireless communication, Prentice Hall
2. Behad Razavi, RF Microelectronics, Prentice Hall

Reference Books:

1. Robert Caverly, CMOS RFIC Design Principles, Artech House Publishers, 2007.

# Professional Elective - VI

**EC1424** **3-0-0 (3)**

# Wireless Communications - 5G Use Cases

**Pre-Requisites:** **EC2304**

## Course Outcomes:

| | |
|---|---|
| **CO1** | Learn 5G Technology advances and their benefits |
| **CO2** | Learn the key RF, PHY, MAC and air interface changes required to support 5G |
| **CO3** | Learn Interference management, mobility management, and security for 5G |
| **CO4** | Understand the Implementation options for 5G |

## Course Articulation Matrix:

| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PO-11 | PO-12 | PSO-1 | PSO-2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO-1 | 1 | 1 | - | - | - | 3 | - | - | - | - | - | - | 1 | 1 |
| CO-2 | 1 | 1 | 3 | - | - | - | - | - | - | - | - | - | 1 | - |
| CO-3 | 1 | - | 2 | 1 | - | - | - | - | - | - | - | - | 2 | - |
| CO-4 | 1 | - | - | - | - | - | - | - | - | - | - | - | 1 | 2 |

**1 - Slightly;** **2 - Moderately;** **3 - Substantially**

## Syllabus:

**Introduction:** Introduction to Cell technologies, handoff, cellular capacity, 2G,3G, 4G standards. Basic Architectural difference in 2G, 3G & 4G systems with introduction to 5G technology. Regulations for 5G, Spectrum Analysis and Sharing for 5G.

**The 5G wireless Propagation Channels:** Multipath Propagation, Doppler spread, large and small-scale propagation models. Flat & frequency selective fading, Fast and slow fading, Various fading distributions, Link budgeting. Channel modeling requirements, propagation scenarios and challenges in the 5G channel modeling.

**5G NR (new radio) and 5G core network (5GCN)**: Basics about RAN architecture, 5G RAN, ORAN, Network slicing, 5G frame structure, NFV and SDN, High-level requirements for the 5G architecture, Integration of LTE and new air interface to fulfill 5G Requirements, Enhanced Multi-RAT coordination features, Physical architecture and 5G deployment.

**Transmission and Design Techniques for 5G:** Basic requirements of transmission over 5G, Modulation Techniques – Orthogonal frequency division multiplexing (OFDM), generalized frequency division multiplexing (GFDM), filter bank multi-carriers (FBMC) and universal filtered multi-carrier (UFMC), Multiple Accesses Techniques – orthogonal frequency division multiple accesses (OFDMA), generalized frequency division multiple accesses (GFDMA), non-orthogonal multiple accesses (NOMA).

**Interference management, mobility management, and security for 5G:** Network deployment types, Ultra-dense network or densification, moving networks, Heterogeneous networks, Interference management in 5G, Interference management in UDN, Interference management for moving relay nodes, Interference cancelation, mobility management in 5G, User equipment controlled versus network-controlled handover, Mobility management in heterogeneous 5G networks.

**Learning Resources:**

Text Books:

1. Martin Sauter “From GSM From GSM to LTE–Advanced Pro and 5G: An Introduction to Mobile Networks and Mobile Broadband”, Wiley-Blackwell, 2017, 2nd Edition.
2. Athanasios G.Kanatos, Konstantina S.Nikita, Panagiotis Mathiopoulos, “New Directions in Wireless Communication Systems from Mobile to 5G”, CRC Press, 2018, 1st Edition.
3. Wei Xiang, Kan Zheng, Xuemin(Sherman) Shen, 5G Mobile Communications, Springer, 2017, 1st Edition.
4. Theodore S.Rappaport, Robert W.Heath, Robert C.Danials, James N.Murdock “Millimeter Wave Wireless Communications”, Prentice Hall Communications, 2015. 1st Edition.

Reference Books:

1. Jonathan Rodriguez, “Fundamentals of 5G Mobile Networks”, John Wiley & Sons, 2015, 1st Edition.
2. Amitabha Ghosh and Rapeepat Ratasuk “Essentials of LTE and LTE-A”, Cambridge University Press, 2011, 1st Edition.

**EC2422** **3-0-0 (3)**

# Reliability of VLSI Systems

**Pre-Requisites:** **EC2104 & EC2201**

## Course Outcomes:

| | |
|---|---|
| **CO-1** | Define the reliability of electronic device and circuit |
| **CO-2** | Understand the failure mechanisms of electronic device and circuit |
| **CO-3** | Understand the concept of yield in electronic manufacturing |
| **CO-4** | Resolve the reliability issues in VLSI design |
| **CO-5** | Predict the circuit performance using reliability models |

## Course Articulation Matrix:

| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PO-11 | PO-12 | PSO-1 | PSO-2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO-1 | 3 | 1 | 1 | 1 | 1 | – | – | – | – | – | – | – | 1 | – |
| CO-2 | 3 | 3 | 1 | 1 | 1 | – | – | – | – | – | – | – | 1 | – |
| CO-3 | 3 | 2 | 1 | 1 | 1 | – | – | – | – | – | – | – | 1 | – |
| CO-4 | 1 | 1 | 3 | 2 | 2 | – | – | – | – | – | – | – | 3 | – |
| CO-5 | 1 | 1 | 2 | 2 | 2 | – | – | – | – | – | – | – | 1 | 3 |

**1 - Slightly;** **2 - Moderately;** **3 - Substantially**

## Syllabus:

**Background and Introduction:** Definitions of reliability, failure modes, mechanisms, Basic concepts – Reliability functions, Relationship between these functions – Baths tubs curve – Exponential failure density and distribution functions - Expected value and standard deviation of Exponential distribution –Measures of reliability – MTTF, MTTR, MTBF

**Introduction to mathematical methods for reliability:** Failure rates, Normal distribution function, Six Sigma, Exponential, Weibull and Lognormal distributions for reliability modeling. Manufacturing yields.

**Physics of failure-based models for:** Mass transport-induced failures (electro migration and stress voiding), Electronic charge-induced failures (Dielectric breakdown, Hot carrier effects, Electrical over-stress and Electrostatic discharge),

**Circuit Performance** considering NBTI, PBTI, oxide breakdown, impact of parasitic effects, process temperature variation, Electromagnetic Interference (EMI) and Electrostatic Discharge (ESD).

**Introduction to semiconductor device packaging:** Materials and processes used for semiconductor device packaging.

## Learning Resources:

Text Books:

1. M. Ohring, Reliability and Failure of Electronic Materials and Devices, Academic Press, 1998, First Edition.
2. J.W. McPherson, Reliability Physics and Engineering, Springer, 2013, Second Edition.

Reference Books:

1. Yuan Taur and T. Ning, “Fundamentals of Modern VLSI Devices,” Cambridge University Press,1998.
2. J.Ross, Microelectronic Failure Analysis, ASTM International, 2011, Sixth Edition.

**EC2424** **3-0-0 (3)**

# High Speed Interfacing Circuits

**Pre-Requisites:** **EC2301**

**Course Outcomes:**

| | |
|---|---|
| **CO-1** | Identifying the challenges of high-speed interfacing circuits |
| **CO-2** | Understand the concepts of ser-des |
| **CO-3** | Develop high speed serial communication architectures |
| **CO-4** | Understand signal integrity issues and develop power efficient solutions |

**Course Articulation Matrix:**

| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PO-11 | PO-12 | PSO-1 | PSO-2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO-1 | 2 | 3 | 1 | 3 | – | – | – | – | – | – | – | – | 2 | – |
| CO-2 | 2 | 1 | 1 | 1 | 2 | – | – | – | – | – | – | – | – | – |
| CO-3 | 1 | 2 | 3 | 2 | 2 | – | – | – | – | – | – | – | 3 | – |
| CO-4 | 3 | 1 | 1 | 1 | – | – | – | – | – | – | – | – | – | – |

**1 - Slightly;** **2 - Moderately;** **3 - Substantially**

## Syllabus:

SerDes Transceiver for High-Speed Serial Communications, Design challenges, Circuit Styles, PISO and SIPO, Clock Multiplier Unit, Equalization, Data and Clock Recovery

**Serdes Concepts:** Source Synchronous Interfaces, High-Speed Serdes, Signal Integrity, Signaling Methods, HSS features and functions: HSS Core Example: HSS EX10 10-GbpsCore, HSS EX10 Transmitter Slice Functions, HSS EX10 Receiver Slice Functions, Phase-Locked Loop (PLL) Slice, Reset and Reconfiguration Sequences.

**HSS Architecture and Design:** Phase Locked Loop (PLL) Slice, Transmitter Slice, Receiver Slice.

**Reference Clocks:** Clock Distribution Network, Clock Jitter, Clock Floor-planning, Signal Integrity of the Clock Network, Signal Integrity: Probability Density Functions itter, Statistical Approach to Signal Integrity.

**Power Analysis:** Digital and non-digital Logic Circuits, HSS power, Reducing Power Dissipation

**Learning Resources:**

Text Books:

1. “High Speed SerDes Devices and Applications” by David R. Stauffer, Jeanne Trinko Mechler, Michael Sorna, Kent Dramstad, Clarence R. Ogilvie, Amanullah Mohammad and James Rockrohr,
2. Hong JiongSong, VLSI High-Speed I/O Circuits: Theoretical Basis, Architecture, Modeling and Circuit Implementation, Xlbris Publications, 2010.

**EC2426** **3-0-0 (3)**

# Introduction to Quantum Computing

**Pre-Requisites:** **None**

**Course Outcomes:**

| | |
|---|---|
| **CO-1** | Understand the principles of quantum computation qubit |
| **CO-2** | Analyze multi-qubit systems and protocols |
| **CO-3** | Apply quantum measurement and entanglement concepts |
| **CO-4** | Design and implement quantum algorithms and circuits |

**Course Articulation Matrix:**

| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PO-11 | PO-12 | PSO-1 | PSO-2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO-1 | 3 | 3 | – | – | – | – | – | – | – | – | – | – | – | – |
| CO-2 | 3 | 3 | 1 | 1 | 3 | – | – | – | – | – | – | – | – | – |
| CO-3 | 3 | 3 | 2 | 1 | 3 | – | – | – | – | – | – | – | 3 | 2 |
| CO-4 | 3 | 3 | 3 | 3 | 3 | – | – | – | – | – | – | – | 3 | 2 |

**1 - Slightly;** **2 - Moderately;** **3 - Substantially**

## Syllabus:

**Review of Quantum Mechanics and Motivation for Quantum Computation Qubit:** The qubit state - matrix and Bloch sphere representation - computational basis unitary evolution.

**Multi-qubit states** - No-cloning theorem - Superdense coding - Pure states to Bell states – Bell inequalities. Protocols with multi-qubits: Swapping - Teleportation - gates: CNOT - Toffoli gate - NAND - FANOUT - Walsh Hadamard.

**Measurement:** Projective operators - General, Projective and POVM measure, Ensemble: Density operators - pure and mixed ensemble - time evolution – post measurement density operator. Composite systems: Partial trace - Reduced density operator - Schmidt decomposition, Purification bipartite entanglement.

**Quantum computing:** Classical computing using qubits - Quantum parallelism - Deutsch's algorithm.

**Quantum circuits:** Basic gates - ABC decomposition - Gray codes - Universal gates.

**Learning Resources:**

Text Books:

1. Quantum Computation and Quantum Information, M. A. Nielsen and I. L. Chuang, Cambridge University Press.
2. Quantum Information and Computation, CIT Lecture Notes by J. Preskill.

Reference Books:

1. Quantum Theory: Concepts and Methods, Asher Peres, Kluwer Academic Publishers.

# Professional Elective - VII

**EC1430** **3-0-0 (3)**

# Optimization Techniques

**Pre-Requisites:** **None**

**Course Outcomes:**

| | |
|---|---|
| **CO-1** | Able to formulate mathematical models of real-world problems. |
| **CO-2** | Understand the major limitations and capabilities of deterministic operations |
| **CO-3** | Handle, Solve and analyze problems using linear programming and other mathematical programming algorithms. |
| **CO-4** | Solve various multivariable optimization problem. |

**Course Articulation Matrix:**

| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PO-11 | PO-12 | PSO-1 | PSO-2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO-1 | 3 | – | – | – | – | – | – | – | – | – | – | 2 | 2 | 2 |
| CO-2 | 3 | – | – | – | – | – | – | – | – | – | – | – | 2 | 2 |
| CO-3 | 3 | – | – | – | – | – | – | – | – | – | – | – | 2 | 2 |
| CO-4 | 3 | – | – | – | – | – | – | – | – | – | – | – | 2 | 2 |

**1 - Slightly;** **2 - Moderately;** **3 - Substantially**

## Syllabus:

**Introduction:** Statement of an optimization problem, Classification of optimization problems, Overview of various optimization Techniques, The simplex optimization technique, Applications of Simplex, Test Functions, Examples

**Unconstrained optimization:** Definitions and existence conditions, General properties of minimization algorithms, Line search, The Steepest-Descent Optimization Technique, Newton's method, The Least-pth Optimization Technique- Least square Algorithm.

**Constrained optimization:** Active Constraints versus Inactive constraints, Transformations, penalty functions

**Advanced Techniques for Optimization:**

**Genetic algorithm (GA):** Fundamentals of Genetic algorithm, History, Basic concepts, working principle, Applications of GA for standard Bench mark test functions.

**Swarm intelligence:** Main inspiration source, early variants of PSO, Basic particle swarm optimization, Initialization techniques, Theoretical investigations and parameter selection, Design of PSO algorithm using computational statistics, Termination conditions. Application of PSO, Standard test function optimization.

**Differential Evaluation:** Classical differential evaluation- An outline, Mutation, cross over, selection

**Teaching Learning Based Optimization:** Applications of TLBO for standard Bench mark test functions, Case studies

**Learning Resources:**

Text Books:

1. Richard W Daniels, An Introduction to Numerical Methods and Optimization Techniques, Elsevier North Holland Inc,
2. Milani Mitchel, An introduction to Genetic algorithms, MIT Press, 1998.
3. AE Eiben and J.E Smith, Introduction to Evolutionary Computing, Springer 2010.

Reference Books:

1. S Rajasekharan, G.A Vijaya Lakshmi Pai, Neural Networks, Fuzzy logic, and Genetic algorithms, Synthesis and Applications, Prentice hall of India, 2007.
2. Weifan Wang, Xuding Zhu, Ding-Zhu Du, Combinatorial Optimization and Applications:5th International Conference, Springer Publications, 2011.

**EC2428** **3-0-0 (3)**

# CAD for IC Design

**Pre-Requisites:** **EC1205**

**Course Outcomes:**

| | |
|---|---|
| **CO-1** | Specify routing techniques in IC design. |
| **CO-2** | Incorporate timing analysis and floor planning. |
| **CO-3** | Design the IC with programmable structures. |
| **CO-4** | Implement EDA/CAD with machine intelligence. |

**Course Articulation Matrix:**

| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PO-11 | PO-12 | PSO-1 | PSO-2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO-1 | 2 | 1 | 3 | – | 2 | – | – | – | – | – | 1 | 2 | 2 | – |
| CO-2 | 2 | 2 | 3 | 2 | 2 | – | – | – | – | – | 1 | 2 | 2 | – |
| CO-3 | 2 | 2 | 3 | 2 | 3 | – | – | – | – | – | 1 | 2 | 2 | – |
| CO-4 | 2 | 2 | 3 | – | 3 | – | – | – | – | – | 1 | 2 | 2 | – |

**1 - Slightly;** **2 - Moderately;** **3 - Substantially**

## Syllabus:

VLSI design Cycle, Physical Design Cycle, Design styles: full custom, standard cell, gate arrays, field programmable gate arrays, and comparison.

Impact of fabrication process on physical design, interconnect delay, noise and cross talk, yield and fabrication cost.

Factors, Complexity Issues and NP-hard Problems, Basic Algorithms (Graph and Computational Geometry): graph search algorithms, spanning tree algorithms, shortest path algorithms, matching algorithms.

Basic Data Structures, atomic operations for layout editors, linked list of blocks, bin-based methods, neighbour pointers, corner stitching, multi-layer operations.

**Graph algorithms for physical design:** classes of graphs, graphs related to a set of lines, graphs related to set of rectangles, graph problems in physical design, maximum clique and minimum coloring, maximum k-independent set algorithm.

**Partitioning algorithms:** design style specific partitioning problems, group migrated algorithms, simulated annealing and evolution, and Floor planning and pin assignment, Routing and placement algorithms.

**Learning Resources:**

Text Books:

1. Naveed Shervani, Algorithms for VLSI Physical Design Automation, Kluwer Academic, 1999, 3rd Edition.
2. Charles J Alpert, Dinesh P Mehta, Sachin S Sapatnekar, Handbook of Algorithms for Physical Design Automation, CRC Press, 2008.

**EC2430** **3-0-0 (3)**

# MEMS & NEMS

**Pre-Requisites:** **None**

**Course Outcomes:**

| | |
|---|---|
| **CO-1** | Analyze Micro/Nano Sensors and Actuators |
| **CO-2** | Apply materials and mechanics in micro-systems design |
| **CO-3** | Design and evaluate MEMS products |
| **CO-4** | Implement microfabrication techniques |

**Course Articulation Matrix:**

| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PO-11 | PO-12 | PSO-1 | PSO-2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO-1 | 3 | 3 | 3 | 2 | 3 | – | – | – | – | – | – | – | 3 | 1 |
| CO-2 | 3 | 3 | 1 | 2 | 3 | – | – | – | – | – | – | – | – | – |
| CO-3 | 3 | 3 | 3 | 3 | 3 | – | – | – | – | – | – | – | 3 | 3 |
| CO-4 | 3 | 2 | 2 | 3 | 2 | – | – | – | – | – | – | – | 2 | – |

**1 - Slightly;** **2 - Moderately;** **3 - Substantially**

## Syllabus:

**Introduction to MEMS:** Historical Background, Scaling Effects. Micro/Nano Sensors, Review of Basic MEMS fabrication modules, Oxidation, Deposition Techniques, Lithography (LIGA), and Etching. Micromachining, Surface Micromachining, sacrificial layer processes, Stiction, Bulk Micromachining, Isotropic Etching, and Anisotropic Etching, Wafer Bonding, Mechanics of solids in MEMS/NEMS.

**Micro-actuators and Micro-sensors:** Micro-sensors, acoustic wave sensors, biomedical and nano sensors, chemical sensors, optical sensors, pressure sensors, thermal sensors, micro-actuation through thermal forces, SMA-Piezo electric crystals, and electrostatic forces, magnetic actuation, micro-grippers, micro-motors, micro-valves, micropumps, micro-accelerometers.

**Materials, Mechanics and design of micro-systems:** Silicon as a substrate, compounds, piezo resistors, polymers, and packaging materials, micro-fabrication and micro-etching: static bending of thin plates, thermo mechanics and thin film mechanics.

**Case studies of MEMS Products:** Micro-fluidic devices, micro/nano transducers, blood pressure sensors, microphone-acceleration sensors, gyroscope, an overview of micro-system packaging.

**Learning Resources:**

Text Books:

1. Marc Madou, Fundamentals of Microfabrication and Nanotechnology, 3rd edition
2. Stephen D. Senturia, Microsystem Design
3. Gregory T.A. Kovacs, Micromachined Transducers.

Reference Books:

1. Guozhong Cao, Ying, Nanostructure and Nano materials, synthesis, properties and applications, World Scientific Publishing Co. 2011.
2. Chang Liu, Foundation of MEMS, Pearson Education, ISBN (978-81-317-6475-6).

Other Suggested Readings:

1. NPTEL Courses(https://nptel.ac.in/courses/117105082)

**EC2432** **3-0-0 (3)**

# Introduction to Power Management IC Design

**Pre-Requisites:** **EC2202**

## Course Outcomes:

| | |
|---|---|
| **CO-1** | Identify challenges of power management for analog and mixed signal circuits |
| **CO-2** | Design low dropout regulators with optimum transient response |
| **CO-3** | Develop efficient switching regulators |
| **CO-4** | Explore on-chip power management solutions for mixed signal systems |

## Course Articulation Matrix:

| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PO-11 | PO-12 | PSO-1 | PSO-2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO-1 | 2 | 3 | 1 | 3 | – | – | – | – | – | – | – | – | 2 | – |
| CO-2 | 2 | 1 | 1 | 1 | 2 | – | – | – | – | – | – | – | – | – |
| CO-3 | 1 | 2 | 3 | 2 | 2 | – | – | – | – | – | – | – | 3 | – |
| CO-4 | 3 | 1 | 1 | 1 | – | – | – | – | – | – | – | – | – | – |

**1 - Slightly;** **2 - Moderately;** **3 - Substantially**

## Syllabus:

**Overview of Power Management:** Significance of Power Management, classification of voltage regulators, merits and demerits of linear and switching regulators, applications.

**Low Drop-Out Voltage Regulators:** Topologies, characterization, challenges and design of on chip LDOs.

**DC-DC Converters:** Principles of DC-DC converters, classification modes of operation compensation techniques.

**Design considerations of regulators:** PWM modulator, intricacies of error amplifier design, design of drivers, layout considerations for pass transistors, topologies to improve power supply rejection, efficiency calculations.

**Power management unit design:** Power management considerations for mixed signal IC, improving the efficiency of power management unit through tandem connection of DC-DC converter and LDO's.

## Learning Resources:

Text Books:

1. Switch-Mode Power Supplies: SPICE Simulations and Practical Designs, Christophe P Basso, BPB Publications, 2010.
2. Power Management Techniques for Integrated Circuit Design by Ke-Horng Chen, Wiley-Blackwell, 2016.

Reference Books:

1. Fundamentals of Power Electronics, 2nd edition by Robert W. Erickson, Dragan Maksimovic, Springer (India) Pvt. Ltd, 2005

# Professional Elective - VIII

**EC1436** **3-0-0 (3)**

# Cloud based Technologies

**Pre-Requisites:** **None**

**Course Outcomes:**

| | |
|---|---|
| **CO-1** | Identify the appropriate cloud services for a given application |
| **CO-2** | Analyze Cloud infrastructure including Google Cloud and Amazon Cloud. |
| **CO-3** | Analyze authentication, confidentiality and privacy issues in Cloud computing environment. |
| **CO-4** | Determine financial and technological implications for selecting cloud computing platforms |

**Course Articulation Matrix:**

| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PO-11 | PO-12 | PSO-1 | PSO-2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO-1 | 2 | 3 | 2 | 2 | 1 | 2 | 2 | 2 | 1 | – | – | – | 2 | 2 |
| CO-2 | 2 | 3 | 2 | 2 | 3 | 2 | 1 | 2 | 1 | – | – | – | 2 | 2 |
| CO-3 | 2 | 3 | 2 | 2 | 1 | 2 | 3 | 2 | 1 | – | – | – | 2 | 2 |
| CO-4 | 2 | 2 | 3 | 3 | 3 | 3 | 2 | 2 | 1 | – | – | – | 2 | 2 |

**1 - Slightly;** **2 - Moderately;** **3 - Substantially**

## Syllabus:

**Introduction:** Cloud Computing Architecture, Cloud Delivery Models, The SPI Framework, SPI Evolution, The SPI Framework vs. the Traditional IT Model, Cloud Software as a Service (SaaS), Cloud Platform as a Service (PaaS), Cloud Infrastructure as a Service (IaaS) Google Cloud Infrastructure - Google File System – Search engine – Map Reduce - Amazon Web Services - REST APIs - SOAP API - Defining Service Oriented Architecture, Combining the cloud and SOA, Characterizing SOA, Loosening Up on Coupling, Making SOA Happen, Catching the Enterprise Service Bus, Telling your registry from your repository, Cataloging services, Understanding Services in the Cloud.

**Serving the Business with SOA and Cloud Computing, Query API:** User Authentication Connecting to the Cloud – OpenSSH Keys - Tunneling / Port Forwarding - Simple Storage Service - S3, EC2 - EC2 Compute Units, Platforms and storage, EC2 pricing, EC2 customers Amazon Elastic Block Storage - EBS - Ubuntu in the Cloud - Apache Instances in EC2 – Amazon Cloud Services- Amazon Elastic Compute Cloud (Amazon EC2), Amazon Simple DB, Amazon Simple Storage Service (Amazon S3), Amazon Cloud Front, Amazon Simple Queue Service (Amazon SQS), Amazon Elastic Map Reduce, Amazon Relational Database Service (Amazon RDS) , EC2 Applications - Web application design - AWS EC2 Capacity Planning – Apache Servers - Mysql Servers - Amazon Cloud Watch - Monitoring Tools.

**Primary Storage Systems** Introduction to DRAM System, DRAM organization, DRAM Controllers and Address Mapping. Tiled Chip Multi-Core Processors & Network-on-Chip Tiled Chip Multicore Processors (TCMP), Network on Chips (NoC), Routing Algorithms, NoC router – architecture, Routing and flow control Energy Efficient NoCs Introduction to deflection routing, Energy Efficient Buffer-less NoC Routers, Side-buffered Deflection Routers. Quality of Service for TCMPs QoS of NoC and Caches in TCMPs, Emerging Trends in Network on Chips, Domain Specific Accelerators.

**Learning Resources:**

Text Books:

1. Anothony T Velte, Toby J Velte, Robert Elsenpeter, Cloud Computing: A Practical Approach, MGH, 2010.
2. Gautam Shroff, Enterprise Cloud Computing, Cambridge, 2010.

Reference Books:

1. Ronald Krutz and Russell Dean Vines, Cloud Security, Wiley, 2010, First Edition.
2. Arshdeep Bahga, Vijay Madisetti, Cloud Computing: A Hands-on Approach, Universities Press (India) Private Limited, 2014.
3. Rajkumar Buyya, James Broberg, Andrzej Goscinski, Cloud Computing Principles and Paradigms, Wiley, 2011.

**EC1442** **3-0-0 (3)**

# IPR and Cyber Laws

**Pre-Requisites:** **None**

**Course Outcomes:**

| | |
|---|---|
| **CO-1** | Explain origin and development of IPRs |
| **CO-2** | Understand the economic importance of IPRs |
| **CO-3** | Understand the international development of cyber laws |
| **CO-4** | Understand the relation between IPR and Cyber laws |

**Course Articulation Matrix:**

| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PO-11 | PO-12 | PSO-1 | PSO-2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO-1 | – | – | – | – | – | 2 | – | 1 | – | – | – | 1 | – | – |
| CO-2 | – | – | – | – | – | 2 | – | 2 | 1 | 2 | 1 | 1 | 1 | 2 |
| CO-3 | – | – | – | – | – | 1 | 1 | 1 | – | – | 1 | 1 | – | – |
| CO-4 | – | – | – | – | – | 1 | – | 2 | 1 | 1 | – | 1 | – | 2 |

**1 - Slightly;** **2 - Moderately;** **3 - Substantially**

## Syllabus:

**Introduction:** Nature and Concept; Meaning; Types of Intellectual Property Rights; Nature of Intellectual Property Rights; Historical Background; Technological Development of IPR; Sustainable Development; Challenges for IPR system; Role of Government in fostering the IPR

**IP Jurisprudence:** Justification and Rationale for Protecting Intellectual Property; Basic elements of Property and Constitutional Aspects of Property and its Protection; Economic importance of Intellectual Property; Commercialization aspects of IPR; Development and IP; Overview of Intellectual Property Law – to cover the various categories and its interplay in innovation and technology delivery mechanisms.

**International & National Regime:** Introduction to the leading international instruments concerning intellectual property rights: the Berne Convention, Universal Copyright Convention, the Paris Convention, the Rome Convention, Trade Related Aspects of Intellectual Property Rights (TRIPS), the World Intellectual Property Rights Organization (WIPO) and the UNESCO; Background to the national regime; Evolution and development of IPR in India.

**Cyber Law and IPRs -** Understanding Copy Right in Information Technology - Software - Department of ECE Scheme and Syllabi

**Copyrights Vs Patents debate -** Authorship and Assignment Issues - Copyright in Internet - Multimedia and Copyright issues - Software Piracy –Patents - Understanding Patents - Indian

**Position on Computer related Patents –Trademarks -** Trademarks in Internet - Domain name registration - Domain Name Disputes & WIPO - Databases in Information Technology - Protection of databases

**Learning Resources:**

Text Books:

1. Ananth Padmanabhan, Intellectual Property Rights: Infringement and Remedies, Lexis Nexis, Nagpur, 2012.
2. N.S. Gopalakrishnan, Principles of Intellectual Property, EBC, Lucknow, 2014.
3. Bently and Sherman, Intellectual Property Law, Oxford University Press, U.K., 2018, 5e.

Reference Books:

1. Paul Torremans, Holyoak & Torremans Intellectual Property Law, Oxford Univ.Press, Cyber Laws, 2010.
2. Justice Yatindra Singh, Cyber Laws, Universal Law Publishing, UP, 2016.

**EC2434** **3-0-0 (3)**

# Multicore Computer Architecture-Storage and Interconnects

**Pre-Requisites:** **None**

**Course Outcomes:**

| | |
|---|---|
| **CO-1** | Understand the microarchitectural design of processors |
| **CO-2** | Develop cache memory optimization techniques |
| **CO-3** | Analyze performance of different pipelining techniques |
| **CO-4** | Understand the concept of multithreading |

**Course Articulation Matrix:**

| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PO-11 | PO-12 | PSO-1 | PSO-2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO-1 | 2 | 1 | 3 | – | 2 | – | – | – | – | – | 1 | 2 | 2 | – |
| CO-2 | 2 | 2 | 3 | 2 | 2 | – | – | – | – | – | 1 | 2 | 2 | – |
| CO-3 | 2 | 2 | 3 | 2 | 3 | – | – | – | – | – | 1 | 2 | 2 | – |
| CO-4 | 2 | 2 | 3 | – | 3 | – | – | – | – | – | 1 | 2 | 2 | – |

**1 - Slightly;** **2 - Moderately;** **3 - Substantially**

## Syllabus:

**Basic Computer Organization:** Review of Basic Computer Organization, Basic operational concepts, fundamental of program execution, memory and I/O addressing, Instruction set architecture- addressing modes, instruction set, instruction encoding and formats. CISC vs RISC ISA.

**Instruction Pipeline Principles:** Performance Evaluation Methods, Introduction to RISC Instruction Pipeline, Instruction Pipeline and Performance. Pipeline Hazards and Analysis

**Pipeline Hazards and Branch Prediction Techniques:** Pipeline Hazards Management Techniques, Branch Prediction, MIPS Pipeline for Multi-Cycle Operations.

**Pipeline Scheduling and Speculative execution:** Compiler Techniques to Explore Instruction Level Parallelism, Dynamic Scheduling with Tomasulo's Algorithm, Speculative Execution.

**Superscalar Processors and GPU architectures:** Advanced Pipelining, Multithreading and Hyperthreading, Superscalar Processors, GPU Architectures.

Cache Memory Principles Introduction to Cache Memory, Block Replacement Techniques and Write Strategy, Design Concepts in Cache Memory. Cache Memory Optimizations Design issues for improving memory access time, Basic and Advanced Optimization Techniques in Cache Memory. Cache Coherence Protocols Cache coherence and memory consistency, Snoop Based and Directory Based Cache Coherence Protocols.

Primary Storage Systems Introduction to DRAM System, DRAM organization, DRAM Controllers and Address Mapping. Tiled Chip Multi-Core Processors & Network-on-Chip Tiled Chip Multicore Processors (TCMP), Network on Chips (NoC), Routing Algorithms, NoC router – architecture, Routing and flow control Energy Efficient NoCs Introduction to deflection routing, Energy Efficient Buffer-less NoC Routers, Side-

buffered Deflection Routers. Quality of Service for TCMPs QoS of NoC and Caches in TCMPs, Emerging Trends in Network on Chips, Domain Specific Accelerators.

**Learning Resources:**

Text Books:

1. John L. Hennessy, David A. Patterson Morgan Kaufman, Computer Architecture - A Quantitative Approach- 5e.
2. Memory System - Cache, DRAM and Disk Bruce Jacob, Spencer W. Ng, David T. Wang Morgan Kaufman.

Reference Books:

1. William J. Dally, Brian P. Towles Elsevier, Principles and Practices of Interconnection Networks.

**EC2436** **3-0-0 (3)**

# On Chip Sensors and Interfacing circuits

**Pre-Requisites:** **EC2202**

**Course Outcomes:**

| | |
|---|---|
| **CO-1** | Understand the sensor parameters |
| **CO-2** | Design of temperature and capacitive sensors |
| **CO-3** | Evaluate different frontend ICs for sensor circuits and design for given specifications |
| **CO-4** | Comprehend the noise issues in sensors and it's circuits |

**Course Articulation Matrix:**

| | PO-1 | PO-2 | PO-3 | PO-4 | PO-5 | PO-6 | PO-7 | PO-8 | PO-9 | PO-10 | PO-11 | PO-12 | PSO-1 | PSO-2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO-1 | 2 | 3 | 1 | 3 | – | – | – | – | – | – | – | – | 2 | – |
| CO-2 | 2 | 1 | 1 | 1 | 2 | – | – | – | – | – | – | – | – | – |
| CO-3 | 1 | 2 | 3 | 2 | 2 | – | – | – | – | – | – | – | 3 | – |
| CO-4 | 3 | 1 | 1 | 1 | – | – | – | – | – | – | – | – | – | – |

**1 - Slightly;** **2 - Moderately;** **3 - Substantially**

## Syllabus:

**Characterization of sensors:** Definitions, terminology, classification, Static vs dynamic properties of transducers, Transfer functions, Ideal and realistic transducer models. Resolution, linearization, dynamic range, detection threshold, Selectivity & sensitivity, Calibration, Errors of the experimental measurements. Physical Principle of Sensing: Resistance, Capacitance, Piezoelectric effect, Pyroelectric effect, Thermal and Optical phenomenon.

**Temperature Sensors:** Basic concepts, Temperature scale, standard temperature points, Thermistor sensors, Thermocouple Sensors, The pyrometer, radiation thermometer, pressure thermometer liquid and gaseous, Temperature sensor applications

**Capacitive sensors:** Various design considerations; guarding, stray fields, offset and stray capacitance, Ratio metric measurement, circuit implementations. Synchronous Phase Detection – multiplier and switching type, Capacitive Angle Transducers

**Front end interface circuits:** Signal Conditioners: Input Characteristics, Amplifiers, Charge-and Current-to-Voltage Converters, Light-to-Voltage Converters, Capacitance-to-Voltage Converters, Null-Balanced bridge, Bridge Amplifiers, Excitation Circuits, ADC for sensor data, PWM Converters.

**Noise in Sensors and Circuits**: Inherent Noise, Transmitted Noise, Electric Bypass Capacitors, Magnetic Shielding, Mechanical Noise, Ground Planes, Ground Loops and Ground Isolation, See beck Noise

**Learning Resources:**

Text Books:

1. Jacob Fraden, (2016), Handbook of Modern Sensors, 5th Edition, Springer.
2. Ramón Pallás-Areny, John G. Webster, Sensors and Signal Conditioning, 2nd Edition, Wiley, 2003.
3. J. G. Webster, The Measurement, Instrumentation and Sensors Handbook, Vol 1 and 2, CRC Press, 1999

Reference Books:

1. Doebelin, E.O., Measurement systems: Application and Design, 5th ed., McGraw hill, 2003