# **Minor Degree Courses**

# **Department of Electronics and Communication** Engineering



The department of Electronics and Communication Engineering offers the following minor degree courses for the students of undergraduate B. Tech. program of other departments in MMMUT Gorakhpur.

# Minor Degree Courses offered by ECED (For the B.Tech. students of another Department)

1. For holistic development of the students and as per NEP-2020 and AICTE guideline, the students may earn additional 20 credits through the minor degree courses offered by different departments of the University from Semester IV to VIII.

2. Minor degree courses are optional, but it will be helpful to align the need of industries.

2. Students can only opt for one minor degree course during his/her studies of the B. Tech. program

3. If students complete all 5 PE (professional elective) category courses offered for the minor degree (total 20 credit) from the other department for minor degree, he/shell get a B. Tech. degree in his/her own branch.

4. No extra fee for a minor degree course will be charged by the students

5. In case if a student is unable to complete all 5 PE courses as offered by the other department for minor degree at the time of completion of B. Tech. program in his/her own branch then student will get B. Tech. degree in his/her own branch without completing the minor degree course from other Department.

6. The minor degree course may be offered by the department through MOOC, as per the guidelines in B. Tech. ordinance 3.0 for the MOOC course.

Category	Subject	Name of Subject	Credit			Total
	Code		L	Т	Р	Credit
PE-1	EEC-101	Introduction to Space	3	1	0	4
		Technology				
PE-3	EEC-301	Launch Vehicle Systems and	3	0	2	4
		Technologies				
PE-5	EEC-501	Spaceflight Mechanics and	3	0	2	4
		Attitude Dynamics				
<b>PE-7</b>	EEC-701	Spacecraft Systems Engineering	3	1	0	4
PE-9	EEC-901	Minor Project	4			
Total						20

# Minor Degree 1: Space Technology

# Name of Minor 2: VLSI Design and Technology

Category	Subject	Name of Subject Credit				Total
	Code		L	Т	Р	Credit
PE1	EEC-102	Electronic Materials, Devices	3	0	2	4
		and Circuits				
PE3	EEC-302	Digital System Design	3	0	2	4
PE5	EEC-502	VLSI Design	3	0	2	4
PE7	EEC-702	Introduction to Microfabrication	3	1	0	4
PE9	EEC-902	Minor Project	0	0	8	4
Total		· · ·	•			20

Minor 1	Degree	1:	Space	Technology
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Category	Subject	Name of Subject	Credit			Total
	Code		L	Т	Р	Credit
PE-1	EEC-101	Introduction to Space	3	1	0	4
		Technology				
PE-3	EEC-301	Launch Vehicle Systems and	3	0	2	4
		Technologies				
PE-5	EEC-501	Spaceflight Mechanics and	3	0	2	4
		Attitude Dynamics				
<b>PE-7</b>	EEC-701	Spacecraft Systems Engineering	3	1	0	4
PE-9	EEC-901	Minor Project 0 0 8				4
Total						20

# **Detailed Syllabus**

Course Code: EEC-101	Intr	oduction to Space Technology
Course Category	:	Program Elective
Pre-requisite Subject	:	NIL
Contact hours/week	:	Lecture:3, Tutorial:1, Practical:0
Number of Credits	:	4
Course Assessment methods	:	Continuous assessments through teaching assessment,
		attendance, home assignments, quizzes, two minor tests
Course Objectives	:	and one major theory examination. Familiarize students with the concepts of launch vehicle
		design and missiles and its various parameters required for
		mission trajectory design and launch. Space data
		products and services of Space technology will be
Course Outcomes	:	communicated to the students. The students are expected to be able to demonstrate the
		following knowledge, skills and attitudes after completing
		this course.

- 1. Understanding of concepts of launch vehicle design and missiles.
- 2. Understanding various parameters required for mission trajectory design and launch.
- 3. Gain knowledge of Space data products and services.
- 4. Able to understand Space technology concepts.
- 5. Understanding of space orbit concept.
- 6. Able to ex[lain the trajectory motion of satellite.

### **Topics Covered**

### Unit I

**Basics of Launch Vehicle Design and Missiles** GNC and Satellite Systems Engineering design. Fundamentals of structure and mechanisms. Introduction to launch facilities, launch vehicle assembly, integration and launch readiness. Communication with the ground stations and ground tracking in collaboration with foreign space centers.

### Unit II

**Fundamentals of mission trajectory design** Coordinate reference frames, space flight mechanics, satellite orbits, Kepler's laws; lunar and interplanetary missions. Attitude dynamics, Attitude parameterization: direction cosine matrix, Euler axis and angles, quaternions, Euler angles; attitude rates; attitude determination; Euler equations of motion and attitude dynamics.

### Unit III

**Basics of Space data products and services including AI and ML** Definition and Overview of Remote Sensing and Remote Sensing Systems: Electromagnetic Radiation, Laws of Radiation, EM Spectrum, Sources of EMR, Interaction between EM Radiation and matter, Reflection, Absorption and Transmission, Interactions between EM Radiation and Atmosphere, Atmospheric windows. Platforms: Types of platforms (Ground, Airborne and Space borne); Satellites for earth observation; Geostationary and UAV platforms.

### Unit IV

**Space Technology** Fundamentals of Digital Image Processing, Fundamentals of Photogrammetry, Cartography, space materials processing; Global Navigation Satellite System (GNSS).

### **Text and Reference Book**

### **Textbook:**

1. Wie, B., Space Vehicle Dynamics and Control, 2nd ed., AIAA Education Series, 2008

2. Zarchan, P., Tactical and Strategic Missile Guidance, 6th ed., Progress in Astronautics and Aeronautics, 2007

### **References:**

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- 1. Joseph, G., Fundamentals of Remote Sensing, Universities Press, 2003
- 2. Fleeman, E. L., Missile Design and System Engineering, AIAA Education Series, 2012
- 3. Noton, M., Spacecraft Navigation and Guidance, Springer 1998 Farrell, J. A., Aided Navigation: GPS with High Rate Sensor, McGraw-Hill 2008.

Course Code: EEC-301	La	unch Vehicle Systems and Technologies
Course Category	:	Program Elective
Pre-requisite Subject	:	NIL
Contact hours/week	:	Lecture:3, Tutorial:0, Practical:2
Number of Credits	:	4
Course Assessment methods	:	Continuous assessments through teaching assessment,
Course Objectives	:	attendance, home assignments, quizzes, two minor tests and one major theory examination. Familiarize students with the Concepts of launch vehicle/missiles design and its subsystem through the dynamics of launch vehicle. Fundamentals of GNC loop, design problem and elegarithms of providentian and its validation
		design problem and algorithms of navigation and its varidation
		through testbeds and simulation setups will be
Course Outcomes	:	communicated. After completing this course, students will be able to show
		the following knowledge and skills.

1: Discuss concepts of launch vehicle design and missiles.

2: Explain Launch Vehicle Dynamics.

**3:** Apply Fundamentals of GNC loop, design problem and algorithms.

4: Implementation on testbeds and simulation setups.

**5:** Understanding various parameters of design of vehicle.

6: Able to explain the physics behind motion of vehicle.

### Topics Covered Unit I

Launch Vehicles and Missiles and their subsystems Launch Vehicles and Missiles and

their subsystems, Fundamentals and Types of Propulsion system: Solid / Liquid / Cryogenic /

Semi-Cryogenic /Mono propellent, Bi-propellent and Electric propulsion systems (including

green propulsion) Fundamentals of Structures and Mechanisms: Structural Dynamics

/Vibration modes for Dynamics modeling.

# Unit II

Launch Vehicle Dynamics Gravity model, Point mass dynamics, Aerodynamics: Multi-

strap-on Vehicles, its aerosurfaces, Fundamentals of Trajectories (Mission Design): Equations of Motion: short period / long period Model development, Slosh Dynamics analysis, Basic principles of inertial measurement units: Gyros, Fiber optic/ Laser Gyros and others, accelerometers, Actuators: Electrohydraulic, Electromechanical, Reaction Control Systems.

## Unit III:

**Fundamentals of GNC loop, design problem and algorithms** Basics of Guidance: Open Loop / Closed Loop: Implicit / Explicit Guidance schemes, Basics of Navigation: Nav algorithm, compensation schemes, multiple sensor fusion, Basics of Control (Autopilot): Linear / nonlinear design Techniques.

### Unit IV:

Validation Testbeds/ Simulation setups On-board computer in the loop simulations (OILS), Hardware in the loop Simulations (HLS), Actuators in Loop Simulations (ALS), Flight Software in Loop Simulations (SILS), reliability analysis, Satellite interface and satellite deployment with separation dynamics.

# Text and Reference Book Textbook:

- 1. Edberg, D., and Costa, W., Design of Rockets and Space Launch Vehicles, AIAA Education Series, 2020.
- Kadam, N. V., Practical Design of Flight Control Systems for Launch Vehicles and Missiles, Allied Publishers, 2009

### **References:**

- 1. Wiesel, W. E., Spacecraft Dynamics, 2nd ed, McGraw-Hill 1997.
- 2. Noton, M., Spacecraft Navigation and Guidance, Springer 1998.

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Course Code: EEC-501	Spa	ceflight Mechanics and Attitude Dynamics
Course Category	:	Program Elective
Pre-requisite Subject	:	NIL
Contact hours/week	:	Lecture:3, Tutorial:0, Practical:2
Number of Credits	:	4
<b>Course Assessment methods</b>	:	Continuous assessments through teaching assessment,
Course Objectives	:	attendance, home assignments, quizzes, two minor tests and one major theory examination. Familiarize students with concepts of spaceflight mechanics, ft attitude dynamics and its control system. Remote sensing and propulsion systems of spaceflight
Course Outcomes	:	along with missile guidance will also be discussed. By the end of this course, students will be able to understand and apply the skills and ideas listed below.

1: Discuss concepts of Spaceflight Mechanics

2: Determine various parameters required for Spacecraft Attitude Dynamics and control systems.

- **3:** Explain remote sensing systems and various Propulsion Systems.
- 4: Describe Flight Mechanics and Missile Guidance.
- **5:** Able to understand the concept of remote sensing mechanism.
- **6:** Able to explain physics behind spaceflight mechanics.

### Topics Covered UNIT-I

**Spaceflight Mechanics** ECI frame, Two-body Orbital dynamics, Integrals of motion, Classical Orbital parameters, Satellite Orbit perturbations, sun-synchronous satellites, geosynchronous, orbital manoeuvres, orbit determination, orbit corrections and maintenance, relative motion in orbits, proximity operations.

# UNIT-II

**Spacecraft Attitude Dynamics** Attitude parameterization: direction cosine matrix, Euler axis and angles, Quaternions, attitude rates, Euler equations of rigid body attitude dynamics. Liquid propellant slosh effects. Attitude stabilization, spin stabilization of a rigid spacecraft and an energy-dissipating Spacecraft, active nutation control, momentum bias satellites, passive and active nutation damping, control with Thrusters.

## UNIT-III

Spacecraft Attitude Control Attitude control with three-axis reaction wheels, thrusters and

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magnets; Three-Axis Stabilization, Disturbing torques, effect of structural flexibility, antenna beam pointing accuracy. Various types of attitude sensors, attitude determination, Propulsion Systems, Liquid Propellant Thrusters, Electric Propulsion.

# UNIT-IV

### Flight Mechanics and Missile Guidance

Re-entry Flight Mechanics, guided re-entry, feedback guidance, Lunar and interplanetary flights: Chandrayan and Mars missions. Missile guidance: Lambert, midcourse and endgame guidance; Tactical and strategic interceptors, zero-effort-miss guidance; Cruise missiles, Fundamentals of Space-based Navigation (GNSS)

# Text and Reference Book

# Textbook:

- De Ruiter, A. H. J., Damaren, C. J., and Forbes, J. R., Spacecraft Dynamics and Control: An Introduction, Wiley 2013
- 2. Montenbruck, O., and Gill, E., Satellite Orbits: Models, Methods, Applications, Springer 2000
- 3. Sidi, M. J., Spacecraft Dynamics and Control, Cambridge University Press 1997
- 4. Wie, B., Space Vehicle Dynamics and Control, 2nd ed., AIAA Education Series, 2008

# Reference

- 1. Chobotov, V. A., (Ed.), Orbital Mechanics, 3rd ed, AIAA Education Series 2002.
- 2. Wiesel, W. E., Spacecraft Dynamics, 2nd ed, McGraw-Hill 1997
- 3. Noton, M., Spacecraft Navigation and Guidance, Springer 1998
- 4. Farrell, J. A., Aided Navigation: GPS with High Rate Sensor, McGraw-Hill 2008
- 5. Joseph, G., Fundamentals of Remote Sensing, Universities Press, 2003
- 6. Fleeman, E. L., Missile Design and System Engineering, AIAA Education Series, 2012
- Zarchan, P., Tactical and Strategic Missile Guidance, 6th ed., Progress in Astronautics and Aeronautics, 2007

Course Code: EEC-701	Sp	acecraft Systems Engineering			
Course Category	:	Program Elective			
Pre-requisite Subject	:	NIL			
Contact hours/week	: Lecture:3, Tutorial:1, Practical:0				
Number of Credits	: 4				
<b>Course Assessment methods</b>	:	Continuous assessments through teaching assessment,			
		attendance, home assignments, quizzes, two minor tests and			
Course Objectives	:	Familiarize students with the fundamentals of spacecraft			
		configurations and satellite subsystems through its Structures			
		and thermal control system. The principles of satellite			
		communication and basics of remote sensing satellites will			
		also be communicated to the students.			
<b>Course Outcomes</b>	:	The students are expected to be able to demonstrate the			
		following knowledge, skills and attitudes after completing			
		this course.			

- 1: Fundamentals of Spacecraft Configurations and Satellite subsystems.
- 2: Spacecraft Structures and Thermal Control System.
- 3: Satellite Communication principles.
- 4: Basics of remote sensing satellites.
- **5:** Understanding of Satellite working.
- **6:** Able to understanding the design aspect of satellite.

### Topics Covered Unit I:

**Spacecraft Configurations and Satellite subsystems** Mission analysis and design, Space Environment and space weather, Disturbances acting on a satellite, Fundamentals of on-board computer and control electronics, on-board software development for attitude and orbit control, propulsion, electrical power, solar arrays, batteries, power control electronics, telemetry and telecommand, mechanism, radiation tolerance, electromagnetic compatibility.

## Unit II:

## Spacecraft Structures and Thermal Control System

Introduction, Spacecraft Structural Configuration, Launch Loads, Stress-Strain Analysis, Matrix Methods of Structural Analysis, Finite Element Analysis, Instability of Structures, Dynamic Analysis, Multi-Degree-of-Freedom System, Random Excitation, Mode Synthesis, Materials, Structural Design Verification Tests, Introduction, Heat Transfer, Thermal Analysis, 9

Thermal Control Techniques, Spacecraft Thermal Design, Thermal Testing.

# Unit III:

### **Satellite Communication**

Basic Units and Definitions in Communications Engineering, Frequency Allocations and Some Aspects of the Radio Regulations, Electromagnetic Waves, Frequency, and Polarization Selection for Satellite Communications, Link Consideration, Communications Subsystem of a Communications Satellite, Some Common Modulation and Access Techniques for Satellite Communications, Satellite Capacity and the Sizing of Satellites, Advanced communication systems in LEO, MEO and GEO, Small satellites: engineering and applications.

### Unit IV:

# **Remote Sensing Satellites**

Payloads of communication satellites, remote sensing satellites, navigation satellites, science mission satellites and missile detection. Optical, Quantum Satellite communication.

## **Text and Reference Books**

Category	Subject	Name of Subject Credit				Total
	Code		L	Т	Р	Credit
PE1	EEC-102	Electronic Materials, Devices	3	0	2	4
		and Circuits				
PE3	EEC-302	Digital System Design	3	0	2	4
PE5	EEC-502	VLSI Design	3	0	2	4
PE7	EEC-702	Introduction to Microfabrication	3	1	0	4
PE9	EEC-902	Minor Project	4			
Total						20

### Name of Minor 2: VLSI Design and Technology

### **Detailed Syllabus**

Course Code: EEC-102 Electronic Materials, Devices and Circuits		
Course category	:	Program Elective
Pre-requisite Subject	:	NIL
Contact hours/week	:	Lecture: 3, Tutorial: 0, Practical: 2
Number of Credits	:	4
Course Assessment methods	:	Continuous assessment through tutorials, attendance, home
		assignments, quizzes and two minor tests and one major
		theory examination.
<b>Course Objectives</b>	:	The course is aimed to develop the concepts of electronic
		devices & circuits skills of engineering students that are
		imperative for effective understanding of engineering
		subjects.
<b>Course Outcomes</b>	:	The students are expected to be able to demonstrate the
		following knowledge, skills and attitudes after completing this
		course.

- 1. Able to categorize materials, explain their properties, explain crystal structure of silicon.
- 2. Able to elucidate working principles of solid-state devices.
- 3. Develop the concept of building discrete amplifiers.
- 4. Able to build OP-AMP based circuits.
- 5. Gain understanding of difference amplifiers.
- 6. Able to explain various types of multivibrators.

### **Topics Covered UNIT-I**

Types of materials, metals, insulators and semiconductors, Band gap, Miller indices, Crystal Structure of Silicon, Intrinsic 'Semiconductors, Extrinsic semiconductors, Fermi level, Thermal Equilibrium, Law of mass action, mobility, generation recombination, Transport Equations, Continuity Equations.

# UNIT-II

P-N junction characteristics, I-V characteristics, and small signal switching models; Avalanche breakdown, Zener diode, Schottky diode, Rectifying circuits, Limiting and clamping circuits. MOSFET device structure, current voltage characteristics, DC biasing, small signal analysis, Common Source, Common Gate and Common Collector Configurations, Discrete circuit amplifiers.

## **UNIT-III**

OPAMP- Ideal Op-AMP, Inverting Configuration, Non inverting configuration, DC imperfections, difference amplifiers, circuits based on Op-amps: Integrators, differentiators, filters, logarithmic amplifiers.

### **UNIT-IV**

Signal generators, waveform shaping circuits, RC oscillatory circuits, LC and Crystal Oscillators, Bistable multivibrators, monostable multivibrators, Timers, Nonlinear waver forming circuits.

### **EXPERIMENTS**

- 1. To study CRO, function generator, power supply.
- 2. To study the basic components of electronics.
- 3. I/V Characteristics of PN junction diode.
- 4. Half-wave rectifier circuits.
- 5. Full-wave rectifier circuits.
- 6. Zener diode as a voltage regulator.
- 7. Design of Clipper circuit.
- 8. Design of Clamper circuit.
- 9. Input-output Characteristics of BJT.
- 10. Input-output Characteristics of FET devices.

### **Text and Reference Books**

- 1. A.S.Sedra and K.C. Smith, Microelectronic Circuits.
- 2. G. Streetman, and S. K. Banerjee, —Solid State Electronic Devices, 7th edition, Pearson, 2014.
- 3. D. Neamen, D. Biswas "Semiconductor Physics and Devices," McGraw-Hill Education
- S. M. Sze and K. N. Kwok, —Physics of Semiconductor Devices, 3rd edition, John Wiley &Sons, 2006.
- C.T. Sah, —Fundamentals of solid state electronics, World Scientific Publishing Co. Inc, 1991.

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Course Code: EEC-302 Digital S	Syst	em Design
Course category	:	Program Elective
Pre-requisite Subject	:	NIL
Contact hours/week	:	Lecture: 3, Tutorial: 0, Practical: 2
Number of Credits	:	4
<b>Course Assessment methods</b>	:	Continuous assessment through tutorials, attendance,
		home assignments, quizzes and two minor tests and one
		major theory examination.
<b>Course Objectives</b>	:	This course is aimed to develop the concepts of VLSI.
		technology and fabrication of the semiconductor devices.
Course Outcomes	:	The students are expected to be able to demonstrate the
		following knowledge, skills and attitudes after completing
		this course.

1. Able to design and analyze combinational logic circuits.

2. Able to design & analyze modular combinational circuits with MUX/DEMUX, Decoder, Encoder.

- 3. Develop the understanding of designing & analyze synchronous sequential logic circuits.
- 4. Able to appropriate EDA tools for digital logic design and simulation.
- 5. Gain understanding of TTL Logics.
- 6. Able to explain various types of Gates .

# **Topics Covered**

## UNIT-I

Logic Simplification and Combinational Logic Design: Review of Boolean Algebra and De Morgan 's Theorem, SOP & POS forms, Canonical forms, Karnaugh maps up to 6 variables, Binary codes, Code Conversion.

# UNIT-II

MSI devices like Comparators, Multiplexers, Encoder, Decoder, Driver & Multiplexed Display, Half and Full Adders, Subtractors, Serial and Parallel Adders, BCD Adder, Barrel shifter and ALU. 9

### **UNIT-III**

Sequential Logic Design: Building blocks like S-R, JK and Master-Slave JK FF, Edge triggered FF, Rippleand Synchronous counters, Shift registers, Finite state machines, Design of synchronous FSM, Algorithmic State Machines charts. Designing synchronous circuits like Pulse train generator, Pseudo Random Binary Sequence generator, Clock generation.

### **UNIT-IV**

Logic Families and Semiconductor Memories: TTL NAND gate, Specifications, Noise margin, Propagation delay, fan-in, fan-out, Tristate TTL, ECL, CMOS families and their interfacing, Memory elements, Concept of Programmable logic devices like FPGA. Logic implementation using Programmable Devices.

### **EXPERIMENTS**

- 1. To design and write test bench of a half adder using gate level modeling.
- 2. To design and write test bench of a full adder using data-flow modeling.
- 3. To design and write test bench of half subtractor using behavioral modeling.
- 4. To design and write test bench of a 2:1 multiplexer using conditional assignment.
- 5. To design and write test bench of 101 sequence detector.
- 6. To design and write test bench of a D flip-flop in Verilog.
- 7. To design and write test bench of a JK flip-flop in Verilog.
- 8. To design and write test bench of a CMOS D flip-flop in Verilog.
- 9. To design and write test bench of a counter in Verilog.
- 10. To design and write test bench of a 4-bit shift register in Verilog.

#### **Text and Reference Books**

- 1. M.Morris Mano and Michel.D.Ciletti, Digital Design with an introduction to HDL, VHDL and Verilog, Sixth edition Pearson education.
- 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, 4th edition, 2009.
- 5. Douglas Perry, —VHDLI, Tata McGraw Hill, 4th edition, 2002.
- 6. W.H. Gothmann, —Digital Electronics- An introduction to theory and practicel, PHI, 2nd edition ,2006.
- 7. D.V. Hall, -Digital Circuits and Systems, Tata McGraw Hill, 1989
- 8. Charles Roth, —Digital System Design using VHDLI, Tata McGraw Hill 2nd edition 2012.

Course Code: EEC-502	VLSI Desi	gn	
Course category		:	Program Elective
Pre-requisite Subject		:	NIL
Contact hours/week		:	Lecture: 3, Tutorial: 0, Practical: 2
Number of Credits		:	4
Course Assessment met	hods	:	Continuous assessment through tutorials, attendance,
			home assignments, quizzes and two minor tests and one
			major theory examination.
<b>Course Objectives</b>		:	The objective of this course is to impart the knowledge of
			HDL language to model the logic circuits and VLSI
			modules using CAD tools.
Course Outcomes		:	The students are expected to be able to demonstrate the
			following knowledge, skills and attitudes after completing
			this course.

1. Able to provide an overview of the digital IC design techniques

- 2. Able to Understand the characteristics of CMOS inverter.
- 3. Able to Analyze the static and dynamic characteristics of CMOS circuits
- 4. Able to Design and implementation of combinational and sequential circuits
- 5. Able to Evaluate the performance of CMOS circuits.
- 6. Gain understanding of CMOS process technology.

### Topics Covered UNIT-I

Overview of VLSI Design: Historical perspective, overview of VLSI design methodologies, VLSI design flow, design hierarchy, concepts of regularity, modularity, and locality, VLSI design styles, design quality, packaging technology, CAD technology.

MOS Transistor Theory: Introduction to The metal oxide semiconductor (MOS) structure, Long-channel I-V characteristics, C-V characteristics, non-linear I-V effects, DC transfer characteristics.

## UNIT-II

Introduction to ASIC and SoC, Overview of ASIC flow, functional verification, RTL-GATE level synthesis, synthesis optimization techniques, pre-layout timing verification, static timing analysis, floor-planning, placement and routing, extraction, post layout timing verification, extraction.

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CMOS Process Technology: Fabrication process flow- basic steps, the CMOS n-Well process, layout design rules, stick diagram, full-custom mask layout design.

### UNIT-III

MOS Inverter (Static Characteristics): Resistive-load inverter, inverter with n-type 16 MOSFET load, CMOS inverter.

MOS Inverters (Switching Characteristics and Interconnects effects): Delay-time definitions, calculation of delay times, logical efforts, inverter design with delay constraints, estimation of interconnect parasitics, calculation of interconnect delay, Bus vs. Network-on Chip (NoC), switching power dissipation of CMOS inverters.

### **UNIT-IV**

Combination CMOS Logic Circuits: MOS logic circuits with depletion nMOS loads, CMOS logic circuits, complex logic circuits, CMOS transmission gates (pass gates), ratioed, dynamic and pass transistor logic circuits.

Sequential MOS logic circuits: Behaviour of bi-stable elements, SR latch circuits, clocked latch and flip-flop circuits, CMOS D-latch and edge-triggered flip-flop. Timing path, Setup time and hold time static, example of setup and hold time static, setup and hold slack, clock skew and jitter, Clock, reset and power distributions.

Semiconductor Memories: Memory Design, SRAM, DRAM structure and implementations Recent Trends in VLSI Design & its research issues in industry: System case studies. Design automation of VLSI Systems: basic concepts. Deep Sub-micron Technologies: Some Design Issues

### **EXPERIMENTS**

- 1. To design a CMOS inverter and perform the DC and transient analysis.
- 2. To write a SPICE netlist of 2:1 Multiplexer and analyze its transient analysis.
- 3. To design a layout of CMOS inverter and perform the LVS check.
- 4. To design a layout of half adder using CMOS logic and verify its performance.
- 5. To design NAND gate using CMOS and verify its LVS.
- 6. To design NOR gate using CMOS and perform its transient analysis at post-layout.
- 7. Write a SPICE code for parity checker and evaluate the performance.

### **Text and Reference Books**

- N. H. E. Weste and C. Harris, "Principles of CMOS VLSI Design: A System Perspective, 3rd Edition, Pearson Education 2007.
- 2. J. Rabaey, A. Chandrakasan and B. Nikolic, Digital Integrated Circuits: A Design

3. Perspective, 2nd Edition, Prentice Hall 2004.

Course Code: EEC-702	Introduction to Microfabrication		
Course category		:	Program Elective
Pre-requisite Subject		:	NIL
Contact hours/week		:	Lecture: 3, Tutorial: 1, Practical: 0
Number of Credits		:	4
Course Assessment metho	ods	:	Continuous assessment through tutorials, attendance,
			home assignments, quizzes and two minor tests and one
Course Objectives			major theory examination.
		:	The objective of this course is to impart the knowledge on
			fundamentals of CMOS VLSI, associated technologies,
			their circuit level models with principles of operation,
			design of the fundamental blocks of VLSI circuits, and
			further to develop hands-on skills of using CAD tools in
Course Outcomes			VLSI design.
		:	The students are expected to be able to demonstrate the
			following knowledge, skills and attitudes after completing
			this course.

- 1. Able to Elucidate the CMOS process flow.
- 2. Able to Analyze various critical processing steps in microfabrication.
- 3. Able to Appreciate the advanced methods involved in IC fabrication.
- 4. Able to understand the concept of diffusion.
- 5. Understanding the knowledge of thin film deposition.
- 6. Gain understanding of CVD techniques.

# **Topics Covered**

# UNIT-I

Introduction: History of IC's; Operation & Models for Devices of Interest: CMOS and MEMS. Electronic Materials: Crystal Structures, Defects in Crystals, Si, Poly Si, Si Crystal Growth. Clean room and Wafer Cleaning: Definition, Need of Clean Room, RCA cleaning of Si.

Oxidation: Dry and Wet Oxidation, Kinetics of Oxidation, Oxidation Rate Constants, Dopant Redistribution, Oxide Charges, Device Isolation, LOCOS, Oxidation System UNIT-II

Lithography: Overview of Lithography, Radiation Sources, Masks, Photoresist, Components of Photoresist Optical Aligners, Resolution, Depth of Focus, Advanced Lithography: E-beam Lithography, X-ray Lithography, Ion Beam Lithography.

## UNIT-III

Diffusion: Pre-Deposition and Drive-in Diffusion Modeling, Dose, 2-Step Diffusions,

Successive Diffusion, Lateral Diffusion, Series Resistance, Junction Depth, Irvin's Curves, Diffusion System. Ion Implantation: Problems in Thermal Diffusion, Advantages of Ion Implantation, Applications in ICs, Ion Implantation System, Mask, Energy Loss Mechanisms, Depth Profile, Range & Straggle, Lateral Straggle, Dose, Junction Depth, Ion Implantation Damage, Post Implantation Annealing, Ion Channeling, Multi Energy Implantation

Thin Film Deposition: Physical Vapor Deposition: Thermal evaporation, Resistive Evaporation, Electron beam evaporation, Laser ablation, Sputtering Chemical Vapor Deposition: Advantages and disadvantages of Chemical Vapor deposition (CVD) techniques over PVD techniques, reaction types, Boundaries and Flow, Different kinds of CVD techniques: APCVD, LPCVD, Metalorganic CVD (MOCVD), Plasma Enhanced CVD etc.

### **UNIT-IV**

Etching: Anisotropy, Selectivity, Wet Etching, Plasma Etching, Reactive Ion Etching. Overview of Interconnects, Contacts, Metal gate/Poly Gate, Metallization, Problems in Aluminum Metal contacts, Al spike, Electromigration, Metal Silicides, Multi-Level Metallization, Planarization, Inter Metal Dielectric.

# **Text and Reference Books**

1. Silicon VLSI Technology, Plummer, Deal and Griffin, 1st Edition,

Pearson Education,2009

2. Fundamental of Semiconductor Fabrication, Sze and May, 2nd Edition, Wiley India, 2009

3. Silicon Process Technology, S K Gandhi, 2nd Edition, Wiley India, 2009

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Course Code: EEC-902	Minor Pro	ojec	et
Course category		:	Program Elective
Pre-requisite Subject		:	NIL
Contact hours/week		:	Lecture: 3, Tutorial:1, Practical:0
Number of Credits		:	4
Course Assessment met	hods	:	Continuous assessment through tutorials, attendance,
			home assignments, quizzes and two minor tests and one
			major theory examination.
<b>Course Objectives</b>		:	The objective of this course is to gain an in-depth
			understanding of theories of VLSI design to model the
			logic circuits for industrial requirements.
<b>Course Outcomes</b>		:	The students are expected to be able to demonstrate the
			knowledge, skills and attitudes after completing this
			course.