B.TECH.
ELECTRONICS ENGINEERING
(VLSI DESIGN & TECHNOLOGY)

CURRICULUM w.e.f. 2025-26
(also applicable to UG students admitted in year 2024 onwards)

Program Outcomes (POs)

1. **Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals to the solution of complex engineering problems for Electronics engineering (VLSI Design and Technology).
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.
3. **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes related to Electronics engineering (VLSI Design and Technology) that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
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.
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.
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.
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.
8. **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
9. **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10. **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
11. **Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one’s own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
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 (PSOs)

1. Apply the knowledge of complete design flow in areas of both digital and analog VLSI Design to implement engineering solutions.

2. Apply appropriate techniques and modern engineering hardware and software tools for the design and integration of semiconductor devices and VLSI systems for the advancement of technology.

Programme Educational Objectives (PEOs)

1. Graduates will have strong engineering knowledge and technical competence to use techniques and skills that allow them to work effectively as VLSI / process engineers in diversified sections of industry, government organizations, public sector undertaking or as an entrepreneur for a successful professional career.

2. Graduates will be actively pursuing higher education for professional development.

3. Graduates will have the motivation for perennial learning and progress their careers by exhibiting leadership qualities with demonstrable attributes in lifelong learning to contribute to the societal needs.

CREDITS BREAK-UP FOR B.TECH. PROGRAMME w.e.f 2025-26 session (Applicable to UG students admitted in the 2024-25 also)

CURRICULAR COMPONENTS	**Institute Existing Credits Breakup (2023-24)**	**Proposed Credits Breakup (2024-25)**
(A) Institute Core Courses (ICC) a) Basic Sciences (BSC) b) Engineering Sciences (ESC) c) General Science (GSN)	 16 20 02	 16 20 02
Total	**38**	**38**
(B) **Humanities, Communication and Management Elective Courses (HSSMEC)**	12	9 + 3#
(C) Department Core Courses (DCC)	56	56
(D) Departmental Elective Courses (DEC)	16	16
(E) Institute Open Elective Courses (OEC)	12	8 + 3$
(F) Projects (Minor/ Major Project-I & II)	12	12
(G)Internship/ Course Work* (4 credits of Deptt. Elective + 4 credits of Open Elective + 4 credits of Project Work) * **Optional**	12	12
(H) Non-Academic Courses (NAC)	4	4
Grand Total (For those who **do not opt** for Honours/Minor Specialization)*****	162	161
(I) Honours/ Minor Specialization	12/18	12/18
Grand Total (For those who **opt** for degree with Honours/Minor Specialization)	162+ 12/18	161+12/18

EVC Course by Wadhwani Foundation.,
$ Mandatory Open Elective course(s) to be taken from MOOCs platform

Semester wise Revised UG Scheme to be implemented w.e.f. 2025-26 session (Applicable to UG students admitted in the 2024-25 also)

S.No.	SEMESTER-I	Credits
1	Orientation	1
2	Introduction to Discipline Engineering	1
	SEMESTER-I (Pool A/ Pool B)	
3	BSC-I (Mathematics)	4
4	BSC-II(Physics) / BSC-IV Chemistry)	4
5	Environmental Science/ Universal Human Values	1
6	ESC-I/ESC-II ***	4
7	HSM-I/ ESC-III & ESCVII***	3/2&2
8	ESC-V(or ESC-VI)/ESC-IV	4
	TOTAL	**22/23**

SEMESTER-II (Pool A/ Pool B)		
S.No.		**Credits**
1	BSC-III (Mathematics)	4
2	BSC-IV (Chemistry)/ BSC-II (Physics)	4
3	Universal Human Values / Environmental Science	1
4	ESC-II/ ESC-I***	4
5	ESC-III & ESCVII ***/ HSM-I	2&2/3
6	ESC-IV/ ESC-V (or ESC-VI)	4
	TOTAL	**21/20**

SEMESTER-III		
S.No.		**Credits**
1	***EVC by Wadhwani Foundation (HSM-II)***	3
2	Deptt Core Courses (DCC)	16
3	***OE-I (MOOCs course)***	**3**
	TOTAL	**22**

SEMESTER-IV		
S.No.		**Credits**
1	Deptt Core Courses (DCC)	24
	TOTAL	**24**

SEMESTER-V		
S.No.		**Credits**
1	Deptt Core Courses (DCC)	16
2	Minor Project	4
	TOTAL	**20**

SEMESTER-VI		
S.No.		**Credits**
1	**Internship Training (Optional)**	12
	Students opting for course work will do Deptt. Elective (4 credits), Open Elective (4 credits) and Project Work (4 credits)	
	TOTAL	**12**

SEMESTER-VII		
S.No.		**Credits**
1	HSM-III	3
2	DEC-I	4
3	DEC-II	4
4	OE-II	4
5	Major Project-I	4

SEMESTER-VIII		
S.No.		**Credits**
1	HSM-IV	3
2	DEC-III	4
3	DEC-IV	4
4	OE-III	4
5	Proficiency	2

	TOTAL	**19**
ABBREVIATIONS		
Basic Science Course		BSC
Engineering Science Course		ESC
Humanities, Social Sciences & Mgmt.		HSM

6	Major Project-II*	4
	TOTAL	**21**
ABBREVIATIONS		
Department Core Course		DCC
Department Elective Course		DEC
Open Elective Course		OE

Total Credits = 161 without Honors/Minor Specialization

Honours Degree

Semester		Credits
V	Honours Project-I	3
VII	Honours Project-II*	4
VIII	Honours Project-III**	5
	TOTAL	**12**

Minor Specialization

Semester		Credits
III	Minor Specialization Course-I	4
IV	Minor Specialization Course-II	4
V	Minor Specialization Course-III	4
VII	Minor Specialization Project-I	3
VIII	Minor Specialization Project-II*	3
	TOTAL	**18**

Total Credits = 161 + 12/18 with Honors/Minor Specialization

* It is proposed that 'A+' grade should only be given to students who have at least one paper accepted/published in refereed Journal or full-length papers published in peer reviewed conferences organized by IISC/IIT/NIT/IIIT/Premier R&D organizations/ Professional societies or any patent published or first 3 position holders in any reputed national hackathons or project competitions or participation in International hackathons or project competitions.

** It is proposed that 'A+' grade should only be given to students who have at least one paper accepted/published in SCI/SCIE/SSCI/Web of Science/SCOPUS Indexed Journals or any patent published or first 3 position holders in any reputed national hackathons or project competitions or participation in international hackathons or project competitions.

*** The following ESC courses are proposed to be mandatory for all branches: -

i. Introduction to Computer Programming (ESC-I)
ii. Engineering Drawing with CAD software (ESC-II)
iii. Skill Development Workshop (IoT& Sensor/Drone Technology etc.) (ESC-III)
iv. Introduction to Mechatronics (ESC-IV)
v. Introduction to Product Design (ESC-VII)

HONOURS / MINOR SPECIALIZATION PROGRAMME

Students with good academic performance (having CGPA ≥ 8.5 for Honours and CGPA ≥ 7 for Minor specialization) and desirous of excelling further in academics have the following opportunities:

a) **Honours:** To get Honours in the parent discipline, a student will have to earn additional 12 credits (over and above 161 credits) in the parent department.

b) **Minor Specialization:** To get Minor specialization, a student will have to complete 18 credits (over and above 161 credits) by doing courses outside the parent department during the entire duration of the programme in the institute.

Honours/ Minor specialization will be awarded to a student on the recommendation of the DAPC of the parent department. A student may do Honours, Honours with Minor Specialization OR Minor Specialization only.

Semester-wise Scheme B.Tech. Electronics Engineering (VLSI Design & Technology)
1ST TO 8TH SEMESTER
2023-24 ONWARDS

SEMESTER-I						
S.No.	**Course ID**	**Course Name**	**L**	**T**	**P**	**Credits**
1	OR2301	Orientation	-	-	-	1
2	OR2302	Introduction to Discipline Engineering	1	0	0	1
3	MA2301	Calculus	3	0	2	4
4	CH2301	Applied Chemistry-I (ECE, VLSI, M&C & AI)	3	0	2	4
5	GS2302	Universal Human Values	1	0	0	1
6	ES2302	Engineering Drawing with CAD Software	2	0	4	4
7	ES2303	Skill Development Workshop	0	0	4	2
8	ES2307	Introduction to Product Design	0	0	4	2
9	ES2304	Introduction to Mechatronics	3	0	2	4
	Total					23

SEMESTER-II						
S.No.	**Course ID**	**Course Name**	**L**	**T**	**P**	**Credits**
1	MA2302	Linear Algebra, Differential Equations and Vector Calculus	3	0	2	4
2	PY2301	Electromagnetic Theory and Quantum Physics (ECE, VLSI, M&C & AI)	3	0	2	4
3	ES2301	Introduction to Computer Programming	3	0	2	4
4	GS2301	Introduction to Environmental Sciences	1	0	0	1
5	HS2351	Communication Skills	2	0	2	3
6	ES2305	Introduction to Electronics & Electrical Engineering (Aero, ECE & VLSI, AI & M&C)	3	0	2	4
	Total					20

SEMESTER-III						
S.No.	**Course Code**	**Course Name**	**L**	**T**	**P**	**Credits**
1		EVC by Wadhwani Foundation (HSM-II)				3
2	VLN301	Digital Logic Design	3	0	2	4
3	VLN302	Semiconductor Devices and Circuits	3	0	2	4
4	VLN303	Network and Circuit Theory	3	1	0	4
5	VLN304	Semiconductor Materials Synthesis and Characterization	3	0	2	4
6		OE-I (MOOCs course)				3
		Total				**22**

SEMESTER-IV						
S.No.	**Course Code**	**Course Name**	**L**	**T**	**P**	**Credits**
1	VLN401	Signals & Systems	3	1	0	4
2	VLN402	Microprocessors and Microcontrollers	3	0	2	4
3	VLN403	Analog Electronics	3	0	2	4
4	VLN404	CMOS Digital VLSI Design	3	0	2	4

5	VLN405	Introduction to Microfabrication	3	0	2	4
6	VLN406	Semiconductor Memories	3	0	2	4
		Total				**24**

SEMESTER-V						
S.No.	**Course Code**	**Course Name**	**L**	**T**	**P**	**Credits**
1	VLN501	Embedded Systems Design	3	0	2	4
2	VLN502	CMOS Analog IC Design	3	0	2	4
3	VLN503	Electronics System Packaging	3	1	0	4
4	VLN504	VLSI Verification and Testing	3	0	2	4
5	VLP511	Minor Project	0	0	8	4
		Total				**20**

SEMESTER-VI						
S.No.	**Course Code**	**Course Name**	**L**	**T**	**P**	**Credits**
1	VLN601	Internship Part-I	0	0	12	6
2.	VLN602	Internship Part-II	0	0	4	2
3.	VLN603	Internship Part-III	0	0	8	4
Or Optional Course Work						
1		Deptt. Elective Course-V	3	1/0	0/2	4
2		Open Elective	3	1	0	4
3	VLP601	Project Work	0	0	8	4
		Total				**12**

SEMESTER-VII						
S.No.	**Course Code**	**Course Name**	**L**	**T**	**P**	**Credits**
1		HSM-III/ HSM-IV				3
2		Deptt. Elective Course-I				4
3		Deptt. Elective Course-II				4
4		Open Elective –I	3	1	0	4
5		Open Elective-II	3	1	0	4
6	VLP701	Major Project-I	0	0	8	4
		Total				**23**

SEMESTER-VIII						
S.No.	**Course Code**	**Course Name**	**L**	**T**	**P**	**Credits**
1		HSM-IV/ HSM-III				3
2		Deptt. Elective Course-III				4
3		Deptt. Elective Course-IV				4
4		Open Elective –III				4
5		Proficiency				2
6	VLP801	Major Project-II	0	0	8	4

		Total	**21**

Minor Specialization in VLSI Design

S.No	Course Code	Semester	Course Name	L	T	P	Credits
1	VLM101	III	HDL Based System Design	3	0	2	4
2	VLM102	IV	Digital and Analog VLSI Design	3	0	2	4
3	VLM103	V	Introduction to Microfabrication	3	0	2	4
4	VLM104	VII	Minor Specialization Project-I	0	0	6	3
5	VLM105	VIII	Minor Specialization Project-II	0	0	6	3
			Total				**18**

Honours Degree

S.No	Course Code	Semester	Course Name	L	T	P	Credits
1	VLH101	V	Honours Project-I	0	0	6	3
2	VLH102	VII	Honours Project-II	0	0	8	4
3	VLH103	VIII	Honours Project-III	0	0	10	5
			Total				**12**

LIST OF DEPARTMENT CORE COURSES

S. No.	Course Code	Department Core Course (DCC)	L	T	P
1	VLN301	Digital Logic Design	3	0	2
2	VLN302	Semiconductor Devices and Circuits	3	0	2
3	VLN303	Network and Circuit Theory	3	1	0
4	VLN304	Semiconductor Materials Synthesis and Characterization	3	0	2
5	VLN401	Signals & Systems	3	1	0
6	VLN402	Microprocessors and Microcontrollers	3	0	2
7	VLN403	Analog Electronics	3	0	2
8	VLN404	CMOS Digital VLSI Design	3	0	2
9	VLN405	Introduction to Microfabrication	3	0	2
10	VLN406	Semiconductor Memories	3	0	2
11	VLN501	Embedded Systems Design	3	0	2
12	VLN502	CMOS Analog IC Design	3	0	2
13	VLN503	Electronics System Packaging	3	1	0
14	VLN504	VLSI Verification and Testing	3	0	2

LIST OF DEPARTMENT ELECTIVE COURSES

S. No.	Course Code		Department Elective Course (DEC)	L	T	P
1	DEC I	VLE105	MEMS and NEMS	3	1	0
2		VLE106	HDL Based System Design	3	0	2
3		VLE107	Optoelectronics	3	0	2
4		VLE108	VLSI Digital Signal Processing	3	1	0
5	DEC II	VLE109	Semiconductor Package Manufacturing	3	1	0
6		VLE110	Semiconductor Device Modelling	3	1	0
7		VLE111	Control Systems	3	1	0
8		VLE112	High Speed Interconnects	3	1	0
9	DEC III	VLE113	Nanoscale Devices	3	1	0
10		VLE114	Low Power VLSI Design	3	1	0
11		VLE115	Silicon Photonics	3	0	2
12		VLE116	Flexible Electronics	3	1	0
13	DEC IV	VLE117	Compound Semiconductors	3	1	0
14		VLE118	Mixed Signal Design	3	1	0
15		VLE119	Computer Architecture	3	1	0
16		VLE120	Quantum Materials and Devices	3	1	0
17	DEC V (for 6th Semester students)	VLE108*	VLSI Digital Signal Processing	3	1	0
18		VLE111*	Control Systems	3	1	0
19		VLE115*	Silicon Photonics	3	0	2
20		VLE119*	Computer Architecture	3	1	0

*Course codes of these courses (Offered to 6th semester students who do not opt for internship) are same as department elective courses (with same names) offered to students in other semesters

LIST OF OPEN ELECTIVE COURSES

S. No.	Semester	Course Code	Open Elective Course (OE)	L	T	P
1	VI	ECO101	ARDUINO Programming and Raspberry Pi	3	1	0
2	VII	ECO102	ARDUINO Programming and Raspberry Pi	3	1	0
3	VII	ECO103	ARDUINO Programming and Raspberry Pi	3	1	0
4	VIII	ECO104	Neural Networks	3	1	0

LIST OF MINOR SPECIALIZATION COURSES

Minor specialization in VLSI Design

S.No.	Semester	Course Code	Minor Specialization Courses	L	T	P
1	III	VLM101	HDL Based System Design	3	0	2
2	IV	VLM102	Digital and Analog VLSI Design	3	0	2
3	V	VLM103	Introduction to Microfabrication	3	0	2
4	VII	VLM104	Minor Specialization Project-I	0	0	6
5	VIII	VLM105	Minor Specialization Project-II	0	0	6

CORE COURSES

Course Name	**:**	**DIGITAL LOGIC DESIGN**
Course Code	**:**	**VLN301**
Credits	**:**	**4**
L T P	**:**	**3-0-2**

Course Objectives:
The student should be able toA

- Apply the rules and laws of Boolean algebra in logic analysis and design.
- Explore the principles and methodology of digital logic analysis and design at the gate level, including both combinational and sequential logic elements.
- Explain the characteristics of different types of memories, logic families and analog to digital and digital to analog converters.
- Develop the digital circuits through laboratory and simulation experiments.

Total No. of Lectures – 42

Lecture wise breakup		**No. of Lectures**
Unit 1	**DIGITAL FUNDAMENTALS** Theorems of Boolean algebra, Sum of Products and Products of Sum forms, Boolean function minimization, Logic gates, Universal building blocks- NAND and NOR gates.	5
Unit 2	**COMBINATIONAL LOGIC** Review of Arithmetic circuits, Parallel binary adder, Combined adder-subtractor, BCD adder-subtractor, binary multiplier, magnitude comparator, code converter, encoder-decoder, function realization using multiplexer- demultiplexer, parity detector and generator, three state gate.	6
Unit 3	**INTRODUCTION TO VHDL** Behavioral – data flow, and algorithmic and structural description, lexical elements, data objects types, attributes, operators; VHDL coding examples, combinational circuit design examples in VHDL and simulation.	5
Unit 4	**SYNCHRONOUS SEQUENTIAL LOGIC** Latches and Flip Flops (SR, D, JK, T), Timing in sequential circuits, Shift registers, Counters – synchronous and asynchronous, Synchronous Sequential circuit analysis and design, Finite state machines.	9
Unit 5	**ASYNCHRONOUS SEQUENTIAL CIRCUITS** Analysis Procedure, Circuits with latches; Design Procedure, Reduction of state and flow table; Race free state assignment.	5
Unit 6	**DIGITAL MEMORIES & PROGRAMMABLE LOGIC** ROM, RAM (static and dynamic), PROM, PLA and PAL.	4
Unit 7	**LOGIC FAMILIES** Brief overview of Transistor as a switch, Logic gate characteristics – propagation delay, speed, noise margin, fan-out and power dissipation, Standard TTL and static CMOS gates.	4

Unit 8	**A/D AND D/A CONVERTERS** Various types of A/D and D/A Converters, Performance Parameters (Resolution, Accuracy etc.).	4

List of Experiments:		**No. of Turns**
1	Introduction to Proteus software and HDL simulation software and front-end work flow using Xilinx Vivado software.	1
2	Implementation of various arithmetic circuits (4-bit parallel adder, combined adder-subtractor, multiplier, BCD adder).	2
3	Implementation and simulation of code converters.	1
4	Implementation and simulation of other combinational circuits like multiplexers, encoders, decoders, etc.	2
5	HDL implementation of various arithmetic and logical circuits.	2
6	Implementation and simulation of synchronous sequential circuits like Flip-flops, registers and counters.	3
7	Simulation of an application based on digital circuits and its logic synthesis using FPGA.	2

Course Outcomes: By the end of this course, students will be able to	
1	Apply the concepts of Boolean algebra for designing and simplifying logic circuits.
2	Design and analyze various combinational circuits like MUX, DEMUX, PLDs, etc.
3	Design and analyze various synchronous and asynchronous sequential circuits like flip-flops, counters, FSMs, etc.
4	Compare different logic families, memories and A/D and D/A converters and compare them on the basis of their performance.
5	Implement different combinational and sequential circuits using the ICs of basic logic gates and simulate them using VHDL.

Suggested Books:

Text Books		
S.No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Digital Design by Morris Mano, PHI, 4th edition	2008
2	Digital principles and Applications, by Malvino Leach, TMH	2011
3	Modern Digital Electronics, by R P Jain, TMH	2006

Reference Books		
S.No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Digital System Principles and Applications, by R J Tocci (PHI)	2009
2	Digital Integrated Electronics, by Taub Schilling, TMH	2004
3	Digital Electronics: Principles, Devices and Applications, by A. K Maini, Wiley	2007

Equivalent MOOCs courses:

S.No.	Course Links	Offered by
1	https://onlinecourses.nptel.ac.in/noc22_ee55/preview	NPTEL
2	https://www.coursera.org/learn/digital-system	Coursera

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	H	H						M				H	H
CO2	H	H	H						M				H	H
CO3	H	H	H						M				H	H
CO4	H	H	H						M				H	H
CO5	H	H	H		H				M	M	H		H	H

Course Name	**:**	**SEMICONDUCTOR DEVICES AND CIRCUITS**
Course Code	**:**	**VLN302**
Credits	**:**	**4**
L T P	**:**	**3-0-2**

Course Objectives:
The student should be able to

- Explain the physics and operation of semiconductor devices such as PN junction diode, BJT and FET.
- Analyze the characteristics and the various biasing techniques of the devices.
- Analyze the mathematical models of transistor and explain the behaviour and frequency response of amplifier circuits using that model.
- Describe the working operation of other semiconductor devices.
- Illustrate and demonstrate hands-on working of active semiconductor devices using discrete components and evaluate their performance with various testing and measuring equipments.

Total No. of Lectures – 42

Lecture wise breakup		**No. of Lectures**
Unit 1	**SEMICONDUCTOR PHYSICS** Electron affinity, work function, quasi-states, fermi level, Equilibrium Carrier concentration, Temperature dependence on carrier concentration, Drift, Diffusion, Recombination-generation	6
Unit 2	**PN JUNCTION DIODE AND DIODE CIRCUITS** Space charge at a junction, electrostatic analysis of junction at different bias conditions, band diagrams, Depletion and Diffusion Capacitances, Switching Characteristics, and Breakdown Mechanisms, Rectifier circuits, Zener diode as Voltage regulators, Clippers, Clampers, Special purpose diodes, Metal-Semiconductor Junctions: Schottky barrier, Rectifying and Ohmic Contacts	8
Unit 3	**BIPOLAR JUNCTION TRANSISTORS** Transistor operation, Carrier Distribution, Transit Time, Transistor configurations, characteristics of CB, CE and CC configuration, Transistor as an amplifier, Load line and Operating point, Bias stability, various biasing circuits, Thermal Runaway, Thermal stability	5
Unit 4	**METAL OXIDE FIELD EFFECT TRANSISTORS** Basic Operation, Ideal MOS Capacitor, Electrostatic analysis, Effects of real surfaces, Threshold Voltage, Body effect, C-V and I-V Characteristics	8
Unit 5	**AMPLIFIERS** Small-Signal Model, FET/MOSFET; Biasing and Design of FET/MOSFET (CS, CG, and CD) Amplifiers, Frequency Response of Amplifiers, High Frequency Device Models, Gain bandwidth product	8
Unit 6	**OTHER SEMICONDUCTOR DEVICES** Compound semiconductor based electronic, optoelectronic, and photonic devices and integrated circuits, CCD and imaging devices	7

List of Experiments		**No. of Turns**
1	To familiarize with electronic components and various testing and measuring equipment.	2
2	To study the V-I characteristics of PN junction diode and determine static resistance and dynamic resistance.	2
3	To simulate and implement clipper and clamper circuits.	2
4	To simulate and implement half wave and full wave rectifier.	2
5	To simulate and implement BJT in different configurations and observe the characteristics.	2
6	To simulate and implement MOSFET in different configurations and observe the characteristics.	2
7	To simulate and verify the operation of BJT/MOSFET as an amplifier and draw the frequency response.	2

Course Outcomes: By the end of this course, students will be able to	
1	Analyse simple electronic circuits based on the knowledge of devices such as diodes and transistors (BJT and FET).
2	Design and analyse bias circuits for BJTs/FETs for the basic configurations.
3	Analyse the modelling of transistor and formulate the performance parameters of the amplifier.
4	Design of amplifiers and perform frequency analysis using small signal model.
5	Demonstrate basic skills using electronic devices simulation programs, implement and analyse the same using discrete devices.

Suggested Books:

Text Books

S.No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	D. A. Neamen and D. Biswas, Semiconductor Physics and Devices, 4th edition. Tata McGraw-Hill, 2012.	2012
2	R. F. Pierret, Semiconductor Device Fundamentals. Pearson	2018
3	B. Razavi, Fundamentals of Microelectronics, 2nd edition. Wiley-India, 2014.	2014

Reference Books		
S.No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	B. G. Streetman and S. K. Banerjee, Solid State Electronic Devices, 7th edition. Pearson, 2015.	2015
2	A. S. Sedra and K. C. Smith, Microelectronic Circuits: Theory and Applications, 7th edition. Oxford, 2017.	2017
3	Millman&Halkias, Electronic devices and circuits, TMH	2017
4	Sedra, A. S., Smith, K. C., and Chandorkar, A. N., (2013), Microelectronic Circuits: International Version, 6th Edition, Oxford University Press	2013

Equivalent MOOCs courses:

S.No.	Course Links	Offered by
1	Semiconductor Devices and Circuits by Prof. Sanjiv Sambandan Semiconductor Devices and Circuits - Course (nptel.ac.in)	NPTEL
2	Fundamentals of Electronic Materials and Devices By Prof. Parasuraman Swaminathan Fundamentals Of Electronic Materials And Devices - Course (nptel.ac.in)	NPTEL
3	Basic Electronics and Lab, IIT Madras, Prof. T.S. Natarajan NPTEL	NPTEL

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	H	H						M				H	H
CO2	H	H	H						M				H	H
CO3	H	H	H						M				H	H
CO4	H	H	H						M				H	H
CO5	H	H	H		H				H	M	H		H	H

Course Name	**:**	**NETWORK AND CIRCUIT THEORY**
Course Code	**:**	**VLN303**
Credits	**:**	**4**
L T P	**:**	**3-1-0**

Course Objectives:
The student should be able

- To apply sinusoidal steady-state analysis techniques to AC circuits.
- To evaluate the responses of circuits in time domain and frequency domain.
- To analyze graph theory principles to electrical networks.
- To explore the synthesis of networks using elements of realizability and stability criteria.
- To design passive filters, including low-pass, high-pass, band-pass and band-stop filters and their frequency responses.

Total No. of lectures: 42

Lecture wise breakup		**No. of Lectures**
Unit 1	**SINUSOIDAL STEADY STATE ANALYSIS** Sinusoids, Phasors, Impedance and admittance, Kirchhoff's law in frequency domain, impedance combinations, steady state analysis: nodal and mesh analysis, dependent, independent voltage and current sources, source transformation, Thevenin and Norton equivalent. AC power analysis: instantaneous and average power, max average power transfer, RMS value, apparent power and power factor, complex power, conservation of AC power. Three phase circuits: types of load and source connections, power in balanced three phase circuits, star delta transformations. Network theorems.	8
Unit 2	**TRANSIENT NETWORK ANALYSIS** Complex frequency and Laplace transforms, circuits analysis in S domain, poles, zeros, transfer Functions and driving point impedances and convolution, Time domain response of RL, RC & RLC Circuits.	8
Unit 3	**TWO PORT NETWORKS** Short circuit admittance parameter, open circuit impedance parameters, hybrid and transmission parameters, series parallel and tandem connection of two port networks, multi-port networks, multi terminal networks, indefinite admittance matrix and its properties, relationships among different network parameters, Concept of Distributed elements, Equations of Voltage and Current, Types of Transmission lines, Standing Waves and Impedance Transformation	6
Unit 4	**NETWORK SYNTHESIS** Elements of realizability theory: causality and stability, Hurwitz polynomials, positive real functions, elementary synthesis procedure, synthesis of one port network with two kinds of element: L-C driving point immittances, synthesis of R-L, L-C functions.	10

Unit 5	**GRAPH THEORY** Introduction, Linear graph of a network, Tie-set and cut-set schedule, incidence matrix, Analysis of resistive network using cut-set and tie-set, Dual of a network.	5
Unit-6	**FILTERS** Series and parallel resonance, single and double tuned circuits. Passive filters: low-pass, high-pass, band-pass and band-stop filters, difference between actual and ideal frequency response.	5

Course Outcomes:

By the end of this course, the students will be able to

1	Solve simple and complex DC and AC circuits using various methods such as nodal, mesh and graph analysis.
2	Predict the circuit response in time domain and frequency domain using Laplace transform.
3	Estimate the stability of a network immittance functions and support the same from pole zero plot analysis.
4	Design a passive electrical network from a given impedance / admittance function.
5	Examine two-port networks using various parameters and describe various filter circuits.

Suggested Books:

Text Books

S.No.	Name of Book/Authors/Publisher	Year of Publication/ Reprint
1	Network Analysis, M.E Van Valkenburg, PHI 3rd edition	2019
2	Fundamentals of Electric Circuits, C K Alexander & Matthew N O Sadiku, Mc Graw Hill, 7th edition.	2022
3	Circuit Theory Analysis and Synthesis, A. Chakrabarty, Dhanpat Rai Publishing Company (P) Limited.	2008

Reference Books

S.No.	Name of Book/Authors/Publisher	Year of Publication/ Reprint
1	Engineering Circuit Analysis, W H Hayt, J E Kemmerly& S M Durbin, Tata McGrawHill Education	2005
2	Sonar for Practicing Engineers (3rd edition), by A.D. Waite, Wiley Publications.	2002
3	Fundamentals of Electric Circuit Theory, by D. Chattopadhyay, P.C Rakhshit, S.Chand (G/L) & Company Ltd	2020

Equivalent MOOCs courses:

S.No.	Course Links	Offered by
1	Circuit Theory, IIT Delhi, Prof. S.C. Dutta Roy https://nptel.ac.in/courses/108102042	NPTEL
2	Network Analysis, IIT Kharagpur, Prof. T.K. Bhattacharya https://nptel.ac.in/courses/108105159	NPTEL

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	H	H						M				H	H
CO2	H	H	H						M				H	H
CO3	H	H	H						M				H	H
CO4	H	H	H						M				H	H
CO5	H	H	H						M				H	H

Course Name	**:**	**SEMICONDUCTOR MATERIAL SYNTHESIS AND CHARACTERIZATION**
Course Code	**:**	**VLN304**
Credits	**:**	**4**
L T P	**:**	**3 0 2**

Course Objectives :
The student should be able

- To explore various material synthesis and characterization techniques.
- To utilize nanomaterials for various applications.
- To explore compound semiconductor materials and associated applications.
- To have hands-on experience of material synthesis and characterization tools.

Total No. of Lectures – 42

Lecture wise breakup		**No. of Lectures**
Unit 1	**INTRODUCTION** Structure of solids: Introduction to engineering materials, Description of materials science tetrahedron, Force - interatomic distance curve, Structure - description of unit cell and space lattices, Coordination number, Miller indices, Non crystalline structures properties of crystalline and amorphous structures, Crystal imperfections.	6
Unit 2	**MATERIAL SYNTHESIS** Top-down and bottom up approaches - physical nanofabrication techniques (PVD, MBE, CVD, self-assembly, lithographic techniques etc.) and wet chemical methods for the synthesis of zero dimensional one dimensional and two dimensional nanostructures-metal nanoparticles, quantum dots, nanoclusters, nanowires and rods, thin films.	10
Unit 3	**COMPOUND SEMICONDUCTORS** Materials properties: Merits of III –V binary and ternary compound semiconductors (GaAs, InP, InGaAs, AlGaAs, SiC, GaN etc.), different SiC structures, silicon-germanium alloys and silicon carbide for high speed devices, as compared to silicon based devices, outline of the crystal structure, dopants and electrical properties such as carrier mobility.	10
Unit 4	**ELECTRON MICROSCOPY** Scanning electron microscopy (SEM), Instrumentation, Electron beam-specimen interaction, Specimen preparation, Transmission electron microscopy (TEM) - Basics of TEM, Electron sources, Specimen preparation, Image modes, Image contrast. Scanning Probe Microscopies: Scanning tunneling microscope (STM) and Atomic force microscope (AFM) - Working principles, working modes, Image artifacts.	8

Unit 5	**APPLICATION OF NANOMATERIALS** Nanomaterials in healthcare, biosenors, coatings environment, catalysis, agriculture, automotives, sensors, electronics, photonics, information technology, quantum computing, energy and aerospace sectors	8

List of Experiments		**No. of Turns**
1	Synthesis of materials using sol-gel technique.	2
2	Thin film depositions using CVD, PECVD, e-beam evaporation.	3
3	Synthesis of Piezoelectric materials.	3
4	Material Characterization from XRD.	3
5	Material Characterization from Scanning Electron Microscope.	3

Course Outcomes: By the end of this course, the students will be able to	
1	Analyze the different concepts of material synthesis through various methods.
2	Develop and use the electrical and material characterization tools.
3	Explain the principles and applications of compound semiconductors.
4	Design the nanomaterials for various applications including healthcare, agriculture etc.

Suggested Books:

Text Books		
S.No.	**Name of Book/ Authors/ Publisher**	**Year of Publication / Reprint**
1	Plummer, Deal , Griffin "Silicon VLSI Technology: Fundamentals, Practice & Modelling" PH, 2001.	2001
2	W.D. Callister, D.G. Rethwisch, Materials science and Engineering: An Introduction, 8th ed., Wiley, 2010.	2010
Reference Books		
S.No.	**Name of Book/ Authors/ Publisher**	**Year of Publication / Reprint**
1	S. Zhang, Lin Li, A. Kumar, Materials Characterisation Techniques, CRC press, 2008	2008
2	Goddard III W.A., et. al.,(Ed.), Handbook of Nanoscience, Engineering, and Technology, Taylor & Francis Group	2018
3	S.M. Sze (Ed), VLSI Technology, 2nd Edition, McGraw Hill.	1998
4	Relevant Research Papers	

Equivalent MOOCs courses:

S.No.	Course Links	Offered by
1	https://archive.nptel.ac.in/courses/118/102/118102003, Nanotechnolgy	NPTEL
2	https://nptel.ac.in/courses/113106062 Fundamentals of Electronic device Fabrication	NPTEL

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	H	H						M				H	H
CO2	H	H	H						M				H	H
CO3	H	H	H						M				H	H
CO4	H	H	H	H	H				M	M			H	H

Course Name	**:**	**SIGNALS AND SYSTEMS**
Course Code	**:**	**VLN401**
Credits	**:**	**4**
L T P	**:**	**3-1-0**

Course Objectives:
The student should be able

- To analyze signals and perform various operations.
- To compute the output of a Linear Time Invariant system given the input and the impulse response through convolution sum and convolution integral.
- To apply Fourier transforms for periodic and non-periodic signals, calculate correlation, and understand energy and power spectral density.
- To apply Laplace transform for signal representation, inversion, and analyzing the region of convergence, transfer functions, causality and stability.
- To apply Z-transform for discrete-time systems, including properties, inverse transforms and computational structures and assess causality and stability.

Total No. of Lectures – 42

Lecture wise breakup		**No. of Lectures**
Unit 1	**INTRODUCTION TO SIGNALS AND SYSTEMS** Signals and systems as seen in everyday life, signals and their classification, basic operations on signals, elementary CT/DT signals, properties and classification of systems, Systems viewed as Interconnection of Operations, Relation between continuous and discrete time systems, Problem Solving using Matlab	8
Unit 2	**TIME DOMAIN REPRESENTATION OF LINEAR TIME INVARIANT SYSTEMS** Introduction, convolution sum and evaluation procedure, convolution integral and evaluation procedure, interconnection of LTI procedures, relation between LTI system properties and impulse response, system representation through differential equations and difference equations, block diagram representation, state variable description, problem solving using MATLAB.	11
Unit 3	**FOURIER REPRESENTATIONS OF SIGNALS** Introduction, complex sinusoids and frequency response of LTI Systems, Fourier representation of discrete time and continuous time periodic signals, Fourier representation of discrete time and continuous time non-periodic signals, properties of Fourier representations, correlation, auto-correlation and cross-correlation and their properties, energy spectral density, power spectral density, sampling theorem, spectra of sampled signals, reconstruction, problem solving using MATLAB	10
Unit 4	**REPRESENTING SIGNALS BY USING CONTINUOUS TIME COMPLEX EXPONENTIALS: THE LAPLACE TRANSFORM:** Introduction, unilateral and bilateral Laplace transform, their inversion and properties, properties of the region of convergence, transfer function, causality and	6

	stability, Laplace transform methods in circuit analysis.	
Unit 5	**REPRESENTING SIGNALS BY USING DISCRETE TIME COMPLEX EXPONENTIALS: THE Z- TRANSFORM:** Z-transform and its properties, region of convergence and its properties, inverse Z-transform, transfer function, causality and stability. Computational structure for implementing discrete time LTI systems, unilateral Z-transforms.	7

Course Outcomes: By the end of this course, students should be able to	
1	Analyze continuous and discrete signals and systems and solve related problems.
2	Represent continuous and discrete signals in the time and frequency domain using different transforms.
3	Analyze and characterize the CT systems through Fourier transform and Laplace transform.
4	Analyze and characterize the DT systems through DTFT and Z-transform
5	Evaluate the responses of linear time-invariant dynamic systems to various input signals

Suggested Books:

Text Books		
S.No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Signals and Systems by A.V. Oppenheim and A.S. Willisky, 2nd edition, Pearson Education	2015
2	Signals and Systems by Simon Haykin and Barry Van Veen, 2nd edition, Wiley	2007
3	Modern Digital & Analog Communication Systems by B.P. Lathi, 4th edition, Oxford	2011
Reference Books		
S.No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Signals And Systems by A. Anand Kumar, 3rd edition, Prentice Hall India Learning Private Limited	2013
2	Introduction to Communication Theory by P.D. Sharma, RoorkeeNem Chand and Sons	1971
3	Circuits and Networks (Analysis and synthesis) by A. Sudhakar and Shyam Mohan S. Palli, 5th edition, McGraw Hill Education	2017

Equivalent MOOCs courses:

S.No.	**Course Links**	**Offered by**
1	Principles of Signals and Systems by Prof. Aditya K. Jagannatham (IIT Kanpur). https://onlinecourses.nptel.ac.in/noc20_ee15/preview.	NPTEL
2	Signals and Systems by Prof. Kushal K. Shah (IISER Bhopal),	NPTEL

	https://onlinecourses.nptel.ac.in/noc21_ee28/preview.	

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	H	H	H						H				H	H
CO2	H	H	H						H				H	H
CO3	H	H	H						H				H	H
CO4	H	H	H						H				H	H
CO5	H	H	H						H				H	H

Course Name	**:**	**MICROPROCESSORS AND MICROCONTROLLERS**
Course Code	**:**	**VLN402**
Credits	**:**	**4**
L T P	**:**	**3 0 2**

Course Objectives:
The student should be able

- To analyze the architecture and operation of typical microprocessors and microcontrollers.
- To explore the programming and interfacing of various microprocessor and microcontroller chips.
- To interface microprocessors with external devices.
- To develop a strong foundation for designing real-world applications using microprocessors and microcontrollers.

Total No. of Lectures – 42

Lecture wise breakup		**No. of Lectures**
Unit 1	**BASIC PROCESSORS** Overview of microcomputer systems and their building blocks, memory interfacing, concepts of interrupts and direct memory access, instruction sets of microprocessors (with examples of 8085 and 8086).	8
Unit 2	**MICROPROCESSORS AND INTERFACING** Interfacing with peripherals - timer, serial I/O, parallel I/O, A/D and D/A converters; arithmetic co-processors; System level interfacing design; Concepts of virtual memory, cache memory, advanced coprocessor architectures- 286, 486, Pentium.	8
Unit 3	**8051 MICROCONTROLLERS ARCHITECTURE AND INSTRUCTION SETS** 8051 Micro-controllers Architecture, Pin configuration, SFR's, memory, 8051 Addressing modes, 8051 assembly language programming, BCD and ASCII Application Programs, 8051 Programming in C: data types and time delay in 8051 C, I/O Programming, logic operations, data conversion programs.	10
Unit 4	**8051 MICROCONTROLLER PROGRAMMING AND INTERFACING** I/O port programming, timers and interrupts, LCD and keyboard interfacing, serial communications Programming etc.	8
Unit 5	**ARM PROCESSOR & ITS INTERFACES** Introduction to RISC processors, ARM microcontrollers and its interface designs, overview of multi-core processors.	8

List of Experiments:		**No. of Turns**
1	Introduction to Microsoft Macro Assemble (MASM)	1
2	Write 8086 ALP for the following: i. 8-bit, 16-bit addition, subtraction, multiplication, division. ii. Searching Largest & Smallest number in an array.	2
3	Write 8086 ALP for the following: i. Sorting in ascending and descending order. ii. Block transfer of data	2

4	Write a program to move a string of data words from offset 2000H to offset 3000H the length of the string is 0FH	2
5	Write an ALP to Add the contents of memory location 2000H:5000H to contents of 3000H:0600H and store the result in 5000H:0700H	1
6	Write an ALP to arrange a given series of hexadecimal bytes in ascending order	1
7	Parallel Communication between two microprocessors using 8255	2
8	Interfacing LCD to 8051	2
9	Interfacing Matrix keyboard to 8051	1
10	ARM microcontroller's basic programs.	2

Course Outcomes:
At the end of this course, students will be able to

1	Recall and apply a basic concept of digital fundamentals to microprocessor and microcontroller based personal computer system.
2	Identify a detailed software and hardware structure of the microprocessor and microcontroller.
3	Illustrate how the different peripherals are interfaced with 8051 microcontroller.
4	Analyze the data transfer information through serial and parallel ports.
5	Develop assembly language programming to design microprocessor / microcontroller based-systems.

Suggested Books:

Textbooks

S.No.	**Name of Book/ Authors/ Publisher**	**Year of Publication / Reprint**
1	Advanced Microprocessors and Peripherals by A. K. Ray and K.M. Bhurchandani, MHE, 2nd Edition, 2006.	Latest edition
2	The 8051 Microcontroller, Kenneth. J. Ayala, Cengage Learning, 3rd Ed.	Latest edition
3	R. S. Gaonkar, Microprocessor Architecture: Programming and Applications with the 8085/8080A, Penram International Publishing, 1996	Latest edition
4	D A Patterson and J H Hennessy, "Computer Organization and Design The hardware and software interface. Morgan Kaufman Publishers.	Latest edition
5	Douglas Hall, Microprocessors Interfacing, Tata McGraw Hill, 1991.	Latest edition

Reference Books

S.No.	**Name of Book/ Authors/ Publisher**	**Year of Publication / Reprint**
1	M.A. Mazidi& J.C. Mazidi Microcontroller and Embedded systems using Assembly & C. (2/e), Pearson Education, 2007.	Latest edition
2	The x86 Microprocessors: 8086 to Pentium, Multicores, Atom and the 8051 Microcontroller: Architecture, Programming and Interfacing by Lyla B Das, Person, 2014.	Latest edition

3	Microprocessors and Interfacing, 9] I4\ I0 D. V. Hall, MGH, 2nd Edition2006	Latest edition
4	The 8051Microcontrollers, Architecture and Programming and Applications - K.Uma Rao, Andhe Pallavi, Pearson, 2009.	Latest edition

Equivalent MOOCs courses:

S. No.	**Course Links**	**Offered by**
1	Microprocessors and Interfacing https://archive.nptel.ac.in/noc/courses/noc20/SEM1/noc20-ee11/	NPTEL
2	Microprocessors and Microcontrollers https://archive.nptel.ac.in/courses/106/108/106108100/	NPTEL

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	H	L	H						M				H	H
CO2	H	L	L						M				H	H
CO3	H	H	H						M				H	H
CO4	H	L	L						M				H	H
CO5	H	H	H		H				M	M			H	H

Course Name	**:**	**ANALOG ELECTRONICS**
Course Code	**:**	**VLN403**
Credits	**:**	**4**
L T P	**:**	**3 0 2**

Course Objectives:
The student should be able to

- Design and analyze feedback amplifier and oscillator circuits.
- Explore the basic building blocks of operational amplifier, their functioning and demonstrate its various applications in analog systems.
- Analyze the working of multivibrators and operating principle of phase locked loop.
- Experience the hands-on working of basic electronic circuits using discrete components and evaluate their performance with various testing and measuring equipments.

Total No. of Lectures – 42

Lecture wise breakup		**No. of Lectures**
Unit 1	**POWER AMPLIFIERS** Class A, B, AB stages, output stages, short circuit protection, power transistors and thermal design considerations	6
Unit 2	**FEEDBACK AMPLIFIERS AND OSCILLATORS** Concept of feedback, negative feedback and its advantages, modification of i/o impedances, sense and return techniques, VCCS, VCVS, CCVS, CCCS, Stability in feedback systems, basic principles of sinusoidal oscillators, tuned collector, tuned base, Hartley oscillator, Colpitt's Oscillator, phase shift oscillator, Wein bridge oscillator, crystal oscillator, frequency stability of oscillator.	8
Unit 3	**CURRENT MIRRORS** Basic current mirrors, Cascode current mirrors, Active current mirrors with large and small signal analysis	6
Unit 4	**DIFFERENTIAL AMPLIFIERS** MOS differential pair's large signal analysis, small signal analysis of differential pairs, cascode differential amplifiers, common-mode rejection, and differential amplifiers with active load, frequency response of cascode and differential amplifiers	10
Unit 5	**OPERATIONAL AMPLIFIERS** Op-Amp characteristics and specifications, concept of virtual ground, Inverting and non-inverting amplifiers, op-amp applications including voltage summer, integrator, differentiator, instrumentation amplifiers, Zero crossing detector, Schmitt trigger, Filter specifications, design of low pass, high pass, band pass and band reject filters using operational amplifiers.	8
Unit 6	**MULTIVIBRATORS** 555 timer as monostable, astable and bistable multivibrator, phase-locked loop (PLL)	4

List of Experiments		No. of Turns
1	To simulate feedback amplifiers and oscillator circuits.	2
2	To simulate and implement the working of RC oscillator.	2
3	To simulate and implement the working of Op-amp as summing and difference amplifier.	1
4	To simulate and implement the working of Op-amp as an integrator and a differentiator.	1
5	To simulate and implement the working of active and passive low-pass filters and observe the frequency response.	2
6	To simulate and implement the working of active and passive high-pass filters and observe the frequency response.	2
7	To simulate and implement the working of astable, monostable and bistable multivibrator using 555 timer.	2
8	Introduce different circuit and design parameters like gain, bandwidth, ICMR, CMRR, PSRR, slew rate and others through DC, AC and transient analysis using SPICE simulations.	2

Course Outcomes: By the end of this course, the students will be able to	
1	Describe and analyze the feedback in amplifiers and operation of various oscillator circuits.
2	Determine the working behavior and analysis of analog circuits like differential amplifiers, current mirrors etc. from the small signal model of the transistors.
3	Explain operational amplifier along with its applications.
4	Identify the multivibrator circuits and explain the basic principle of a phase-locked loop.
5	Demonstrate and use circuit design software and hardware equipment to validate the functioning of analog devices and circuits and their applications.

Suggested Books:

Text Books

S.No.	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1	Sedra, A. S., Smith, K. C., and Chandorkar, A. N., (2013), Microelectronic Circuits: International Version, 6th Edition, Oxford University Press	2013
2	B. Razavi, *Fundamentals of Microelectronics,* 2nd edition. Wiley-India, 2014.	2014

Reference Books

S.No.	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1	Op-amps and linear integrated circuits by Ramakant A Gayakward Prentice hall 4th edition.	2000

2	Electronics Devices & Circuit Theory, R L Boylestead & L Nashelsky, PHI.	2008
3	Electronics Circuit Analysis and Design, Donald A. Neamen, Tata McGraw Hill.	2009
4	Millman, Halkias, Integrated Electronics, TMH.	2016

Equivalent MOOCs courses:

S.No.	**Course Links**	**Offered by**
1	Analog Electronic Circuits, by Prof. Shanthi Pavan Analog Electronic Circuits - Course (nptel.ac.in)	NPTEL
2	ANALOG ELECTRONIC CIRCUITS , IIT Delhi by Prof. S.C. Dutta Roy NPTEL	NPTEL

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	H	H	H						M				H	H
CO2	H	H	H						M				H	H
CO3	H	H	H						M				H	H
CO4	H	H	H						M				H	H
CO5	H	H	H		H				M	M			H	H

Course Name	**:**	**CMOS DIGITAL VLSI DESIGN** *(Pre-requisites: Digital Electronics and Electronic devices and circuits)*
Course Code	**:**	**VLN404**
Credits	**:**	**4**
L T P	**:**	**3 0 2**

Course Objectives:
The student should be able

- To explain the scaling effects on MOSFET.
- To explain the static and dynamic power dissipation in CMOS circuits.
- To design combinational and sequential CMOS circuits.
- To describe the effect of interconnects on crosstalk and delay.

Total No. of Lectures – 42

Lecture wise breakup		**No. of Lectures**
Unit 1	**MOSFET SCALING AND ITS EFFECTS** MOSFET Short Channel Effects, Geometric Scaling Theory and its effects– Full-Voltage Scaling, Constant Voltage Scaling.	5
Unit 2	**DESIGN FLOW AND CMOS INTEGRATED CIRCUITS LAYOUT** 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. CMOS process flow, stick diagram and layout – MOSFET Dimensions, design rules, latch-up.	9
Unit 3	**CMOS INVERTERS** CMOS Inverter, switching threshold and noise margin and their evaluation, static and dynamic behavior, switching characteristics- delay time calculation, Static and dynamic power dissipation, techniques to reduce the power dissipation. Energy and Energy-delay calculations, interconnects: resistance, capacitance and inductance estimation, delay and crosstalk	10
Unit 4	**CMOS COMBINATIONAL LOGIC GATES** Complementary CMOS, Ratioed logic, Pass Transistors logic, Transmission Gate, CVSL, Dynamic logic: basic principle, Speed and Power Dissipation of Dynamic Logic, Issues in Dynamic Design, Cascading Dynamic Gates, NORA-CMOS—A Logic Style for Pipelined Structures	9
Unit 5	**SEQUENTIAL MOS LOGIC CIRCUITS** Behavior of bistable elements, SR latch circuits, clocked latch and flip-flop circuits, CMOS D-latch and edge triggered flip-flop, dynamic transmission-gate edge-triggered registers. Clocks skew.	9
Unit 6	**CASE STUDY** Static timing analysis from cadence e-learning resources	

List of Experiments		**No. of Turns**
1	Familiarization with Simulation Software for schematic, layout entry and circuit simulation	2
2	Perform the DC analysis of an n-channel MOSFET with W/L = 1.4µm/ 0.35µm at 180 nm technology node and plot it's transfer characteristics and output characteristics.	2
3	Design a symmetric CMOS inverter with a load capacitance of 1 pF: a. Perform it's transient analysis. b. Calculate and verify the rise time, fall time and propagation delay.	2
4	Design a symmetric CMOS inverter having W/L=1µm/ 0.18µm: a. Draw it's layout b. Perform the post layout simulations and compare it with schematic for C_L= 2 pF	2
5	Design and verify a 2-input CMOS NAND and NOR gates which can drive a load capacitance of 1 pF. Calculate and verify it's rise time, fall time and propagation delay.	2
6	Design and plot the characteristics of a positive and negative SR latch	2
7	Design and plot the characteristics of a positive and negative edge triggered register.	2

Course Outcomes: By the end of this course, the students will be able to	
1	Describe the scaling effects on MOS devices.
2	Analyse the complete design of CMOS inverter, static and dynamic power dissipation in CMOS circuits.
3	Explain various MOS combinational and sequential circuits.
4	Analyse delay and noise effect of interconnects.
5	Design and analyse the layout and schematics of various digital VLSI circuits using CAD tools.

Suggested Books:

Text Books		
S.No.	**Name of Book/ Authors/ Publisher**	**Year of Publication / Reprint**
1	Digital Integrated Circuits – A Design Perspective, J.M. Rabaey, A.P. Chandrakasen and B. Nikolic, Pearson Education 2nd ed.	Latest edition
2	CMOS Digital Integrated Circuits – Analysis and Design, S. Kang and Y. Leblebici, Tata McGraw Hill 3rd ed.	2008

Reference Books		
S.No.	**Name of Book/ Authors/ Publisher**	**Year of Publication / Reprint**
1	CMOS VLSI Design: A Circuits and Systems Perspective, N.H.E. Weste and K. Eshraghian, Addision Wesley 2nd ed.	1998
2	CMOS Circuit Design, Layout and Simulation, R.J. Baker, H. W. Lee, and D. E. Boyce, Wiley - IEEE Press 2nd ed	2004

Equivalent MOOCs courses:

S.No.	Course Links	**Offered by**
1	CMOS Digital VLSI Design By Prof. Sudeb Dasgupta, IIT Roorkee https://archive.nptel.ac.in/courses/108/107/108107129/	NPTEL

Keeping in view the demand for VLSI Design Circuit Engineers, the last unit, that is, the static timing analysis must be covered by the students through E- learning resources of cadence design systems as case study and submit a certificate for its completion.

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	H	H	H						M				H	H
CO2	H	H	H						M				H	H
CO3	H	H	H						M				H	H
CO4	H	H	H						M				H	H
CO5	H	H	H	H	H				M	M		L	H	H

Course Name	**:**	**INTRODUCTION TO MICROFABRICATION**
Course Code	**:**	**VLN405**
Credits	**:**	**4**
L T P	**:**	**3 0 2**

Course Objectives : The student should be able
● To develop a basic understanding of wafer processing, device fabrication technique, device performance, and intended applications. ● To explore the fundamental concepts of device integration on different substrates, as well as the benefits and drawbacks of emerging technology that will be employed in future devices. ● To characterise new materials, study methods and tools for VLSI devices, circuits, and systems. ● To experience hands-on introduction fabrication of semiconductor devices.

Total No. of Lectures – 42

Lecture wise breakup		**No. of Lectures**
Unit 1	**INTRODUCTION** History of IC's; Operation & Models for Devices of Interest: CMOS and MEMS, Definition, Need of Clean Room, RCA cleaning of wafers, Silicon wafers; Crystallography, Production and Defects: Basic silicon wafer parameters, solid solubility of dopants in silicon, defects, and basic economics of operations.	6
Unit 2	**DIFFUSION** Pre-Deposition and Drive-in Diffusion Modelling, 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 Channelling, Multi Energy Implantation.	8
Unit 3	**LITHOGRAPHY** Basic steps in lithography; lithography techniques-optical lithography, electron beam lithography, x-ray lithography, ion beam lithography; resists and mask preparation of respective lithography techniques, printing techniques-contact, proximity printing and projection printing; merits and demerits of lithography techniques; recent trends in lithography at nanoscale.	6
Unit 4	**ETCHING** Performance metrics of etching; types of etching- wet and dry etching; dry etching techniques-ion beam or ion-milling, sputter ion plasma etching and reactive ion etching (RIE); merits and demerits of etching; etching induced defects; recent trends in etching.	6

Unit 5	**THIN FILM DEPOSITION** Thermal evaporation, electron beam evaporation, laser ablation, sputtering, chemical vapour deposition (CVD), Different kinds of CVD techniques: APCVD, LPCVD, metal-organic CVD (MOCVD), plasma enhanced CVD etc, physical vapour deposition (PVD), reaction types.	8
Unit 6	**CHARACTERIZATION AND MEASUREMENT TECHNIQUES** Optical microscope, Scanning Electron Microscope, X-rays diffraction, Atomic Force Microscopy, Secondary Ion Mass Spectroscopy (SIMS), Electrical measurement techniques, SMU, CVU, Probe Station, two probe and four probe measurement technique.	8

List of Experiments		**No. of Turns**
1	Working in cleanroom environment, protocols, wafer handling.	2
2	Thin film deposition using thermal/ e-beam evaporation.	2
3	Pattern transfer using optical lithography.	2
4	Wet and Dry Etching technique.	3
5	Fabrication of MOS capacitors/Schottky diodes.	3
6	Measurement of electrical properties of MOS capacitors/ Schottky diodes.	2

Course Outcomes: By the end of this course, the students will be able to	
1	Work in the cleanroom environment for semiconductor device fabrication.
2	Recognize the basic operation principles of semiconductor fabrication equipment.
3	Analyze IC fabrication methodologies and evaluate component effects on IC design for VLSI and ULSI domains.
4	Demonstrate in-depth knowledge in wafer preparation, lithography and etching, diffusion process, material, device characterization and electrical measurement techniques.

Suggested Books:

Text Books		
S.No.	**Name of Book/ Authors/ Publisher**	**Year of Publication / Reprint**
1	S.M. Sze (Ed), VLSI Technology, 2nd Edition, McGraw Hill,	1988
2	Plummer, Deal , Griffin “Silicon VLSI Technology: Fundamentals, Practice & Modelling” PH.	2001

Reference Books		
S.No.	**Name of Book/ Authors/ Publisher**	**Year of Publication / Reprint**
1	Shubham, Kumar, and Gupta, Ankaj. Integrated Circuit Fabrication. United Kingdom, Manakin Press	2021
2	DIETER K. SCHRODER, Semiconductor Material and Device Characterization	2005
3	MOS Device Physics and Technology, Nicloean and Brews	1982
4	Relevant Research Papers	

Equivalent MOOCs courses:

S.No.	Course Links	Offered by
1	https://nptel.ac.in/courses/117106093 VLSI Technology	NPTEL
2	https://nptel.ac.in/courses/108101089 Fabrication of Silicon VLSI Circuits using the MOS technology, IIT Bombay	NPTEL

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	H			H				M	H			H	H
CO2	H	H		M	H				M	H			H	H
CO3	H	H	H	H	H				M	H			H	H
CO4	H	H	H	H	H				M	H			H	H

Course Name	**:**	**SEMICONDUCTOR MEMORIES**
Course Code	**:**	**VLN406**
Credits	**:**	**4**
L T P	**:**	**3 0 2**

Course Objectives:
The student should be able

- To acquire knowledge about different types of semiconductor memories.
- To describe the architecture and operations of different semiconductor memories.
- To develop the memory design techniques and methodologies.
- To experience hands-on simulations, fabrication and characterization of memory devices.

Total No. of Lectures – 42

Lecture wise breakup		**No. of Lectures**
Unit 1	**INTRODUCTION** Introduction to Semiconductor Memory and CMOS Scaling Overview, Technology scaling. Static Random Access Memories (SRAMs): SRAM Cell Structures-MOS SRAM Architecture, SRAM Technologies-Silicon On Insulator (SOl) Technology-Advanced SRAM Architectures and Technologies- Application Specific SRAMs. Dynamic Random Access Memories (DRAMs), CMOS DRAMs-DRAMs Cell Theory and Advanced Cell Structures	8
Unit 2	**NON-VOLATILE MEMORIES** Masked Read, only memories (ROMs): High density ROMs, programmable read-only memories (PROMs)- bipolar PROMs, CMOS PROMs, erasable (UV)-Programmable read-only memories (EPROMs), EEPROM technology and architecture, non-volatile SRAM-Flash memories (EPROMs or EEPROM), Advanced flash memory architecture	8
Unit 3	**ADVANCE MEMORY DEVICES** ReRAM, FeRAM, PCRAM, MRAM, Nanotube RAM, Comparison among different storage elements, 1T and 1T-1C memory structure, Memory cell characterization: Capacitance Voltage Characteristics, Current Voltage Characterization, Multibit storage, Capacitance time characteristics, Charge retention, Traps as a storage element, Endurance	10
Unit 4	**COMPUTING MEMORY DEVICES** Advance Memory Devices and Computing, Multibit data storage, MIM structure for ReRAM: Types of traps and Filament formation, Resistive memory for neuromorphic computing, Brain Inspired computing, Beyond CMOS compatibility	8
Unit 5	**FAULT MODELLING AND TESTING** Memory fault modelling, testing and memory design for Testability and fault tolerance, RAM fault modelling, electrical testing, Pseudo random testing, megabit DRAM testing non-volatile memory modelling and testing	8

List of Experiments:		**No. of Turns**
1	To design and simulate SRAM cell and create its layout. Analyse the various performance parameters.	2
2	To simulate 1T-1C based DRAM cell and analyse the various performance parameters.	2
3	To deposit thin films of metals and dielectrics for the fabrication of ReRAM.	4
4	To pattern the thin films of metals and dielectrics using Lithography and Etching for ReRAM.	2
5	Measure the V-I Characteristics to understand the hysteresis behaviour of Memory devices.	2
6	To measure Retention and Endurance characteristics of ReRAM.	2

Course Outcomes: By the end of this course, the students will be able to	
1	Analyze the different types of Memory cell design.
2	Design and understand different non-volatile memory cell.
3	Analyze the memory testing and fault tolerance.
4	Design, fabricate and perform electrical characterizations of the memory cell using CAD tools as well as fabrication and measurement equipments.

Suggested Books:

Text Book		
S. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Ashok K. Sharma, Semiconductor Memories Technology, testing and reliability, Prentice hall of India Private Limited, New Delhi 1997.	1997
2	Ashok K Sharna, Advanced Semiconductor Memories – Architecture, Design and Applications, Wiley 2002.	2002
Reference Books		
S. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Nishi, Yoshio, and Blanka Magyari-Kope, eds. Advances in non-volatile memory and storage technology, Woodhead Publishing, 2019.	2019
2	MOS Device Physics and Technology, Nicolean and Brews 1982	1982
3	DIETER K. SCHRODER, Semiconductor Material and Device Characterization	2002
4	Relevant Research Papers	

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	H	H						M				H	H
CO2	H	H	H						M				H	H
CO3	H	H	H						M				H	H
CO4	H	H	H	H	H				M	H			H	H

Course Name	**:**	**EMBEDDED SYSTEMS DESIGN**
Course Code	**:**	**VLN501**
Credits	**:**	**4**
L T P	**:**	**3-0-2**

Course Objectives:
The student should be able

- To examine the AVR microcontroller's architecture, its organization and programming.
- To design and encode an embedded system using high level language.
- To explore the various interfaces for system design.
- To explore advanced microprocessor's architecture and real time operating systems.

Total No. of Lectures – 42

Lecture wise breakup		**No. of Lectures**
Unit 1	**INTRODUCTION TO EMBEDDED SYSTEMS** Basics of developing for embedded systems, embedded system initialization, Fundamentals of Microcontrollers for Embedded Systems, Embedded Versus External Memory Devices, CISC Versus RISC Processors, and Harvard Versus Von-Neumann architecture.	4
Unit 2	**AVR MICROCONTROLLER** ATmega16/32 Microcontroller (Basic architecture, Pin configuration, Memory organization (registers and i/o ports), Embedded C programming, Timers, on chip PWM, on chip ADC, Interrupts and Serial Communication.	10
Unit 3	**EMBEDDED PROGRAMMING** Introduction to C, Difference between C and Embedded C, Data Types used in Embedded C, Arithmetic & Logical Operators, Control Flow, If & If – else, While & Do – while, For, Switch & Case, Continue & Break, Array & String, Functions and Header files, Pointers	6
Unit 4	**INTERFACING** ADC and DAC interfacing, sensors and motors interfacing, display interfacing, serial interfacing	10
Unit 5	**ADVANCED MICROPROCESSOR** Real Time Operating System (RTOS), Types of real time tasks, Task Periodicity, Process state diagram, Kernel and Scheduler, Scheduling algorithms, Shared data (Resource) and Mutual Exclusion, Semaphore, Introduction to ARM, Features, ARM Pipeline, Instruction Set Architecture (ISA), Thumb Instructions, Exceptions in ARM, Embedded Wireless Protocols (Infrared Data Association (IrDA), Bluetooth, IEEE 802.11).	12

List of Experiments		**No. of Turns**
1	Familiarization with microcontroller platforms for system design and	1

	implementation.	
2	Write assembly language program to 1. Multiply two 16 bit binary numbers. 2. Find the sum of first 10 integers. 3. Find the number of 0's and 1's in a 32 bit data. 4. Determine the given 16 bit number is ODD or EVEN. 5. Write data in RAM.	2
	Conduct the following experiments on Microcontroller board to	
3	Implement ADC & DAC interface with Microcontroller.	2
4	Implement a serial communication interface.	2
5	Interface a 4x4 keyboard and display the key code on an LCD.	1
6	Implement a VGA interface.	2
7	Implement a PS2 keypad interface.	2
8	Implement a 4-digit seven segment display.	1
9	Interface a Stepper motor and rotate it in clockwise and anti-clockwise direction.	1

Course Outcomes: By the end of this course, the students will be able to	
1	Describe the fundamental concepts for embedded systems design and complete architecture of the ATMEGA16/32 microcontroller.
2	Identify various on chip peripherals of the ATMEGA16/32 microcontroller and their use in embedded applications.
3	To design FPGA and microcontroller based embedded system using sensors and actuators.
4	Examine the ARM7 microcontroller architecture (32 bit) and wireless protocols.

Suggested Books:

Text Book		
S.No.	**Name of Book/ Authors/ Publisher**	**Year of Publication / Reprint**
1	Muhammad Ali Mazidi, "The AVR microcontroller and Embedded Systems using Assembly and C", 2nd Edition, Pearson Education	2008
Reference Books		
S.No.	**Name of Book/ Authors/ Publisher**	**Year of Publication / Reprint**
1	Frank Vahid / Tony Givargis, "Embedded System Design", Willey India, 2002.	2004
2	A.N. Sloss, D. Symes and C. Wright, "ARM System Developer's Guide: Design and Optimizing System Software", Morgan Kaman Publishers	2004
3	Santanu Chattopadhyay, "Embedded System Design", 1st Edition, PHI Learning, 2010	2003
4	David Simon, "An Embedded Software Primer", Addison Wesley	2000

Equivalent MOOCs courses:

S.No.	Course Links	Offered by
1	Introduction to FPGA Design for Embedded Systems https://www.colorado.edu/ecee/academics/online-programs/ms-ee-coursera/curriculum/embedded-systems/ecea-5360-introduction-fpga	University of Color Boulder
2	Embedded Systems Design https://onlinecourses.nptel.ac.in/noc20_cs14/preview	NPTEL

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	H	H						M				H	H
CO2	H	H	H						M				H	H
CO3	H	H	H	H	H				M	H			H	H
CO4	H	H	H						M				H	H

Course Name	**:**	**CMOS ANALOG IC DESIGN** (*Pre-requisites: Analog electronics and Networks and Systems)*
Course Code	**:**	**VLN502**
Credits	**:**	**4**
L T P	**:**	**3 0 2**

Course Objectives: The student should be able
● To design the layout of analog integrated circuits using analog layout techniques while understanding the analog process flow. ● To analyze the noise characteristics and feedback in basic analog integrated circuits. ● To design operational amplifiers for given specifications. ● To illustrate noise issues, stability and compensation in two stage operational amplifiers and examine bandgap reference circuits.

Total No. of Lectures – 42

Lecture wise breakup		**No. of Lectures**
Unit 1	**INTRODUCTION TO ANALOG PROCESS FLOW AND LAYOUT** Analog process flow. General layout considerations, design rules, antenna effect. Analog layout techniques: multifinger transistors, symmetry, reference distribution.	6
Unit 2	**NOISE** Statistical characteristics of noise-noise spectrum, amplitude distribution correlated and uncorrelated sources. Types of noise- flicker noise and thermal noise. Representation of noise in circuits,Noise in single-stage amplifiers: CG, CS, CD (source follower) and cascode stage. Noise in differential pairs, Noise Bandwidth.	7
Unit 3	**FEEDBACK** Effect of loading: 2-port network models, loading in voltage–voltage feedback, loading in current–voltage feedback, loading in voltage– current feedback, loading in current –current. Effect of feedback on noise.	8
Unit 4	**DESIGN OF THE CMOS OPERATIONAL AMPLIFIERS** Performance parameters, One-stage op-amps and two-stage op-amps, Gain boosting techniques,-comparison, common mode feedback (CMFB) amplifier, input range limitations, slew rate, power supply rejection, noise in op-amps.	8
Unit 5	**STABILITY AND FREQUENCY COMPENSATION** General considerations, multipole systems, phase margin, Frequency compensation, compensation of 2-stage op-amps: slewing in 2-stage op-amps	7
Unit 6	**BANDGAP REFERENCES** Supply independent biasing, temperature independent references: negative-TC voltage, positive-TC voltage, bandgap reference. PTAT current generation, Constant-G_m biasing, speed and noise issues.	6

List of Experiments:		No. of Turns
1	Plot the transfer and output characteristics of n-channel MOSFET. Calculate extrapolated threshold voltage, CLM coefficient and transconductance parameter.	2
2	Design a single-stage common source amplifier with resistive load: a. Perform it's transient analysis b. Perform the AC analysis to find the bandwidth	2
3	Draw the layout of a resistive load common source amplifier and perform the post layout simulation.	2
4	Design a single-stage common source amplifier with current mirror circuit as a load: a. Perform it's transient analysis. b. Obtain bode plot and calculate the bandwidth.	2
5	Design a differential amplifier wi-th an active load for a gain of 200: a. Perform it's transient analysis. b. Calculate the slew rate. c. Perform the AC analysis to find the practical value of gain.	2
6	Design a 2-stage operational amplifier with the first stage as a differential amplifier with an active load and the second stage as a common source amplifier. Perform its transient and AC analysis.	2
7	Design a bandgap reference circuit for supply independent biasing.	2

Course Outcomes: By the end of this course, the students will be able to	
1	Describe the analog design flow and demonstrate the analog layout techniques through CAD tools.
2	Design different configurations of Amplifiers and feedback circuits.
3	Analyze the characteristics of the frequency response of the amplifier and its noise.
4	Analyze the performance of operation amplifier circuits using transient and AC analysis.
5	Determine and validate the characteristics of various analog circuits using VLSI CAD tool.

Suggested Books:

Text Book		
S.No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	"Design of Analog CMOS Integrated Circuits" by Behzad Razavi, McGraw Hill Education.	2000
2	"CMOS Analog Circuit Design" by Phillip Allen and Douglas R. Holberg, OUP USA; Third Edition.	2011
Reference Books		
S.No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**

1	Operation and Modeling of the MOS Transistor" by Yannis Tsividis, Oxford University Press; 2nd Edition.	2003
2	Microelectronic Circuits-Theory & Applications" by A.S. Sedra and K.C. Smith, Adapted by A.N. Chandorkar, 6th Edition, Oxford.	2013
3	A.V.N. Tilak, Design of Analog Circuits, Khanna Publishing House	2022

Equivalent MOOCs courses:

S.No.	Course Links	Offered by
1	Analog IC Design https://archive.nptel.ac.in/courses/117/106/117106030/	NPTEL
2	Analog IC Design https://www.classcentral.com/course/swayam-analog-ic-design-10032	IIT Madras via Swayam

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	H	H	H	H				M	M			H	H
CO2	H	H	H						M				H	H
CO3	H	H	H						M				H	H
CO4	H	H	H	H	H				M	M			H	H
CO5	H	H	H	H	H				M	M			H	H

Course Name	**:**	**ELECTRONICS SYSTEM PACKAGING**
Course Code	**:**	**VLN503**
Credits	**:**	**4**
L T P	**:**	**3 1 0**

Course Objectives:
The student should be able

- To describe electronic device packaging and testing techniques.
- To explore electrical and thermal issues in IC packaging.
- To apply the role of interconnection and assembly materials to meet electrical and mechanical requirements.
- To develop the understanding of interdisciplinarity of packaging involving electrical, mechanical, thermal, materials, and processes.

Total No. of Lectures – 42

Lecture wise breakup		**No. of Lectures**
Unit 1	**OVERVIEW OF ELECTRONIC SYSTEMS PACKAGING** Functions of an Electronic Package, Packaging Hierarchy, IC packaging: MEMS packaging, consumer electronics packaging, medical electronics packaging, Trends, Challenges, Driving Forces on Packaging Technology, Materials for Microelectronic packaging, Packaging Material Properties, Ceramics, Polymers, and Metals in Packaging, Material for high density interconnect substrates.	8
Unit 2	**ELECTRICAL ISSUES IN PACKAGING** Electrical Issues of Systems Packaging, Signal Distribution, Power Distribution, Electromagnetic Interference, Transmission Lines, Clock Distribution, Noise Sources, Digital and RF Issues. Design Process Electrical Design: Interconnect Capacitance, Resistance and Inductance fundamentals; Packaging roadmaps - Hybrid circuits - Resistive, Capacitive and Inductive parasitics.	8
Unit 3	**PACKAGING ASSEMBLY** IC Assembly – Purpose/ Types-Single/ Multichip, Requirements, Technologies, Wafer Thinning, Dicing, Die Attach, Wire bonding, Flip Chip process, Flux Cleaning, Underfill, Encapsulation, Laser Marking, Solder Ball Attach, Reflow, Singulation, Wafer Level Packaging, 3D-IC technology, Introduction to Heterogeneous Packaging, TSV Technology.	10
Unit 4	**PCB, SURFACE MOUNT TECHNOLOGY AND THERMAL CONSIDERATIONS** Printed Circuit Board: Anatomy, CAD tools for PCB design, Standard fabrication, Micro via Boards. Board Assembly: Surface Mount Technology, Through Hole Technology, Incoming Material Inspection, Process Control and Design challenges. Thermal Management, Heat transfer fundamentals, Thermal conductivity and resistance, Conduction, convection, and radiation – Cooling requirements.	8

Unit 5	**TESTING** Design for Testability, Reliability, Package Testing- Active Circuit Testing / Parametric/ Boundary Scan /In-Circuit Test/ Flying Probe Test. Reliability, Thermal Cycling, Moisture & Humidity Testing, Package Strength.	8

Course Outcomes:
By the end of this course, the students will be able to

1	Describe the various packaging types used.
2	Explain various robust hermetic package designs.
3	Describe the development of reliable IC packages.
4	Illustrate the concepts of package testing methods.

Suggested Books:

Text Book

S.No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Rao R. Tummala, Fundamentals of Microsystems Packaging, McGraw Hill, NY, 2001.	Latest edition

Reference Books

S.No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	William D. Brown, Advanced Electronic Packaging, IEEE Press, 1999.	Latest edition
2	Bosshart, Printed Circuit Boards Design and Technology, Tata McGraw Hill, 1988	Latest edition
3	Blackwell (Ed), The electronic packaging handbook, CRC Press, 2000.	Latest edition

Equivalent MOOCs courses:

S.No.	**Course Links**	**Offered by**
1	Electronic Manufacturing and Packaging https://nptel.ac.in/courses/112105267	NPTEL
2	Intro to Electronic Packaging https://ep.jhu.edu/courses/525607-intro-to-electronic-packaging/	Johns Hopkins University, United States

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	H	H						H				H	H
CO2	H	H	H						H				H	H
CO3	H	H	H						H				H	H
CO4	H	H	H						H				H	H

Course Name	**:**	**VLSI VERIFICATION AND TESTING**
Course Code	**:**	**VLN504**
Credits	**:**	**4**
L T P	**:**	**3 0 2**

Course Objectives:
Students should be able

- To analyze the use of procedural statements and routines in testbench design with system Verilog.
- To explore the use of multi-threading and inter process communication in testbench design.
- To apply randomization concepts in designing testbench.
- To interface a system Verilog testbench with system C.

Total No. of Lectures – 42

Lecture wise breakup		**No. of Lectures**
Unit 1	**INTRODUCTION** Role of testing in VLSI design, Issues in test and verification of complex chips, VLSI test process and equipment, Test economics, Yield analysis and product quality.	6
Unit 2	**FAULTS MODELLING AND FAULT SIMULATION** Physical faults and their modelling, Stuck-at faults, bridging faults, Fault collapsing, Fault simulation, Deductive, Parallel and Concurrent fault simulation, Combinational and sequential SCOAP measures.	10
Unit 3	**ATPG FOR COMBINATIONAL CIRCUITS** D-Algorithm, Boolean Difference, PODEM, Random, Exhaustive and Weighted Test Pattern Generation, Aliasing and its effect on Fault coverage.	6
Unit 4	**ATPG FOR SEQUENTIAL CIRCUITS** ATPG for Single-Clock Synchronous Circuits, Time frame expansion method, Simulation-Based Sequential Circuit ATPG.	6
Unit 5	**MEMORY TESTING AND BIST** Permanent, Intermittent and pattern sensitive faults, March test notion, Memory testing using march tests, PLA testing, Ad-Hoc DFT methods, Scan design, Partial scan design, Random logic for BIST, Memory BIST.	7
Unit 6	**VERIFICATION** Design verification techniques based on simulation, Analytical and formal approaches, Functional verification, Timing verification, Formal verification, Basics of equivalence checking and model checking, Hardware emulation.	7
Unit 7	**CASE STUDY:** Complete RTL to GDS design flow from Cadence Tutorials	

List of Experiments:		**No. of Turns**
1	Introduction to test bench architecture.	1
2	Development of an exhaustive test bench for the 1-bit full adder.	1
3	Development of exhaustive test bench for 16 X 1 Multiplexer using file reading writing features.	1
4	Development of layered testbench components for functional verification of 8-bit ALU.	2
6	Development of layered testbench components for functional verification of synchronous FIFO.	2
7	Development of layered testbench components for functional verification of Round Robin Arbiter.	1
8	Analysis of code coverages and write development of functional coverage.	2
9	Design for Test and Automatic Test pattern Generation for a 4-bit counter.	2
10	Perform the logic equivalence (formal verification).	2

Course Outcomes: After completion of this course, the student will be able to	
1	Describe the fault modelling and collapsing methods.
2	Classify various combinational and sequential automatic test pattern generation techniques.
3	Analyze different memory faults and its testing methods.
4	Develop the verification plan for the small to complex VLSI designs.
5	Develop test-bench using HDL for testing and verification of VLSI designs using CAD tools.

Suggested Books:

Text Book		
S.No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Delay Fault Testing for VLSI Circuits, A. Krstic and K-T Cheng,3rd Kluwer Academic Publishers, 2003.	Latest Edition
Reference Books		
S.No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Essentials of Electronic Testing for Digital, Memory and Mixed-Signal VLSI Circuits, 2002.	Latest Edition
2	Testing of Digital Systems, N. K. Jha and S. Gupta, 2nd, Cambridge University Press. 2003.	Latest Edition
3	Fault Tolerant and Fault Testable P. K. Lala, 4th, Hardware Design, Prentice-Hall, 2020.	Latest Edition

4	Chris Spear, System Verilog for Verification, Springer, 2014.	Latest Edition

Equivalent MOOCs courses:

S.No.	Course Links	Offered by
1	VLSI Design Verification and test https://archive.nptel.ac.in/courses/117/103/117103125/	NPTEL
2	**Digital VLSI Testing** https://onlinecourses.nptel.ac.in/noc20_ee76/preview	Swayam

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	M	H						M				H	H
CO2	H	H	H						M				H	H
CO3	H	H	H						M				H	H
CO4	H	H	H						M				H	H
CO5	H	H	H	H	H				M	M			H	H

DEPARTMENT ELECTIVE COURSES

DEC-I

Course Name	**:**	**MEMS AND NEMS**
Course Code	**:**	**VLE105**
Credits	**:**	**4**
L T P	**:**	**3-1-0**

Course Objectives: The student should be able
● To explain the sensing mechanisms for various physical properties. ● To analyze the scaling impacts on MEMS sensors and actuators. ● To explore the fabrication techniques of various MEMS devices. ● To develop and design the MEMS/NEMS sensors for various applications.

Total No. of Lectures – 42

Lecture wise breakup		**No. of Lectures**
Unit 1	**INTRODUCTION TO MICRO-FABRICATION** Cleaning, Oxidation, Diffusion, Mask making, Lithography, Etching, Ion Implantation, CVD, PVD, Metallization; Surface micromachining and Bulk Micromachining, DRIE, LIGA, Fabrication of high aspect ratio deformable structures.	8
Unit 2	**ELASTICITY IN MATERIALS** Stress, strain calculations, Normal and Shear strains and constitutive relations, Plane stress, biaxial stress, residual stress, energy relations, Load-deflection calculations in beams, cantilevers (rectangular cross section), Elastic deformation in square plate, Resonant frequency calculations: Rayleigh-Ritz method.	8
Unit 3	**MEMS CAPACITIVE SWITCH** Lumped model, pull-in voltage, Electromechanical deflection modeling, pull-in instability, switching time and pull-in voltage scaling, Physical effects in nanoscale gap-size, squeeze-film damping , perforated MEMS Capacitive switch, Comb actuators, Accelerometer, Pressure sensor, Energy approach: Lagrangian Mechanics applicable to MEMS capacitive switches, Reliability in RF-capacitive switch.	10
Unit 4	**MEMS SENSORS:**Thermal sensor, Interaction of Thermal-Electrical Fields, Numerical design of thermal sensors, Bio-MEMS design problems.	8
Unit 5	**NEMS SENSORS:** Nano-Electro-Mechanical Systems (NEMS), NEMS oscillators and sensors, Optical MEMS/NEMS :2-D, 3-D switches, design examples.	8

Course Outcomes: By the end of this course, the students will be able to	
1	Describe the fabrication methods of various MEMS and NEMS Devices
2	Illustrate the sensing mechanisms for various physical quantities
3	Design the MEMS sensors for various applications

4	Apply the mathematical equations to model the different MEMS devices
5	Comprehend and explain the working of NEMS devices and related applications

Suggested Books:

Text Books		
S.No.	**Name of Book/ Authors/ Publisher**	**Year of Publication / Reprint**
1	Stephen D. Senturia, Microsystem Design, Kluwer Academic	2001
2	Madou, M., Fundamentals of Microfabrication, CRC Press	2002
Reference Books		
S.No.	**Name of Book/ Authors/ Publisher**	**Year of Publication / Reprint**
1	Plummer, Deal , Griffin “Silicon VLSI Technology: Fundamentals, Practice & Modelling” PH.	2001
2	Rebeiz, G.M., RF MEMS: Theory Design and Technology,Wiley	2003
3	MEMS and NEMS: System Devices and structures	2002
4	Relevant Research Papers	

Equivalent MOOCs courses:

S.No.	**Course Links**	**Offered by**
1	https://archive.nptel.ac.in/courses/112/108/112108092/ Micro and Smart Systems	NPTEL
2	https://nptel.ac.in/courses/117105082 Introduction to MEMS & Microsystems	NPTEL

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	H	H	H	H					H				H	H
CO2	H	H	H	H					H				H	H
CO3	H	H	H	H					H				H	H
CO4	H	H	H	H					H				H	H
CO5	H	H	H	H					H				H	H

Course Name	**:**	**HDL BASED SYSTEM DESIGN**
Course Code	**:**	**VLE106**
Credits	**:**	**4**
L T P	**:**	**3 0 2**

Course Objectives:
The students should be able

- To explore the syntax and various constructs of Verilog HDL language and programming.
- To design the digital logic using various programmable logic devices.
- To develop the test benches using system Verilog.
- To execute finite state machine modelling

Total No. of Lectures – 42

Lecture wise breakup		**No. of Lectures**
Unit 1	**BASIC VERILOG ELEMENTS** Lexical Conventions, Modules, Instances, Design Blocks, Stimulus Blocks, Data Types, Compiler Directives, Ports, Hierarchical Names, Tasks and Functions.	6
Unit 2	**MODELING IN VERILOG HDL** Gate-Level Modelling: Gate Types (And/ Or Gates, Buf/ Not Gates, Bufif/ NotifGates), Gate Delays (Rise, Fall and Turn-Off Delays, Min, Max, and Typical Delays). Data-Flow Modelling: Continuous Assignments, Delay Specification, Expressions, Operators, Operands, Operator Types. Behavioural modelling: Structured Procedures (initial and always), Procedural Assignments (Blocking and Non-Blocking Statements), Timing Controls, Conditional Statements, Multi-way Branching, Loops, Sequential and Parallel Blocks. Generate Blocks. Switch-Level Modelling: Switch modelling Elements. Universal verification methodology (UVM).	10
Unit 3	**ADVANCED FEATURES OF VERILOG HDL** Procedural Continuous Assignments, Overriding Parameters, Conditional Compilation and Execution, Time Scales, Useful System Tasks, Timing and Delays (Delay Model Types, Path Delay modelling, Timing Checks, Delay Back-Annotation), User-Defined Primitives (Basics of UDPs, Combinational UDPs, Sequential UDPs, UDP Shorthand Symbols. Programming Language, Logical Synthesis: Introduction and Impact of Logic Synthesis, Verilog HDL Synthesis.	8
Unit 4	**INTRODUCTION TO SYSTEM VERILOG** Introduction, data types, arrays, structures and unions, procedures and functions.	8
Unit 5	**MODELING IN SYSTEM VERILOG** Finite state machine modelling, Design hierarchy, Interfaces, behavioral and transaction level modelling.	10

List of Experiments		**No. of Turns**
1	Write Verilog code to realize all the logic gates and flip-flops.	2
2	Write Verilog codes for combinational designs like encoders and decoders, multiplexers and de-multiplexers.	2
3	Write a Verilog code to describe the functions of a Full Adder using Data flow, gate level and behavioral modeling styles.	2
4	Write a Verilog code to model 8-bit ALU with logical and arithmetical operations.	2
5	Develop the Verilog code for a sequence detector using FSM modeling.	2
6	Design a 4-bit BCD counter (Synchronous reset and Asynchronous reset) using Verilog code.	1
7	Write Verilog code to display messages on an alphanumeric LCD.	1
8	Implement full adder and multiplexer on FPGA kit.	2

Course Outcomes: By the end of this course, the students will be able to	
1	Identify and encode the digital modules using different Verilog HDL modeling styles.
2	Construct various digital logic circuits by using advanced features of Verilog HDL language.
3	Implement synthesizable circuits using logic synthesis tools.
4	Design and verify various circuits using test benches in system Verilog.

Suggested Books:

Text Books		
S.No.	**Name of Book/ Authors/ Publisher**	**Year of Publication / Reprint**
1	Verilog HDL: A Guide to Digital Design and Synthesis, S. Palnitkar, Prentice Hall NJ, USA	2003
2	A SystemVerilog Primer, by J. Bhasker	Latest edition

Reference Books		
S.No.	**Name of Book/ Authors/ Publisher**	**Year of Publication / Reprint**
1	Switching and Finite Automata Theory, ZviKohavi and Niraj K, CambridgeUniversity Press, Third Edition.	2010
2	‘Circuit design with VHDL’ by VoleniA Pedroni, MIT Press.	2011
3	System Verilog For Design: A Guide to Using SystemVerilog for Hardware Design , Stuart Sutherland, Simon Davidmann, Peter Flake, Springer Science	Latest edition

Equivalent MOOCs courses:

S.No.	Course Links	Offered by
1	Hardware modeling using Verilog by Prof. Indranil Sen Gupta https://archive.nptel.ac.in/courses/106/105/106105165/	NPTEL

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	H	H		H				M				H	H
CO2	H	H	H		H				M				H	H
CO3	H	H	H	M	H				M	M			H	H
CO4	H	H	H	M	H				M	M			H	H

Course Name	**:**	**OPTOELECTRONICS**
Course Code	**:**	**VLE107**
Credits	**:**	**4**
L T P	**:**	**3-0-2**

Course Objectives:
The student should be able

- To explain the fundamental working principle of optoelectronic devices.
- To describe various components of fiber optical communication systems, their working principle, and performance parameters.
- To explore the various types of optical sources and detectors and their characteristics.
- To examine the use of optoelectronic devices in current and future generation networks.

Total No. of Lectures – 42

Lecture wise breakup		**No. of Lectures**
Unit 1	**INTRODUCTION** Need of optoelectronics, advantages, applications in Network, Military, Civil, Industrial, Sensors etc. Optoelectronic Device Physics: Carrier recombination generation, optoelectronic materials, optical properties of materials, carrier recombination, direct and indirect bandgap semiconductors.	8
Unit 2	**OPTOELECTRONIC SOURCES** Basic concepts, Optical emission from semiconductor, Semiconductor injection Laser & its various structures, injection laser characteristics, threshold condition, wavelength tunable Lasers, LED power and efficiency, Hetero-junction, LED structure designs, characteristics, Modulation response of an LED.	9
Unit 3	**OPTOELECTRONIC DETECTORS** Introduction, Device types, basic principle of optoelectronic detection, absorption, quantum efficiency, responsivity, wavelength cutoff, types of photodiodes with and without internal gain, mid -infrared photodiode, phototransistors, photo conducting detectors, noise considerations.	9
Unit 4	**PASSIVE NETWORK COMPONENTS** Couplers, splitters, WDM multiplexer, demultiplexer, filter, isolator, circulator, attenuator, electro -optic modulators, acousto-optic modulators and their application areas, liquid crystal devices, optical MEMS.	10
Unit 5	**OPTOELECTRONICS IN CURRENT SCENARIO** Optoelectronic devices and its working for WDM, OFDM, OTDM, spatial division multiplexing, passive optical networks and 5G.	6

List of experiments		No. of Turns
1	To characterize the optical amplifiers using Optsim software.	3
2	To design and characterize passive optical components using RSoft Synopsys software.	2
3	To design and characterize waveguide using RSoft Synopsys software.	1
4	To simulate and evaluate the performance of passive optical devices like splitter, coupler, AWG, OADM etc. using VPI Transmission Maker Optical Communication software.	3
5	To check the performance of optoelectronics devices in the scenario of a WDM system.	1
6	Simulation for photodiode to determine I-V characteristics through TCAD simulation.	2
7	Simulation of Avalanche photodiode through TCAD simulations.	2

Course Outcomes: By the end of this course, the students will be able to	
1	Describe the basics of optoelectronic devices and their working principle.
2	Explain the structure, characteristics and performance parameters of optoelectronic sources and detectors.
3	Explain the various passive optical components used in Optical communication systems.
4	Describe the use of optoelectronics devices and circuits for latest generation networks.
5	Design and analyse the performance of various optoelectronics devices using Simulation software.

Suggested Books:

Text Books

S.No.	Name of Book/Authors/Publisher	Year of Publication /Reprint
1	Optical Fiber Communications, 3rd edition – John M. Senior, PHI.	2009
2	Fiber-Optic Communications Technology – Djafar K. Mynbev, Lowell L. Scheiner. Pearson Education Asia.	2000
3	Optical Fiber Communications, 5th edition– Gerd Keiser, McGraw-Hill.	2017
4	Physics of Semiconductor Devices, 2nd edition, S. M. Sze, John Wiley & Sons	2004

Reference Books		
S.No.	**Name of Book/Authors/Publisher**	**Year of Publicaion /Reprint**
1	Photonics, A Yariv and P. Yeh, Oxford Univ. Press.	2007
2	Nonlinear Fiber Optics, G P Agarwal, Academic Press, Boston, 2013	2013
3	Optical Electronics, AjoyGhatak and K Thyagarajan, Cambridge University Press	1989

Equivalent MOOCs courses:

S.No.	Course Links	Offered by
1	Optoelectronic Material and Devices https://archive.nptel.ac.in/courses/113/104/113104012/	NPTEL
2	Semiconductor Optoelectronics https://onlinecourses.nptel.ac.in/noc20_ph24/preview	NPTEL
3	Optical Communications https://onlinecourses.nptel.ac.in/noc21_ee42/preview	NPTEL

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	H	H						M				H	H
CO2	H	H	H						M				H	H
CO3	H	H	H						M				H	H
CO4	H	H	H						M				H	H
CO5	H	H	H	H	H				M	H			H	H

Course Name	**:**	**VLSI DIGITAL SIGNAL PROCESSING**
Course Code	**:**	**VLE108**
Credits	**:**	**4**
L T P	**:**	**3-1-0**

Course Objectives:
The student should be able

- To analyze and apply the signals and systems in real-world applications.
- To explore advanced techniques in DFT for applications like image and audio processing.
- To design high-speed, and low-power VLSI systems for a broad range of DSP applications.
- To describe multirate systems for various applications.

Total No. of lectures: 42

Lecture wise breakup		**No. of Lectures**
Unit 1	**INTRODUCTION** Review of discrete signals and systems analysis, sampling, quantization and reconstruction processes, Typical applications of DSP. Basics of DFT and IDFT. circular convolution using DFT, Fast Fourier Transform (FFT), Decimation in time and decimation in frequency algorithms. Applications of DFT in speech and audio coding.	10
Unit 2	**DIGITAL FILTERS** Recursive and non-recursive systems, Frequency domain representation of discrete time systems, systems function, Ideal low pass filter.	2
Unit 3	**DESIGN OF FIR AND IIR FILTERS** Impulse invariance transformation technique, Bilinear transformation. Design of IIR Filters using Butterworth, chebyshev and elliptic filter. Design of FIR filters: Design of FIR filters using Window technique, frequency sampling technique, Equiripple Approx. technique, comparison of IIR and FIR filters	12
Unit 4	**VLSI DSP TECHNIQUES** Retiming – definitions and properties, Retiming Techniques - Unfolding, properties of unfolding, Critical path, Register Minimization, Folding, Folding order, Folding Factor, Retiming for folding, Register Minimization technique, folding of Multirate systems- Systolic array Methodology, Selection of Scheduling Vector, Matrix multiplication and 2D Systolic array design, Fast Convolution- Iterated Convolution, Cyclic Convolution.	8
Unit 5	**ALGORITHM STRENGTH REDUCTION** Introduction, Parallel FIR filters, Polyphase decomposition, Fast FIR filters Algorithms, Discrete Cosine Transform and Inverse Discrete Cosine Transform, Algorithm-Architecture Transformation, Pipelined and Parallel Recursive, Look-Ahead Computation, Look-Ahead Pipelining, Parallel processing in IIR Filters. Case Studies: Complete Design of DSP Processor, filters.	10

Course Outcomes: By the end of this course, the students will be able to	
1	Analyze signal processing tasks from VLSI perspective.
2	Perform the algorithmic transformations using pipelining, parallel processing techniques for the development of high speed and low power systems.
3	Realize area efficient systems using folding and unfolding approaches.
4	Describe various concepts for numerical strength reduction.

Suggested books:

Text Books		
S.No.	**Name of Book/ Authors/ Publisher**	**Year of Publication / Reprint**
1	VLSI Digital Signal Processing Systems, Design and implementation, Keshab K. Parhi, John Wiley & Sons, New Delhi.	2012
2	Digital Signal Processing, Proakis, J.G., and Manolakis, D.G., PHI, 3rd ed.	2001
3	Digital Filters: Analysis, Design and Application, Proakis, J.G., McGraw Hill, 2^{nd} ed.	1981
Reference Books		
S.No.	**Name of Book/ Authors/ Publisher**	**Year of Publication / Reprint**
1	Digital Signal Processing with Field Programmable Gate Arrays, U. Meyer – Baese, Springer, Second Edition	2007
2	Multirate Systems and Filter Banks by P.P. Vaidyanathan, Pearson Education	2003
3	Digital Signal Processing: A Practical Approach by by Barrie Jervis (Author), Emmanuel Ifeachor, 2^{nd} edition, Pearson	2001

Equivalent MOOCs courses:

S.No.	**Course Links**	**Offered by**
1	Digital Signal Processing by Prof. S.C. Dutta Roy (IIT Delhi). https://nptel.ac.in/courses/117102060.	NPTEL
2	Digital Signal Processing by C. S. Ramalingam (IIT Madras). https://nptel.ac.in/courses/108106151.	NPTEL

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	H	H	H						H				H	H
CO2	H	H	H						H				H	H
CO3	H	H	H						H				H	H
CO4	H	H	H						H				H	H

DEPARTMENT ELECTIVE COURSES

DEC II

Course Name	**:**	**SEMICONDUCTOR PACKAGE MANUFACTURING**
Course Code	**:**	**VLE109**
Credits	**:**	**4**
L T P	**:**	**3-1-0**

Course Objectives:
The student should be able

- To explain the basic concepts of package manufacturing process.
- To describe the various testing methods and their principles for components and package testing.
- To analyse the IC failure mechanisms, EMI testing and material qualification criterias for IC packages.
- To explore the various methods of maintaining industrial quality and process control methods for Semiconductor packages.

Total No. of Lectures – 42

Lecture wise breakup		**No. of Lectures**
Unit 1	**PACKAGE MANUFACTURING PROCESSES** Packaging Assembly Technology, Wafer Thinning, Dicing, Die Attach, Wire bonding, Flip Chip process, Flux Cleaning, Underfill, Encapsulation, Laser Marking, Solder Ball Attach, Reflow, Singulation, IC Packaging Toolsets & equipment operation, clean room operations.	8
Unit 2	**SEMICONDUCTOR COMPONENT AND PACKAGE TEST** Overview of Testing methodologies, components tested & their characteristics, Challenges in testing, Types of Testers (Automated test Equipment & Benchtop Testers), Components & Subsystems of Testers, Principles of Functional Testing, Parametric/ Boundary Scan /In-Circuit Test/ Flying Probe Test, Test Data Analysis, Design for Testability & Tester Calibration & Maintenance, Future Trends.	10
Unit 3	**ELECTRICAL AND PHYSICAL FAILURE ANALYSIS** Package failure modes, Failure detection mechanisms, Failure analysis tools, Test programs debugging, Data Analytics, ESD & EMI Management	8
Unit 4	**SEMICONDUCTOR PACKAGE MATERIALS AND QUALIFICATION** Reliability testing & qualification- MST/MSL, TC/TS, HAST &uHAST, Mold Compounds (Moldability), Underfill Materials, Die Attach Adhesives & Films, Substrate Technology, Bonding Wire, Solder & Dielectric materials	8
Unit 5	**INDUSTRIAL QUALITY AND STATISTICAL PROCESS CONTROL** Quality Control Plan (QCP) & Quality Management System (QMS), Incoming Material Inspection, In-Line Quality, Measurement System Analysis, Statistical analysis methods, Statistical Process Control (SPC), Fault Detection Control (FDC), Run-to-Run Control (R2R), Auto Defect Classification (ADC), Data Analytics, Machine Communication Protocol and System Integration.	8

Course Outcomes:
By the end of this course, the students will be able to

1	Comprehend the manufacturing process of various semiconductor packages.
2	Describe various package materials, testing and failure analysis.

3	Explain the package qualification methods and industrial quality management for the same.
4	Explain EMI and ESD effects, test programs analysis and statistical process control of package manufacturing.

Suggested Books:

Text Books		
S.No.	**Name of Book/ Authors/ Publisher**	**Year of Publication / Reprint**
1	Semiconductor Packaging: Materials interaction and reliability, Andrea Chen and R. Yu Lo, CRC	2012
2	Semiconductor Manufacturing, H. Geng, TMH	Latest edition
Reference Books		
S.No.	**Name of Book/ Authors/ Publisher**	**Year of Publication / Reprint**
1	Gary S. May, Costas J. Spanos, Fundamentals of Semiconductor Manufacturing and Process Control (Wiley - IEEE)	2006
2	Semiconductor advanced packaging, John H. Lau, Springer	2021

Equivalent MOOCs courses:

S.No.	**Course Links**	**Offered by**
1	Electronic Manufacturing and Packaging https://nptel.ac.in/courses/112105267	NPTEL
2	Intro to Electronic Packaging https://ep.jhu.edu/courses/525607-intro-to-electronic-packaging/	Johns Hopkins University, United States

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	H	H	H						H				H	H
CO2	H	H	H						H				H	H
CO3	H	H	H						H				H	H
CO4	H	H	H						H				H	H

Course Name	**:**	**SEMICONDUCTOR DEVICE MODELLING**
Course Code	**:**	**VLE110**
Credits	**:**	**4**
L T P	**:**	**3 -1- 0**

Course Objectives: The student should be able
● To analyze the concept of numerical modelling and different finite element methods. ● To apply transport equations for different MOS architectures. ● To describe quantum effects in advance semiconductor devices. ● To explain the modelling methods of nanoscale devices.

Total No. of Lectures – 42

Lecture wise breakup		**No. of Lectures**
Unit 1	**INTRODUCTION TO NUMERICAL MODELING** Fundamental semiconductor equations, Finite difference scheme, Error analysis, Solution of a system of Linear Equations, Direct Method: LU- decomposition, Tri-diagonal system, Relaxation Method, Numerical solution of Non-Linear Equations: Newton Raphson method, Finite difference discretization example: Current continuity and energy relations, Introduction to circuit simulations.	8
Unit 2	**DRIFT-DIFFUSION TRANSPORT MODEL** Equations, Boundary Conditions, Mobility and Generation / Recombination, Energy band diagrams, Explain the concept of crystal momentum, ε-k and ε-x diagrams of a semiconductor, ε-k diagrams of Si and GaAs.	8
Unit 3	**MOSFET MODELS** Structure and Characteristics, Qualitative Model, Equations, Boundary Conditions and Approximations, Surface Potential based and Threshold based solutions, Testing, Improvement and Parameter Extraction.	10
Unit 4	**QUANTUM PHYSICS ASPECTS OF DEVICE MODELING** Quantum Physics Aspects of Device Modeling: Effective mass Schrödinger equation, Matrix representation, Dirac notation, WKB Approximation, Time dependent and independent perturbation theories, Fermi's golden rule, semiclassical transport in semiconductors: Boltzmann transport equation, numerical scheme, Introduction to Monte Carlo simulations.	8
Unit 5	**QUANTUM EFFECTS** Introduction to Quantum Effect Device Modeling: Double barrier resonant tunneling diode, Device modeling through transfer matrix approach, Numerical estimation of diode current density, coupled Poisson-Schrödinger scheme for electron transmission simulations.	8

Course Outcomes: By the end of this course, the students will be able to	
1	Analyze the transport phenomena in semiconductors.
2	Illustrate the E-k and E-x diagram for various semiconductor devices.
3	Recognize the basic operation principles involved in the modelling of devices.
4	Analyze classical, semi-classical and quantum modelling techniques.
5	Model the different architectures of semiconductor devices.

Suggested Books:

Text Book		
S.No.	**Name of Book/ Authors/ Publisher**	**Year of Publication / Reprint**
1	M. Lundstrom,"Fundamentals of Carrier Transport", Cambridge University Press, 2000.	2000
2	C.Snowden, "Introduction to Semiconductor Device Modeling", World Scientific, 1986	1986
Reference Books		
S.No.	**Name of Book/ Authors/ Publisher**	**Year of Publication / Reprint**
1	Y. Tsividis and C. McAndrew,"MOSFET modeling for Circuit Simulation", Oxford University Press, 2011	2011
2	Semiconductor Device and Modeling, Nandita Das Gupta, Amitava Das Gupta	2004
3	BSIM Manuals available on BSIM homepage on the internet	
4	Relevant Research Papers	

Equivalent MOOCs courses:

S.No.	**Course Links**	**Offered by**
1	Semiconductor Device Modeling. https://archive.nptel.ac.in/courses/117/106/117106033/	NPTEL
2	Semiconductor Device Modeling and Simulation https://nanohub.org/resources/37981#series	Nano-hub

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	H	H	H	M					H				H	H
CO2	H	H	H	H					H				H	H
CO3	H	H	H	H					H				H	H
CO4	H	H	H	H					H				H	H
CO5	H	H	H	H					H				H	H

Course Name	**:**	**CONTROL SYSTEMS**
Course Code	**:**	**VLE111**
Credits	**:**	**4**
L T P	**:**	**3-1-0**

Course Objectives:
The student should be able to

- Develop the model of a control system using different approaches.
- Analyze the system in time domain and frequency domain and investigate its stability.
- Design compensators and controllers for the specified requirements.
- Analyze transform analysis and state variable approach to control systems.

Total No. of Lectures – 42

Lecture wise breakup		**No. of Lectures**
Unit 1	**INTRODUCTION and MODELLING of CONTROL SYSTEMS** Basic components of a control system, classification of control system, Servomechanism, Regulator and process control, Feedback control Systems-Characteristics and Performance, Transfer function approach, Block Diagram Representation, Signal flow graphs	6
Unit 2	**TIME RESPONSE ANALYSIS** Time response of first order systems, second order systems, performance specifications, steady state errors and error constants, Sensitivity	6
Unit 3	**CONCEPT OF STABILITY** Conditions of stability, Routh-Hurwitz criterion, Root locus technique	5
Unit 4	**FREQUENCY RESPONSE ANALYSIS** Correlation between time and frequency response, Polar Plots, Bode Plot, stability margins on Bode plots, Nyquist criteria, Assessment of stability using Nyquist criteria	8
Unit 5	**COMPENSATOR DESIGN USING BODE PLOTS** Preliminary considerations of classical design, realization of basic compensators, Lead compensator, Lag compensator, Lag-Lead Compensator, Introduction to Computer-aided design using MATLAB	6
Unit 6	**CONTROL ACTIONS AND CONTROLLER CHARACTERISTICS** Proportional, Integral and Derivative Control Actions, Proportional plus integral control action, proportional plus derivative control action, PID controller	3
Unit 7	**DIGITAL CONTROL SYSTEMS** Introduction, Z-transform analysis of sampled data control systems, Z and s-domain relationship, stability analysis	4
Unit 8	**STATE VARIABLE ANALYSIS OF CONTROL SYSTEMS** Concepts of state, state variables and state model, state models for linear continuous-time systems, transfer function from state model, solution of state	4

	equation, State Transition Matrix, Single Input Single output system, multiple input multiple output system, concept of controllability and observability	

Course Outcomes: By the end of this course, the students will be able to	
1	Determine the transfer function of the system using different approaches.
2	Analyze the system in time domain and investigate the stability.
3	Analyze the system in frequency domain and investigate the stability.
4	Design compensators and PID controller for the specified requirements.
5	Develop and analyze the state space models of systems and apply Z- transform to analyze digital control systems.

Suggested Books:

Text Books		
S.No.	**Name of Book/ Authors/ Publisher**	**Year of Publication / Reprint**
1	Control Systems Engineering By Nagrath and Gopal, New Age International,4th Ed	2006
2	Digital Control Engineering by M Gopal, New Age International	2003
3	Control Systems Engineering, Nise, N. S., 6th Ed., Wiley India	2010
Reference Books		
S.No.	**Name of Book/ Authors/ Publisher**	**Year of Publication / Reprint**
1	Modern Control Engineering, Ogata, K., 5th Ed., Pearson Education. 2008	2009
2	Modern Control Systems, Dorf, R.C. and Bishop, R.H., 12th Ed., Prentice-Hall of India.	2010
3	Automatic Control Systems, Kuo, B.C, 9th Ed., Wiley India	2009

Equivalent MOOCs courses:

S.No.	**Course Links**	**Offered by**
1	Course Name: Systems and Control https://ocw.mit.edu/courses/2-04a-systems-and-controls-spring-2013/	MIT Open courseware
2	Course Name: Control Systems https://onlinecourses.nptel.ac.in/noc19_de04/preview	NPTEL

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	H	H						H				H	H
CO2	H	H	H		L				H				H	H
CO3	H	H	H		L				H				H	H
CO4	H	H	H		L				H				H	H
CO5	H	H	H						H				H	H

Course Name	**:**	**HIGH SPEED INTERCONNECTS**
Course Code	**:**	**VLE112**
Credits	**:**	**4**
L T P	**:**	**3-1-0**

Course Objective:
The student should be able

- To explore the importance of on-chip interconnects in VLSI circuits.
- To explore the various equivalent circuit models of interconnects and their comparison.
- To perform time domain analysis of different interconnect networks.
- To analyse the effect of crosstalk in different interconnect models.
- To explain latest interconnects technologies.

Total No. of lectures: 42

Lecture wise breakup		**No. of Lectures**
Unit 1	**INTRODUCTION** Introduction to VLSI Interconnects, Technology trends and interconnect scaling. Basic materials: Copper and aluminium. Problem with existing material in deep submicron: Electro-migration effect, surface and grain boundary effect.	8
Unit 2	**INTERCONNECT MODELS** RC model and RLC model, Elmore delay, Elmore delay in interconnects, Elmore delay in RC tree and branched interconnects, Effect of capacitive coupling, Effect of inductive coupling, Transmission line model, Power dissipation, Interconnect reliability.	8
Unit 3	**INTERCONNECT ANALYSIS** Time domain analysis: RLC network analysis, RC network analysis and responses in time domain, S domain analysis, circuit reduction via matrix approximation, Analysis using moment matching, transmission lines: step input response.	9
Unit 4	**CROSSTALK ANALYSIS** Introduction, Capacitive coupled and inductive coupled interconnect model and analysis, Transmission line-based model.	8
Unit 5	**ANALYSIS OF COUPLED INTERCONNECTS** Simulation of RC coupled interconnects, Extraction of capacitance, Extraction of inductance.	6
Unit 6	**ADVANCED INTERCONNECT TECHNOLOGIES** On-chip interconnects, CNTs as interconnects, Graphene interconnects, Optical interconnects, and 3D interconnects. Network On-chip architectures.	3

Course Outcomes: By the end of this course, the students will be able to	
1	Analyse and design electrical interconnects using equivalent circuit models.
2	Analyse inductive and capacitive coupling effects in interconnect models.
3	Analyse the time domain and S domain response of various interconnects.
4	Demonstrate the effect of crosstalk in different interconnect models.
5	Review latest interconnects technologies.

Suggested Books:

Textbooks		
S.No.	**Name of the Book/Author/Publisher**	**Year of publication/ Reprint**
1	"Interconnect Analysis and Synthesis," Chung-Kang Cheng, John Lillis, Shen Lin and Norman H.Chang, A Wiley Interscience Publication.	2000
2	"CMOS Digital integrated circuits analysis and design," Sung-Mo (Steve) Kang, Yusuf Leblebigi, by Tata Mcgraw-Hill.	2007
Reference Books		
S.No.	**Name of Book/Authors/Publisher**	**Year of Publication /Reprint**
1	"Interconnect Technology and Design for Gigascale Integration," J. Davis and J. Meindl, Springer Science Business Media, LLC.	2003
2	"Fundamentals of Electro-migration-Aware Integrated Circuit Design," Jens Lienig and Matthias Thiele, Springer.	2018
3	"Circuits, Interconnections, and Packaging for VLSI", H. B. Bakoglu, Addison Wesley Longman Publishing, 1st Edition.	1990

Equivalent MOOC courses:

S.No.	**Course Links**	**Offered by**
1	VLSI Interconnects by Prof.SarangPendharker, IIT Kharagpur https://onlinecourses.nptel.ac.in/noc22_ee125/preview	NPTEL

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	H	H	H						H				H	H
CO2	H	H	M						H				H	H
CO3	H	H	M						H				H	H
CO4	H	L	L						H				H	H
CO5	H	M	M						H				H	H

DEPARTMENT ELECTIVE COURSES

DEC III

Course Name	**:**	**NANOSCALE DEVICES**
Course Code	**:**	**VLE113**
Credits	**:**	**4**
L T P	**:**	**3 1 0**

Course Objectives:

The student should be able

- To analyze the MOS device behaviour with scaling.
- To explain the short channel effects and mitigation techniques.
- To describe the different MOS architectures of nanoscale regime.
- To examine the latest emerging devices and their working principles.

Total No. of Lectures – 42

Lecture wise breakup		**No. of Lectures**
Unit 1	**INTRODUCTION** Long Channel MOSFETS: History; Introduction – MOSFET as a barrier controlled device; MOSFET I-V characteristics; Drain current models, MOSFET scaling; subthreshold characteristics; substrate bias and temperature dependence, MOSFET electrostatics – energy band picture, 1D electrostatic Poisson-Boltzmann equation, depletion approximation, onset of inversion, gate voltage and surface potential, static and mobile charges	6
Unit 2	**SHORT CHANNEL EFFECTS** Charge sharing; channel length modulation; DIBL; GIDL; velocity saturation; MOSFET breakdown; concepts of high-K/metal gate	8
Unit 3	**ADVANCE MOS ARCHITECTURES** Advanced planar and 3D transistors: FDSOI, DG-ETSOI; FINFETs, Gate all around FETs.	10
Unit 4	**BALLISTIC TRANSPORT** Nanoscale transport: Bottom-up approach, Landauer's formalism, Ballistic and diffusive transport – modes, IV characteristics, conductance, voltage drop and heat dissipation, ballistic MOSFET, ballistic injection velocity, Virtual Source Model.	8
Unit 5	**EMERGING DEVICES** Quantum devices, Single electron transistors, Self-switching diode, ballistic rectifiers, Schottky source based FETs.	8

Course Outcomes: By the end of this course, the students will be able to	
1	Explain the fundamentals of long channel and short channel MOSFETs.
2	Analyze the various MOSFET architectures developed to mitigate the scaling effects.
3	Explain the Nanoscale transport models and its use in designing the novel devices.
4	Describe the novel nanoscale devices for various applications.

Suggested Books:

Text Books		
S.No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Mark Lundstorm, “Fundamentals of Nanotransistors,” World Scientific	2015
2	Tak H. Ning and Yuan Taur, “Fundamentals of Modern VLSI Devices” Pearson Education India Pvt. Ltd	2015
Reference Books		
S.No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Donald A. Neamen, “Semiconductor Physics and Devices”, McGraw Hill Higher Education	2011
2	S.M. Sze (Ed), VLSI Technology, 2nd Edition, McGraw Hill.	1998
3	Relevant Research Papers	

Equivalent MOOCs courses:

S.No.	**Course Links**	**Offered by**
1	Nano HUB-U: Fundamentals of Nano transistors, 2nd Edition https://nanohub.org/courses/NT	Nanohub
2	Introduction to Nanoelectronics https://nptel.ac.in/courses/117108047	NPTEL

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	H	H	H						H				H	H
CO2	H	H	H	H					H				H	H
CO3	H	H	H	H					H				H	H
CO4	H	H	H						H				H	H

Course Name	**:**	**LOW POWER VLSI DESIGN**
Course Code	**:**	**VLE114**
Credits	**:**	**4**
L T P	**:**	**3 1 0**

Course Objectives

The student should be able to

- Describe the sources of power dissipation in VLSI circuits.
- Analyze the power reduction techniques.
- Explore emerging trends and technologies in low-power VLSI design.
- Categorize the low-power design approaches.

Total No. of lectures: 42

Lecture wise breakup		**No. of Lectures**
Unit 1	**LOW POWER BASICS** Introduction: Need for Low Power Circuits, Low Power Techniques at different Hierarchical Levels, Parameters involved in Power Dissipation, Need for Low power VLSI chips, Dynamic Power Dissipation, Short Circuit Power, Switching Power, Glitching Power, Static Power Dissipation. Emerging Low power approaches. Physics of Power Dissipation in CMOS devices. Silicon- on-Insulator.	9
Unit 2	**DEVICE & TECHNOLOGY IMPACT ON LOW POWER** Dynamic dissipation in CMOS, Transistor sizing & gate oxide thickness, Impact of technology Scaling, Technology & Device innovation.	9
Unit 3	**LOW-POWER DESIGN APPROACHES** Low-power Design Methodologies: Supply voltage scaling approaches at different levels of hierarchy, Leakage Power minimization Approaches: Variable-threshold-voltage CMOS (VTCMOS) approach, Multi-threshold-voltage CMOS (MTCMOS) approach. Architectural Level Approach: Pipelining and Parallel Processing Approaches.	8
Unit 4	**SWITCHED CAPACITANCE MINIMIZATION APPROACHES** System Level Measures, Circuit Level Measures.	6
Unit 5	**ARITHMETIC COMPONENTS AND POWER ESTIMATION** Low power design techniques, Low Power arithmetic components: Introduction, Standard Adder Cells, CMOS Adder's Architectures – Ripple Carry Adders, Carry Look- Ahead Adders.	10

Course Outcomes:

By the end of this course, the students will be able to

1	Demonstrate the sources of power dissipation in ICs.
2	Summarize the different power reduction techniques.
3	Describe various power estimation techniques.
4	Analyse the low power approach implementing different technology nodes.

Suggested Books:

Textbooks		
S.No.	**Name of Book/Authors/Publisher**	**Year of Publication /Reprint**
1	Kaushik Roy, Sharat C. Prasad, "Low power CMOS VLSI circuit design", Wiley Inter science Publications.	1987
2	Practical Low Power Digital VLSI Design – Gary K. Yeap, Kluwer Academic Press.	2002
Reference Books		
S. No.	**Name of Book/Authors/Publisher**	**Year of Publication /Reprint**
1	Low Power CMOS VLSI Circuit Design – A. Bellamour, M. I. Elamasri, Kluwer Academic Press.	1995
2	Ajit Pal, ―Low-Power VLSI Circuits and Systems‖, Springer.	2015
3	J. B. Kuo and J-H. Lou, ―Low-Voltage CMOS VLSI Circuits, Wiley.	1999
4	Research and review papers in specific area.	

Equivalent MOOCs courses:

S.No.	**Course Links**	**Offered by**
1	Low Power VLSI Circuits & Systems by Prof.Ajit Pal, IIT Kharagpur https://nptel.ac.in/courses/106105034	NPTEL

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	H	H	H	M					H				H	H
CO2	H	H	H	M					H				H	H
CO3	H	H	H	M					H				H	H
CO4	H	H	H	M					H				H	H

Course Name	**:**	**SILICON PHOTONICS**
Course Code	**:**	**VLE115**
Credits	**:**	**4**
L T P	**:**	**3-0-2**

Course Objectives:
The student should be able to

- Explain the key principles underlying the analysis and design of integrated photonic devices and circuits.
- Describe the differences in on-chip rectangular optical waveguides and circular waveguides.
- Describe the on-chip optical fabrication technology and materials.
- Explore the issues related to co-integration of electrical and optical devices.

Total No. of Lectures: 42

Lecture wise breakup		**No. of Lectures**
Unit 1	**INTRODUCTION** Distinction between electronic, optoelectronic and photonic devices; Electrical and optical bandwidth, requirement of Photonic Integrated circuits.	3
Unit 2	**OPTICAL WAVEGUIDES** Planar slab waveguides, symmetric and asymmetric waveguides; rectangular waveguides, Marcatili's method, Effective index method; graded index waveguides; loss in planar slab waveguide; Coupled mode theory and applications.	12
Unit 3	**ADVANCED WAVEGUIDES AND DEVICES** Silicon-on Insulator waveguide, Silicon plasmonic waveguide, and silicon wire waveguide couplers, multimode interference-based couplers, tapers, bends, y-branch, gratings, switches, polarizers, filters, resonators, multiplexer/demultiplexer, Semiconductor Sources (LDs (Double heterojunction, DFB, Quantum wire & dot), Semiconductor Detectors (Structure and analysis of PIN and APD detectors.	12
Unit 4	**TECHNOLOGY** Materials-glass, lithium niobate, silicon, compound semiconductors, polymers, metamaterial; fabrication techniques - lithography, ion-exchange, deposition, diffusion process, and device characterization, packaging and environmental issues.	10
Unit 5	**INTEGRATION OF PHOTONIC DEVICES** Major Issues, photonic device integration, photonic-electronic integration, power and power density issues on-chip.	5

List of Experiments		No. of Turns
1	Familiarization with CAD software for photonic design. Overview of CAD tools for photonics. Basic navigation and interface understanding Initial setup for photonic simulations.	2
2	Design of 2D passive photonic devices. Design and simulate 2D waveguides, couplers, and bends. Analyze modes, refractive index profiles, dispersion, and losses.	2
3	Design of 3D passive photonic devices. Design and simulate 3D photonic devices (switches, directional couplers).Analyze modes, refractive index profiles, and losses in 3D space.	3
4	Design of 2D and 3D photonic bandgap structures. Design and simulate 2D photonic bandgap structures. Extend to 3D structures and analyze their performance.	3
5	Design of plasmonic-based optical sensor - Case Study Study principles of plasmonic sensing. Design a plasmonic-based optical sensor. Simulate and analyze its performance.	3

Course Outcomes: By the end of this course, the students will be able to	
1	Illustrate the importance of photonic integration and its applications
2	Design and analyse optoelectronic and photonic circuits including planar waveguides, high speed laser diodes, tapers, bends and couplers etc.
3	Describe fabrication technology and select the materials for design of optoelectronic device.
4	Explore the issues related to co-integration of electrical and optical devices.
5	Illustrate the use of modern Photonic CAD tools for the design of integrated optical devices and circuits.

Suggested Books:

Text books		
S.No.	**Name of Book/ Authors/ Publisher**	**Year of Publication / reprint**
1	C R Pollock and M Lipson: Integrated photonics, Kluwer Academic Pub,	2003
Reference books		
S.No.	**Name of Book/ Authors/ Publisher**	**Year of Publication / reprint**
1	Govind P Agrawal: Lightwave technology: component and devices, John Wiley ,	2004
2	Katsunari Okamoto: Fundamentals of Optical Waveguides Academic Press	2006
3	Silicon Photonics: Fueling the Next Information Revolution by Daryl Inniss, Roy Rubenstein	2017

Equivalent MOOCs courses:

S.No.	Course Links	Offered by
1	Photonic integrated circuit By Prof. Shankar Kumar Selvaraja Photonic integrated circuit - Course (nptel.ac.in)	NPTEL
2	Integrated Photonics Devices And Circuits by Prof. B K Das, NPTEL :: Electrical Engineering - NOC: Integrated Photonics Devices and Circuits	NPTEL

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	H	H	H					M				H	H
CO2	H	H	H	H	H				M	M			H	H
CO3	H	H	H	H	M				M	M			H	H
CO4	H	H	H	H					M				H	H
CO5	H	H	H	H	H				M	M			H	H

Course Name	**:**	**FLEXIBLE ELECTRONICS**
Course Code	**:**	**VLE116**
Credits	**:**	**4**
L T P	**:**	**3-1-0**

Course Objective:
The student should be able

- To explore the basic concepts of flexible electronics.
- To develop an understanding of the relationship between various printing techniques.
- To analyze the flexible substrate devices, its performance and target applications for electronics on soft matter.
- To describe the integration of devices on flexible platforms for future applications.

Total No. of Lectures – 42

Lecture wise breakup		**No. of Lectures**
Unit 1	**INTRODUCTION** Introduction to Flexible & Printable electronics- Historical background - Materials, devices, systems, applications - Fabrication techniques -Unique aspects, status in the field and trends, Stretchable electronics, Wearable Electronics, Potential level of printed electronics in the industry, area of applications of printed electronics.	10
Unit 2	**PRINTING AND FABRICATION TECHNOLOGY** Basics and fundamentals sheet to sheet and roll to roll printing techniques-imprint lithography, spray pyrolysis, multilayer patterning, Functional inks–Conductive, semi-conductive, insulating inks, and their characterization, different materials and their properties in printed electronics, Various substrates and their types.	10
Unit 3	**FLEXIBLE AND PRINTABLE DEVICES** Organic devices on flexible substrate, Thin film transistors, Sensors and biosensors, RFID, Antenna, FET etc., Examples of flexible physical, chemical and optical sensors, Actuators, Examples of flexible optical and thermal actuators, Displays, sensor arrays, memory devices.	10
Unit 4	**FUTURE TRENDS OF FLEXIBLE ELECTRONICS TECHNOLOGY** Advanced technologies used in printed electronics production, Energy harvesting and storage components - Energy harvesters - Principles and fundamentals - Examples of flexible energy harvesters - Storage components - Principles and fundamentals, barrier materials, Examples of flexible super-capacitors and batteries, Further processing components - Interconnections, memories, opportunities, obstacles and future trends printed electronics.	12

Course Outcomes:
By the end of this course, the students will be able to

1	Explain the concepts of flexible and printable electronics.
2	Illustrate the conductive, semi-conductive, insulating inks, and their characterization.

3	Design a system with flexible and printable devices.
4	Describe the basic concepts for integration of devices on flexible platforms.

Suggested Books:

Text books		
S.No.	**Name of the Book/Author/Publisher**	**Year of publication/ Reprint**
1	"Large Area and Flexible Electronics", M. Caironi and Y.Y. Noh, WILEY-VCH.	2015
2	"Flexible Electronics: Materials and Applications", W. S. Wong, A. Salleo, Springer.	2009
Reference Books		
S.No.	**Name of Book/Authors/Publisher**	**Year of Publication /Reprint**
1	Organic and Printed Electronics: Fundamentals and Applications, G. Nisato, D. Lupo, S.Ganz, CRC Press.	2016
2	Organic Flexible Electronics: Fundamentals, Devices, and Applications, P. Coseddu and M. Caironi, Elsevier.	2020
3	Christoph Brabec, Ullrich Scherf, Vladimir Dyakonov (Editors), Organic Photovoltaics: Materials, Device Physics, and Manufacturing Technologies, WileyVCH.	2014

Equivalent MOOC courses:

S.No.	**Course Links**	**Offered by**
1	Not available	

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	H	H	H						H				H	H
CO2	H	H	H						H				H	H
CO3	H	H	H						H				H	H
CO4	H	H	H						H				H	H

DEPARTMENT ELECTIVE COURSES

DEC IV

Course Name	**:**	**COMPOUND SEMICONDUCTORS**
Course Code	**:**	**VLE117**
Credits	**:**	**4**
L T P	**:**	**3-1-0**

Course Objectives: The student should be able
● To explain the fundamental properties of compound semiconductors. ● To illustrate high frequency devices such as MESFET, HEMT, terahertz devices etc. ● To identify and categorize optoelectronic and high power devices. ● To describe the fabrication of various compound semiconductor based devices.

Total No. of Lectures – 42

Lecture wise breakup		**No. of Lectures**
Unit 1	**Introduction:** Fundamentals of compound semiconductors- material properties, synthesis, high speed performance parameters: Transit time of charge carriers, carrier mobility, doping concentration and temperature; high power performance parameters: Break down voltage, device geometries, doping concentration and temperature.	8
Unit 2	**High frequency devices:** Metal semiconductor contacts, Schottky barrier diode, MESFETs, GaAs based MESFET, High Electron Mobility Transistors (HEMT): Principle of operation and its features. The generic Modulation Doped FET (MODFET), InGaAs/InP HEMT structures, advantages of GaAs, InP and GaN based devices for high speed operation. Terahertz devices: Nonlinear crystals, Quantum cascade lasers, THz diodes, THz transistors, Resonant tunneling diodes, Plasma-wave devices, Meta-materials.	10
Unit 3	**Optoelectronic devices:** Fundamentals of compound semiconductor based optical devices, optoelectronic devices: solar cells, photodiodes, LEDs and LASERS on compound semiconductors.	8
Unit 4	**High power devices:** GaN power devices- structures, potential and benefits, SiC power devices- structures, potential and benifits.	8
Unit 5	**Technology:** Synthesis of Compound semiconductors, Fabrication of MESFET and HEMT structures, Fabrication of LED and LASER structures.	8

Course Outcomes: By the end of this course, the students should be able to	
1	Illustrate the fundamentals of compound semiconductors.
2	Interpret the material properties and fabrication of compound semiconductors.
3	Explain the concepts of tera hertz devices and optoelectronic devices.
4	Examine the high frequency devices based on the fundamentals of compound semiconductors.

Suggested Books:

Text Books		
S.No.	**Name of Book/ Authors/ Publisher**	**Year of Publication / Reprint**
1	C.Y. Chang, F. Kai, GaAs High-Speed Devices: Physics, Technology and Circuit Applications, Wiley & Sons.	Latest edition
2	Cheng T. Wang, Ed., Introduction to Semiconductor Technology: GaAs and Related Compounds, John Wiley & Sons.	Latest edition
Reference Books		
S.No.	**Name of Book/ Authors/ Publisher**	**Year of Publication / Reprint**
1	Avishay Katz, Indium Phosphide and Related materials: Processing, Technology and Devices, Artech House.	1992
2	S.M. Sze, High Speed Semiconductor Devices, Wiley .	1990
3	Ralph E. Williams, Modern GaAs Processing Methods, Artech .	1990
4	Sandip Tiwari, Compound Semiconductor Device Physics, Academic Press.	1991

Equivalent MOOCs courses:

S.No.	**Course Links**	**Offered by**
1	Fundamentals of semiconductor devices https://archive.nptel.ac.in/courses/108/108/108108122/	NPTEL

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	H	H	H	M					H				H	H
CO2	H	H	H	M					H				H	H
CO3	H	H	H	M					H				H	H
CO4	H	H	H	M					H				H	H

Course Name	**:**	**MIXED SIGNAL DESIGN**
Course Code	**:**	**VLE118**
Credits	**:**	**4**
L T P	**:**	**3-1-0**

Course Objective:
The student should be able

- To explain the working of mixed-signal circuits like DAC, ADC, PLL etc.
- To examine the operation of basic building blocks for CMOS amplifiers and other mixed-signal circuits.
- To analyze the different design architectures in mixed signal mode.
- To review the performance of sample and hold circuits.

Total No. of lectures: 42

Lecture wise breakup		**No. of Lectures**
Unit 1	**PHASE LOCKED LOOP** Characterization of a comparator, basic CMOS comparator design, analog multiplier design, PLL - simple PLL, charge-pump PLL, applications of PLL.	7
Unit 2	**BUILDING BLOCKS FOR CMOS AMPLIFIERS** Design of current mirrors, differential amplifiers, CMOS operational trans-conductance amplifiers: design of single ended telescopic cascade and folded cascode amplifiers.	8
Unit 3	**A/D CONVERTER ARCHITECTURES** Input/output characteristics and quantization error of an A/D converter, performance metrics of pipelined architectures, Successive approximation architectures, interleaved architectures.	8
Unit 4	**D/A CONVERTER ARCHITECTURES** Input/output characteristics of an ideal D/A converter, performance metrics of D/A converter, D/A converter in terms of voltage, current, and charge division or multiplication, switching functions to generate an analog output corresponding to a digital input. Resistor-Ladder architectures, Current steering architectures.	9
Unit 5	**SAMPLING CIRCUITS** Basic sampling circuits for analog signal sampling, performance metrics of sampling circuits, different types of sampling switches. Sample-and-Hold Architectures- Open-loop & closed-loop architectures, open-loop architecture with miller capacitance, multiplexed-input architectures, recycling architecture, switched capacitor architecture, current-mode architecture.	10

Course Outcomes:
By the end of this course, the students will be able to

1	Explain PLL design and explore its applications.
2	Design the mixed signal circuits like DAC, ADC etc.
3	Design and evaluate the performance of fully differential amplifiers.

4	Describe various Sample-and-Hold circuits and their various architectures.

Suggested Books:

Text Books		
S.No.	**Name of the Book/Author/Publisher**	**Year of Publication /Reprint**
1	Razavi, "Design of analog CMOS integrated circuits", McGraw Hill. Second Edition.	2017
2	Jacob Baker, "CMOS Mixed-Signal circuit design", IEEE Press.	2009
Reference Books		
S.No.	**Name of Book/Authors/Publisher**	**Year of Publication /Reprint**
1	Razavi, "Principles of data conversion system design", Wiley IEEE Press.	1996
2	Gregorian, Temes, "Analog MOS Integrated Circuit for signal processing", John Wiley & Sons.	1986
3	Baker, Li, Boyce, "CMOS: Circuit Design, layout and Simulation", PHI.	2000

Equivalent MOOC courses:

S.No.	**Course Links**	**Offered by**
1	"CMOS Mixed Signal VLSI Design" by Professor Prof. Maryam ShojaeiBaghini and Prof. Dinesh Sharma, IIT Bombay CMOS Mixed Signal VLSI Design online course video lectures by IIT Bombay (freevideolectures.com)	Free Video Lectutres.com
2	Mixed Signal Integrated Circuits Design by Prof.NithinMuralidharan https://www.youtube.com/watch?v=oia9paQF06k&list=PLG4LDxYH2oQqN5f_eGRCUveQ6xkTPWZd-	You tube

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	H	H	H						H				H	H
CO2	H	H	H						H				H	H
CO3	H	H	H						H				H	H
CO4	H	H	H						H				H	H

Course Name	**:**	**COMPUTER ARCHITECTURE**
Course Code	**:**	**VLE119**
Credits	**:**	**4**
L T P	**:**	**3-1-0**

Course Objectives:
The student should be able

- To explore and define the architecture and organization of the basic computer.
- To explore the role of different modules like control unit, central processing unit, I/O, and memory organization of basic computers.
- To analyze computer arithmetic.
- To define the concept of parallel processing.

Total No. of lectures: 42

Lecture wise breakup		**No. of Lectures**
Unit 1	**REGISTER TRANSFER AND MICRO OPERATIONS** Register transfer Language, Register transfer, Bus & memory transfer, micro-operations, Instruction codes, Computer instructions, Timing & control, Instruction Cycles, Memory reference instruction, Input /Output & Interrupts, Complete computer description & design of a basic computer.	10
Unit 2	**CENTRAL PROCESSING UNIT** Hardwired vs. Microprogrammed control unit, Instruction sequencing. Introduction of GPU. General register organization, Stack organization, Instruction format, Data transfer & manipulation, Program control, RISC, CISC.	12
Unit 3	**COMPUTER ARITHMETIC** Addition & subtraction, Multiplication Algorithms, and Division algorithms.	6
Unit 4	**I/O AND MEMORY ORGANIZATION** Peripheral devices, I/O interface, Data transfer schemes, Program control, Interrupt, DMA transfer, I/O processor. Memory hierarchy, Processor vs. memory speed, Hard disk drive, High-speed memories, Cache memory, Associative memory, Interleave, Virtual memory, and Memory management.	10
Unit 5	**PARALLEL PROCESSING** Types of parallel processors, performance considerations, pipeline processors, array processors, multicore systems, and multiprocessors.	4

Course Outcomes:
By the end of this course, the students will be able to

1	Define the syntax of Register Transfer Language and different micro-operations.
2	Design and construct the instruction format & addressing modes for a given operation and algorithms for addition, subtraction, multiplication & division.
3	Explain the interdependence of different modules like the control unit, CPU and I/O interface and their design aspects.
4	Summarize the working of different types of memories like associate memory, cache memory, virtual memory, etc. and their mapping techniques.

5	Outline the concept of pipelining and multiprocessors.

Suggested Books:

Text Book		
S.No.	**Name of Book/ Authors/ Publisher**	**Year of Publication / Reprint**
1	Computer System Architecture, Morris M. Mano, Prentice Hall, 3rd ed.	1992
2	Computer Architecture and Organization, J.P. Hayes, McGraw Hill, 3rd ed.	1998
3	Computer Architecture: A Quantitative Approach, J.L. Hennessy, D.A. Patterson and D. Goldber, Pearson Education Asia, 5th ed.	2006
Reference Books		
S.No.	**Name of Book/ Authors/ Publisher**	**Year of Publication / Reprint**
1	Computer Organization, C. Hamacher, Z. Vranesic, S. Zaky, McGraw Hill Education, 6th ed.	2011
2	Computer Organization and Architecture: Designing for Performance, W. Stallings, Pearson, 8th ed.	2010
3	Computer Organization and Design, D. A. Patterson, J. L. Hennessy, Morgan Kaufmann series, 4th ed.	2010
4	System Architecture: software and hardware concepts, W.E. Leigh, and D.L. Ali, South Wester Publishing Co.	2000

Equivalent MOOC courses:

S. No.	**Course Links**	**Offered By**
1	Computer architecture and organization by Prof. Indranil Sengupta, Prof. Kamalika Datta, IIT Kharagpur https://nptel.ac.in/courses/106105163	NPTEL
2	Computer Architecture by Prof. Smruti Ranjan Sarangi, IIT Delhi https://onlinecourses.nptel.ac.in/noc23_cs67/preview	NPTEL

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	H	M	M						H				H	H
CO2	H	H	M						H				H	H
CO3	H	H	L						H				H	H
CO4	H	H	L						H				H	H
CO5	H	H	L						H				H	H

Course Name	**:**	**QUANTUM MATERIALS AND DEVICES**
Course Code	**:**	**VLE120**
Credits	**:**	**4**
L T P	**:**	**3-1-0**

Course Objectives:
The student should be able to

- Analyze tunneling through single quantum dots and the coulomb blockade phenomenon.
- Explore the principles and operation of quantum well & quantum dot lasers.
- Apply knowledge of different types of single-photon detectors, including photomultiplier tubes and superconducting nanowire single-photon detectors.
- Explore approaches for quantum computers, such as optical, ion trap, atom-based, and superconducting approaches.
- Develop knowledge of superconducting qubits, XMON Qubit Hamiltonian, and eigenstates.

Total No. of lectures: 42

Lecture wise breakup		**No. of Lectures**
Unit 1	**QUANTUM ELECTRONICS AND QUANTUM LOGIC** Quantum Dots: size quantization effects, Exciton confinements, increase in the bandgap, density of states of quantum dots, quantum 2D electron gas materials.Quantum Conductance: ballistic transport, resistance quantization, derivation of Landauer formula, break-junction experiments. Tunnel junctions: tunnelling through single Quantum dots – Coulomb blockade phenomenon. Gated tunnel devices.	8
Unit 2	**QUANTUM OPTOELECTRONIC DEVICES** Quantum well lasers, Quantum dot lasers, Tunnel injection quantum dot lasers.	7
Unit 3	**SINGLE PHOTON SOURCES AND DETECTORS** Deterministic single-photon sources: Single atoms, ions and molecules, colour centres of diamond, Quantum dots; Probabilistic single-photon sources: spontaneous parametric down conversion in bulk crystals, four-wave mixing in optical fibers and atoms. Single photon detectors: Non-photon-number-resolving detectors single-photon detector: photomultiplier tubes, single-photon avalanche photodiodes, superconducting nanowire single-photon detectors. Single photon counting modules, time to amplitude converter.	8
Unit 4	**QUANTUM DEVICES AT ULTRA-LOW TEMPERATURE** Transport spectroscopy and spintronics materials. Superconducting electronics: N-I-N, S-I-N, S-I-S tunnelling, Josephson effect, SQUID, single photon detection, topological insulators.Candidates for quantum computer: optical, ion trap, atoms, super-conductors.	9

Unit 5	**SUPERCONDUCTING QUANTUM COMPUTERS** Qubit dynamics and coupling: two-state Quantum System, qubits and qubit control, entanglement, Josephson Junction and Superconducting Quantum Interference Device (SQUID), Flux tuneable Josephson energy, Quantized Electronic Devices: Canonical Quantization, Josephson Junction quantization, Josephson Junction Qubit. Qubit state measurement and entanglement, coupling through Jaynes-Cummings Hamiltonian. Superconducting Qubit, XMON Qubit Hamiltonian and eigenstates. Quantum Supremacy,Google Sycamore QCPU: XMON State control, readout, entanglement, performance, QCPU operations, Qubit programmable QCPU.	10

Course Outcomes:
By the end of this course, the students will be able to

1	Analyze the size quantization effects in quantum dots and their impact on electronic properties.
2	Explore the characteristics of quantum dot lasers and their advantages.
3	Apply the principles of single photon detectors, including photomultiplier tubes and superconducting nanowire single-photon detectors.
4	Explain the operation and applications of Superconducting Quantum Interference Devices (SQUIDs).
5	Enable qubit state measurement and entanglement analysis through the Jaynes-Cummings Hamiltonian also, understand quantized electronic devices, canonical quantization, and Josephson Junction quantization.

Suggested Books:

Text Books

S. No.	Name of Book/Authors/Publisher	Year of Publication /Reprint
1	Experimental Techniques in Condensed Matter Physics at Low Temperatures: Richardson and Smith	1998
2	Matter and Methods at Low Temperatures: Frank Pobell, Springer.	2007

Reference Books

S. No.	Name of Book/Authors/Publisher	Year of Publication /Reprint
1	Single Photon Generation and Detection: Migdall, Polyakov, Fan and Bienfang.	2013
2	Introduction to Superconductivity, A. C. Rose-Innes and E. H. Rhoderick, Pergamon.	1978
3	Physics of Semiconductor Devices, S.M. Sze, Wiley Publications.	2006

Equivalent MOOCs courses:

S.No.	Course Links	Offered by
1	Quantum Physics, IIT Madras, Prof. V. Balakrishnan https://nptel.ac.in/courses/122106034	NPTEL
2	Quantum Computing, IIT Kanpur, Prof.DebabrataGoswami https://nptel.ac.in/courses/104104082	NPTEL

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	H	H						H				H	H
CO2	H	H	H						H				H	H
CO3	H	H	H						H				H	H
CO4	H	H	H						H				H	H
CO5	H	H	H						H				H	H

DEPARTMENT ELECTIVE COURSES

DEC V (for VI Semester)

Course Name	**:**	**VLSI DIGITAL SIGNAL PROCESSING**
Course Code	**:**	**VLE108**
Credits	**:**	**4**
L T P	**:**	**3-1-0**

Course Objectives:
The student should be able

- To analyze and apply the signals and systems in real-world applications.
- To explore advanced techniques in DFT for applications like image and audio processing.
- To design high-speed, and low-power VLSI systems for a broad range of DSP applications.
- To describe multirate systems for various applications.

Total No. of lectures: 42

Lecture wise breakup		**No. of Lectures**
Unit 1	**INTRODUCTION** Review of discrete signals and systems analysis, sampling, quantization and reconstruction processes, Typical applications of DSP. Basics of DFT and IDFT. circular convolution using DFT, Fast Fourier Transform (FFT), Decimation in time and decimation in frequency algorithms. Applications of DFT in speech and audio coding.	10
Unit 2	**DIGITAL FILTERS** Recursive and non-recursive systems, Frequency domain representation of discrete time systems, systems function, Ideal low pass filter.	2
Unit 3	**DESIGN OF FIR AND IIR FILTERS** Impulse invariance transformation technique, Bilinear transformation. Design of IIR Filters using Butterworth, chebyshev and elliptic filter. Design of FIR filters: Design of FIR filters using Window technique, frequency sampling technique, Equiripple Approx. technique, comparison of IIR and FIR filters.	12
Unit 4	**VLSI DSP TECHNIQUES** Retiming – definitions and properties, Retiming Techniques - Unfolding, properties of unfolding, Critical path, Register Minimization, Folding, Folding order, Folding Factor, Retiming for folding, Register Minimization technique, folding of Multirate systems- Systolic array Methodology, Selection of Scheduling Vector, Matrix multiplication and 2D Systolic array design, Fast Convolution-Iterated Convolution, Cyclic Convolution.	8
Unit 5	**ALGORITHM STRENGTH REDUCTION** Introduction, Parallel FIR filters, Polyphase decomposition, Fast FIR filters Algorithms, Discrete Cosine Transform and Inverse Discrete Cosine Transform, Algorithm-Architecture Transformation, Pipelined and Parallel Recursive, Look-Ahead Computation, Look-Ahead Pipelining, Parallel processing in IIR Filters. Case Studies: Complete Design of DSP Processor, filters.	10

Course Outcomes: By the end of this course, the students will be able to	
1	Analyze signal processing tasks from VLSI perspective.
2	Perform the algorithmic transformations using pipelining, parallel processing techniques for the development of high speed and low power systems.
3	Realize area efficient systems using folding and unfolding approaches.
4	Describe various concepts for numerical strength reduction.

Suggested books:

Text Books		
S.No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	VLSI Digital Signal Processing Systems, Design and implementation, Keshab K. Parhi, John Wiley & Sons, New Delhi.	2012
2	Digital Signal Processing, Proakis, J.G., and Manolakis, D.G., PHI, 3rd ed.	2001
3	Digital Filters: Analysis, Design and Application, Proakis, J.G., McGraw Hill, 2nd ed.	1981
Reference Books		
S.No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Digital Signal Processing with Field Programmable Gate Arrays, U. Meyer – Baese, Springer, Second Edition	2007
2	Multirate Systems and Filter Banks by P.P. Vaidyanathan, Pearson Education	2003
3	Digital Signal Processing: A Practical Approach by Barrie Jervis (Author), Emmanuel Ifeachor, 2nd edition, Pearson	2001

S.No.	**Course Links**	**Offered by**
1	Digital Signal Processing by Prof. S.C. Dutta Roy (IIT Delhi). https://nptel.ac.in/courses/117102060.	NPTEL
2	Digital Signal Processing by C. S. Ramalingam (IIT Madras). https://nptel.ac.in/courses/108106151.	NPTEL

Equivalent MOOCs courses:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	H	H	H						H				H	H
CO2	H	H	H						H				H	H
CO3	H	H	H						H				H	H
CO4	H	H	H						H				H	H

Course Name	**:**	**CONTROL SYSTEMS**
Course Code	**:**	**VLE111**
Credits	**:**	**4**
L T P	**:**	**3-1-0**

Course Objectives: The student should be able to
• Develop the model of a control system using different approaches. • Analyze the system in time domain and frequency domain and investigate its stability. • Design compensators and controllers for the specified requirements. • Analyze transform analysis and state variable approach to control systems.

Total No. of Lectures – 42

Lecture wise breakup		**No. of Lectures**
Unit 1	**INTRODUCTION and MODELLING of CONTROL SYSTEMS** Basic components of a control system, classification of control system, Servomechanism, Regulator and process control, Feedback control Systems-Characteristics and Performance, Transfer function approach, Block Diagram Representation, Signal flow graphs.	6
Unit 2	**TIME RESPONSE ANALYSIS** Time response of first order systems, second order systems, performance specifications, steady state errors and error constants, Sensitivity.	6
Unit 3	**CONCEPT OF STABILITY** Conditions of stability, Routh-Hurwitz criterion, Root locus technique	5
Unit 4	**FREQUENCY RESPONSE ANALYSIS** Correlation between time and frequency response, Polar Plots, Bode Plot, stability margins on Bode plots, Nyquist criteria, Assessment of stability using Nyquist criteria.	8
Unit 5	**COMPENSATOR DESIGN USING BODE PLOTS** Preliminary considerations of classical design, realization of basic compensators, Lead compensator, Lag compensator, Lag-Lead Compensator, Introduction to Computer-aided design using MATLAB.	6
Unit 6	**CONTROL ACTIONS AND CONTROLLER CHARACTERISTICS** Proportional, Integral and Derivative Control Actions, Proportional plus integral control action, proportional plus derivative control action, PID controller.	3
Unit 7	**DIGITAL CONTROL SYSTEMS** Introduction, Z-transform analysis of sampled data control systems, Z and s-domain relationship, stability analysis.	4
Unit 8	**STATE VARIABLE ANALYSIS OF CONTROL SYSTEMS** Concepts of state, state variables and state model, state models for linear continuous-time systems, transfer function from state model, solution of state equation, State Transition Matrix, Single Input Single output system, multiple	4

	input multiple output system, concept of controllability and observability.	

Course Outcomes: By the end of this course, the students will be able to	
1	Determine the transfer function of the system using different approaches.
2	Analyze the system in time domain and investigate the stability.
3	Analyze the system in frequency domain and investigate the stability.
4	Design compensators and PID controller for the specified requirements.
5	Develop and analyze the state space models of systems and apply Z- transform to analyze digital control systems.

Suggested Books:

Text Books		
S.No.	**Name of Book/ Authors/ Publisher**	**Year of Publication / Reprint**
1	Control Systems Engineering By Nagrath and Gopal, New Age International,4th Ed	2006
2	Digital Control Engineering by M Gopal, New Age International	2003
3	Control Systems Engineering, Nise, N. S., 6th Ed., Wiley India	2010
Reference Books		
S.No.	**Name of Book/ Authors/ Publisher**	**Year of Publication / Reprint**
1	Modern Control Engineering, Ogata, K., 5th Ed., Pearson Education. 2008	2009
2	Modern Control Systems, Dorf, R.C. and Bishop, R.H., 12th Ed., Prentice-Hall of India.	2010
3	Automatic Control Systems, Kuo, B.C, 9th Ed., Wiley India	2009

Equivalent MOOCs courses:

S.No.	**Course Links**	**Offered by**
1	Course Name: Systems and Control https://ocw.mit.edu/courses/2-04a-systems-and-controls-spring-2013/	MIT Opencourse ware
2	Course Name: Control Systems https://onlinecourses.nptel.ac.in/noc19_de04/preview	NPTEL

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	H	H						H				H	H
CO2	H	H	H		L				H				H	H
CO3	H	H	H		L				H				H	H
CO4	H	H	H		L				H				H	H
CO5	H	H	H						H				H	H

Course Name	**:**	**SILICON PHOTONICS**
Course Code	**:**	**VLE115**
Credits	**:**	**4**
L T P	**:**	**3-0-2**

Course Objectives:
The student should be able to

- Explain the key principles underlying the analysis and design of integrated photonic devices and circuits.
- Describe the differences in on-chip rectangular optical waveguides and circular waveguides.
- Describe the on-chip optical fabrication technology and materials.
- Explore the issues related to co-integration of electrical and optical devices.

Total No. of Lectures: 42

Lecture wise breakup		**No. of Lectures**
Unit 1	**INTRODUCTION** Distinction between electronic, optoelectronic and photonic devices; Electrical and optical bandwidth, requirement of Photonic Integrated circuits	3
Unit 2	**OPTICAL WAVEGUIDES** Planar slab waveguides, symmetric and asymmetric waveguides; rectangular waveguides, Marcatili's method, Effective index method; graded index waveguides; loss in planar slab waveguide; Coupled mode theory and applications.	12
Unit 3	**ADVANCED WAVEGUIDES AND DEVICES** Silicon-on Insulator waveguide, Silicon plasmonic waveguide, and silicon wire waveguide couplers, multimode interference-based couplers, tapers, bends, y-branch, gratings, switches, polarizers, filters, resonators, multiplexer/demultiplexer, Semiconductor Sources (LDs (Double heterojunction, DFB, Quantum wire & dot), Semiconductor Detectors (Structure and analysis of PIN and APD detectors,	12
Unit 4	**TECHNOLOGY** Materials-glass, lithium niobate, silicon, compound semiconductors, polymers, metamaterial; fabrication techniques - lithography, ion-exchange, deposition, diffusion process, and device characterization, packaging and environmental issues.	10
Unit 5	**INTEGRATION OF PHOTONIC DEVICES** Major Issues, photonic device integration, photonic-electronic integration, power and power density issues on-chip.	5

List of Experiments		**No. of Turns**
1	Familiarization with CAD Software for Photonic Design. Overview of CAD tools for photonics. Basic navigation and interface understanding Initial setup for photonic simulations.	2
2	Design of 2D Passive Photonic Devices. Design and simulate 2D waveguides, couplers, and bends. Analyze modes, refractive index profiles, dispersion, and losses.	2
3	Design of 3D Passive Photonic Devices. Design and simulate 3D photonic devices (switches, directional couplers).Analyze modes, refractive index profiles, and losses in 3D space.	3
4	Design of 2D and 3D Photonic Bandgap Structures. Design and simulate 2D photonic bandgap structures. Extend to 3D structures and analyze their performance.	3
5	Design of Plasmonic-Based Optical Sensor - Case Study Study principles of plasmonic sensing. Design a plasmonic-based optical sensor. Simulate and analyze its performance.	3

Course Outcomes: By the end of this course, the students will be able to	
1	Illustrate the importance of photonic integration and its applications
2	Design and analyse optoelectronic and photonic circuits including planar waveguides, high speed laser diodes, tapers, bends and couplers etc.
3	Describe fabrication technology and select the materials for design of optoelectronic device.
4	Explore the issues related to co-integration of electrical and optical devices.
5	Illustrate the use of modern Photonic CAD tools for the design of integrated optical devices and circuits.

Suggested Books:

Text books		
S.No.	**Name of Book/ Authors/ Publisher**	**Year of Publication / reprint**
1	C R Pollock and M Lipson: Integrated photonics, Kluwer Academic Pub,	2003
Reference books		
S.No.	**Name of Book/ Authors/ Publisher**	**Year of Publication / reprint**
1	Govind P Agrawal: Lightwave technology: component and devices, John Wiley ,	2004
2	Katsunari Okamoto: Fundamentals of Optical Waveguides Academic Press	2006
3	Silicon Photonics: Fueling the Next Information Revolution by Daryl Inniss, Roy Rubenstein	2017

Equivalent MOOCs courses:

S.No.	Course Links	Offered by
1	Photonic integrated circuit By Prof. Shankar Kumar Selvaraja Photonic integrated circuit - Course (nptel.ac.in)	NPTEL
2	Integrated Photonics Devices And Circuits by Prof. B K Das, NPTEL :: Electrical Engineering - NOC:Integrated Photonics Devices and Circuits	NPTEL

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	H	H	H									H	H
CO2	H	H	H	H									H	H
CO3	H	H	H	H									H	H
CO4	H	H	H	H									H	H
CO5	H	H	H	H	H				H	H			H	H

Course Name	**:**	**COMPUTER ARCHITECTURE**
Course Code	**:**	**VLE119**
Credits	**:**	**4**
L T P	**:**	**3-1-0**

Course Objectives: The student should be able
• To explore and define the architecture and organization of the basic computer. • To explore the role of different modules like control unit, central processing unit, I/O, and memory organization of basic computers. • To analyze computer arithmetic. • To define the concept of parallel processing.

Total No. of lectures: 42

Lecture wise breakup		**No. of Lectures**
Unit 1	**REGISTER TRANSFER AND MICRO OPERATIONS** Register transfer Language, Register transfer, Bus & memory transfer, micro-operations, Instruction codes, Computer instructions, Timing & control, Instruction Cycles, Memory reference instruction, Input /Output & Interrupts, Complete computer description & design of a basic computer.	10
Unit 2	**CENTRAL PROCESSING UNIT** Hardwired vs. Microprogrammed control unit, Instruction sequencing. Introduction of GPU. General register organization, Stack organization, Instruction format, Data transfer & manipulation, Program control, RISC, CISC.	12
Unit 3	**COMPUTER ARITHMETIC** Addition & subtraction, Multiplication Algorithms, and Division algorithms.	6
Unit 4	**I/O AND MEMORY ORGANIZATION** Peripheral devices, I/O interface, Data transfer schemes, Program control, Interrupt, DMA transfer, I/O processor. Memory hierarchy, Processor vs. memory speed, Hard disk drive, High-speed memories, Cache memory, Associative memory, Interleave, Virtual memory, and Memory management.	10
Unit 5	**PARALLEL PROCESSING** Types of parallel processors, performance considerations, pipeline processors, array processors, multicore systems, and multiprocessors.	4

Course Outcomes: By the end of this course, the students will be able to	
1	Define the syntax of Register Transfer Language and different micro-operations.
2	Design and construct the instruction format & addressing modes for a given operation and algorithms for addition, subtraction, multiplication & division.
3	Explain the interdependence of different modules like the control unit, CPU and I/O interface and their design aspects.
4	Summarize the working of different types of memories like associate memory, cache memory, virtual memory, etc. and their mapping techniques.
5	Outline the concept of pipelining and multiprocessors.

Suggested Books:

Text Book		
S.No.	**Name of Book/ Authors/ Publisher**	**Year of Publication / Reprint**
1	Computer System Architecture, Morris M. Mano, Prentice Hall, 3rd ed.	1992
2	Computer Architecture and Organization, J.P. Hayes, McGraw Hill, 3rd ed.	1998
3	Computer Architecture: A Quantitative Approach, J.L. Hennessy, D.A. Patterson and D. Goldber, Pearson Education Asia, 5th ed.	2006
Reference Books		
S.No.	**Name of Book/ Authors/ Publisher**	**Year of Publication / Reprint**
1	Computer Organization, C. Hamacher, Z. Vranesic, S. Zaky, McGraw Hill Education, 6th ed.	2011
2	Computer Organization and Architecture: Designing for Performance, W. Stallings, Pearson, 8th ed.	2010
3	Computer Organization and Design, D. A. Patterson, J. L. Hennessy, Morgan Kaufmann series, 4th ed.	2010
4	System Architecture: software and hardware concepts, W.E. Leigh, and D.L. Ali, South Wester Publishing Co.	2000

Equivalent MOOC courses:

S. No.	Course Links	Offered By
1	Computer architecture and organization by Prof. Indranil Sengupta, Prof. Kamalika Datta, IIT Kharagpur https://nptel.ac.in/courses/106105163	NPTEL
2	Computer Architecture by Prof. Smruti Ranjan Sarangi, IIT Delhi https://onlinecourses.nptel.ac.in/noc23_cs67/preview	NPTEL

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	H	M	M						H				H	H
CO2	H	H	M						H				H	H
CO3	H	H	L						H				H	H
CO4	H	H	L						H				H	H
CO5	H	H	L						H				H	H

OPEN ELECTIVE COURSES

Course Name	**:**	**ARDUINO PROGRAMMING AND RASPBERRY PI**
Course Code	**:**	**ECO101**
Credits	**:**	**4**
L T P	**:**	**3 1 0**

Course Objectives:
The student should be able to

- To explore the components, features and architecture of AVR microcontroller.
- To design an electronics system using Arduino.
- To explore the basic functionality and configuration of Raspberry Pi and analyze the programming and interfacing with Raspberry Pi.
- To explore the Python programming language on the Raspberry Pi.

Total No. of Lectures – 42

Lecture wise breakup		**No. of Lectures**
Unit 1	**EMBEDDED SYSTEM DESIGN: BASICS** Introduction to embedded systems, Components of embedded system. Advantages and applications of embedded systems, Examples of real time embedded systems and how they are manufacturedindustry ready, Different Microcontroller Architectures (CISC, RISC, ARISC), Internal Resources & Hardware Chips in Details, History of AVR Microcontrollers and Features, Memory Architectures (RAM/ROM).	10
Unit 2	**LEARNING ARDUINO PLATFORM** Introduction to ARDUINO, ARDUINO History and Family, General Programming and Hardware Interfacings with Arduino, The basic sensors and actuators using Arduino, Controlling embedded system based devices using Arduino.	8
Unit 3	**GETTING STARTED WITH RASPBERRY Pi** Basic functionality of the Raspberry Pi board and its Processor, setting and configuring the board, differentiating Raspberry Pi from other platform like Arduino, Begal, Asus thinker etc., Overclocking, Component overview.	8
Unit 4	**PROGRAMMING THE RASPBERRY Pi** Introducing to Python programming language: Python Programming Environment, Python Expressions, Strings, Functions, Function Arguments, Lists, List Methods, Control Flow, Numpy, PIP (Python Installation Package) and customized libraries.	8
Unit 5	**EXPLORING ELECTRONICS WITH THE RASPBERRY Pi** Communication facilities on raspberry Pi (I2C, SPI, UART), working with RPi. GPIO library, Interfacing of Sensors and Actuators.	8

Course Outcomes:
By the end of this course, the students will be able to

1	Illustrate how the Arduino platform works in terms of the physical board, libraries, and the IDE (Integrated Development Environment).
2	Program Arduino using C code and access the pins on the board via the software to control external devices.
3	Analyze the working and programming of Raspberry Pi, its features and how various components can be used with it.
4	Develop an understanding of interfacing of components with Raspberry Pi.

Suggested Books:

Textbooks

S.No.	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1	Margolis, M. Arduino cookbook: Recipes to begin, expand, and enhance your projects. O'Reilly Media, Inc.	2011
2	ARM System Developer's Guide -Designing and Optimizing System Software by: Andrew N Sloss, Dominic Symes, Chris Wright;Elseiver	2004
3	Mark Lutz, "Learning Python", O'Reilly Media, 5th Edition.	2016

Reference books

S.No.	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1	The official raspberry Pi Projects Book: https://www.raspberrypi.org/magpi-issues/Projects_Book_v1.pdf	NA
2	Raspberry Pi Assembly Language RASPBIAN Beginners THIRD EDITION, CreateSpace Independent Publishing Platform.	2013

Equivalent MOOCs courses

S.No.	Course Links	Offered by
1	Introduction to Internet of Things https://onlinecourses.nptel.ac.in/noc22_cs53/preview	NPTEL

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	M	M						H				H	H
CO2	H	H	H	H	L				H				H	H
CO3	H	M	M						H				H	H
CO4	H	H	H	H	M				H				H	H

Course Name	**:**	**COMPUTER NETWORKS**
Course Code	**:**	**ECO102**
Credits	**:**	**4**
L T P	**:**	**3 1 0**

Course Objectives:
The student should be able

- To analyze the concepts of data communications and networks in the real world.
- To explore the various layers of the OSI Model and their functionalities.
- To apply the channel allocation, framing, error, and flow control techniques.
- To develop network architecture, assign IP addressing and apply various routing algorithms to find the shortest paths for network-layer packet delivery.
- To analyse the computer network infrastructure and study various security mechanisms in real-world applications.

Total No. of Lectures – 42

Lecture wise breakup		**No. of Lectures**
Unit 1	**OVERVIEW OF DATA COMMUNICATION AND NETWORKING** Data communications, Networks, The Internet, Protocols and standards, Layered tasks, OSI model, TCP /IP protocol Architecture, History of the computer network, Internetworking Devices, overview of SS7, Diameter and Sigtran protocols.	3
Unit 2	**PHYSICAL LAYER** Data rate limit, Transmission impairments, Line coding, Block coding, Sampling, Transmission mode, Modulation of digital data, Telephone modems, Modulation of analog signal, FDM, WDM, TDM, Guided media, Unguided media.	5
Unit 3	**DATA LINK LAYER** Types of errors, Detection, Error correction, Flow and error control, Stop and wait ARQ, go back n ARQ, Selective repeat ARQ, HDLC, point-to-point protocol, PPP stack, Random access (ALOHA, CSMA), Controlled access (Reservation, Polling, Token Passing), Channelization (FDMA, TDMA, CDMA), Traditional Ethernet, Fast Ethernet, Gigabit Ethernet.	8
Unit 4	**NETWORK LAYER** Repeaters, Bridges, Type of Bridges, Routers, Routing concepts, Gateways, Internetworks, ARP, IP, ICMP, IPV6, Unicast routing, Unicast routing protocol, Multicast routing, Multicast routing protocols, introduction to Security, Cryptography, and SSL, Security - firewalls, DoS, etc.	6
Unit 5	**TRANSPORT LAYER** Process to process delivery, User datagram protocol (UDP), Multiplexing and Demultiplexing, Connection less transport (UDP), Principles of reliable data transfer, Transmission control protocol (TCP), Data traffic, Congestion, Congestion control, Quality of service	4
Unit 6	**PRESENTATION LAYER AND SESSION LAYER** Session layer function, Token Management, and Session Layer Protocols, Presentation layer function and Protocols	4
Unit 7	**APPLICATION LAYER** DNS, Electronics mail architecture and services, message formats and transfers, WWW architectural overview, static and dynamic web pages, HTTP, Digital audio and video.	4
Unit 8	**WIRELESS NETWORKS AND SWITCHING**	8

	Cordless system, WiMAX and IEEE 802.16 broadband wireless access standards, Mobile IP, Wireless Application Protocol, IEEE 802 Architecture, IEEE 802.11 Architecture and Services, IEEE 802.11 Medium Access Control, IEEE 802.11 Physical Layer, Other IEEE 802.11 Standards, Wi-Fi Protocol Access, Bluetooth and IEEE 802.15, LTE. Emerging Applications: NFC, RFID, VoIP, SIP, video over P2P, VolTE Switching: Circuit Switching, Space division switching, Time division switching, Space and time division switching combinations, Packet switching, Data gram approach, Virtual circuit approach, message switching.	

Course Outcomes: By the end of this course, the students will be able to	
1	Describe the computer network system and its communication.
2	Classify and compare the various layers of a computer network model, their role, and characteristics.
3	Apply the concepts of channel allocation, framing, error, and flow control techniques.
4	Analyze the various wireless network models.
5	Implement various protocols (using Net Sim software) and prepare a comprehensive case study of the computer network infrastructure.

Suggested Books:

Textbooks		
S.No.	**Name of Book/ Authors/ Publisher**	**Year of Publication / Reprint**
1	Data Communication & Networking by Behrouz A. Forouzan, 6th edition, McGraw Hill	2022
2	Computer Networking: A Top-Down Approach by James F. Kurose and Keth W. Ross, 8th edition, Pearson Education	2022
3	Computer Networks by Andrew S. Tanenbaum, Nick Feamster and David J. Wetherall, 6th edition, Pearson Education	2022
Reference Books		
S.No.	**Name of Book/ Authors/ Publisher**	**Year of Publication / Reprint**
1	Computer Networks: A Systems Approach by Larry L. Peterson and Bruce S. Davie, 6th edition, Elsevier Science	2021
2	Data and Computer Communications by William Stallings, 10th edition, Pearson Education	2017
3	Data Communication and Distributed Networks by Ulylers D. Black, 3rd edition, Prentice Hall India Learning Private Limited	1994

Equivalent MOOCs courses:

S.No.	**Course Links**	**Offered by**
1	Computer Networks and Internet Protocol by Prof. Soumya Kanti Ghosh Prof. Sandip Chakraborty (IIT Kharagpur) https://onlinecourses.nptel.ac.in/noc21_cs18/preview	NPTEL
2	Computer Networking by Nick Feamster **(**Georgia Institute of Technology**)**. https://www.my-mooc.com/en/mooc/computer-networking--ud436/	Udacity

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	M	M						M				H	H
CO2	H	M	M						M				H	H
CO3	H	M	H	H					M				H	H
CO4	H	M	H	M					M				H	H
CO5	H	H	M	H	H				M	M			H	H

Course Name	**:**	**SEMICONDUCTOR PACKAGE MANUFACTURING**
Course Code	**:**	**ECO103**
Credits	**:**	**4**
L T P	**:**	**3-1-0**

Course Objectives:
The student should be able

- To explain the basic concepts of package manufacturing process.
- To describe the various testing methods and their principles for components and package testing.
- To analyse the IC failure mechanisms, EMI testing and material qualification criterias for IC packages.
- To explore the various methods of maintaining industrial quality and process control methods for Semiconductor packages.

Total No. of Lectures – 42

Lecture wise breakup		**No. of Lectures**
Unit 1	**PACKAGE MANUFACTURING PROCESSES** Packaging Assembly Technology, Wafer Thinning, Dicing, Die Attach, Wire bonding, Flip Chip process, Flux Cleaning, Underfill, Encapsulation, Laser Marking, Solder Ball Attach, Reflow, Singulation, IC Packaging Toolsets & equipment operation, clean room operations	8
Unit 2	**SEMICONDUCTOR COMPONENT AND PACKAGE TEST** Overview of Testing methodologies, components tested & their characteristics, Challenges in testing, Types of Testers (Automated test Equipment & Benchtop Testers), Components & Subsystems of Testers, Principles of Functional Testing, Parametric/ Boundary Scan /In-Circuit Test/ Flying Probe Test, Test Data Analysis, Design for Testability & Tester Calibration & Maintenance, Future Trends	10
Unit 3	**ELECTRICAL AND PHYSICAL FAILURE ANALYSIS** Package failure modes, Failure detection mechanisms, Failure analysis tools, Test programs debugging, Data Analytics, ESD & EMI Management	8
Unit 4	**SEMICONDUCTOR PACKAGE MATERIALS AND QUALIFICATION** Reliability testing & qualification- MST/MSL, TC/TS, HAST &uHAST, Mold Compounds (Moldability), Underfill Materials, Die Attach Adhesives & Films, Substrate Technology, Bonding Wire, Solder & Dielectric materials	8
Unit 5	**INDUSTRIAL QUALITY AND STATISTICAL PROCESS CONTROL** Quality Control Plan (QCP) & Quality Management System (QMS), Incoming Material Inspection, In-Line Quality, Measurement System Analysis, Statistical analysis methods, Statistical Process Control (SPC), Fault Detection Control (FDC), Run-to-Run Control (R2R), Auto Defect Classification (ADC), Data Analytics, Machine Communication Protocol and System Integration	8

Course Outcomes:
By the end of this course, the students will be able to

1	Comprehend the manufacturing process of various semiconductor packages.
2	Describe various package materials, testing and failure analysis.

3	Explain the package qualification methods and industrial quality management for the same.
4	Explain EMI and ESD effects, test programs analysis and statistical process control of package manufacturing.

Suggested Books:

Text Books		
S.No.	**Name of Book/ Authors/ Publisher**	**Year of Publication / Reprint**
1	Semiconductor Packaging: Materials interaction and reliability, Andrea Chen and R. Yu Lo, CRC.	2012
2	Semiconductor Manufacturing, H. Geng, TMH	Latest edition
Reference Books		
S.No.	**Name of Book/ Authors/ Publisher**	**Year of Publication / Reprint**
1	Gary S. May, Costas J. Spanos, Fundamentals of Semiconductor Manufacturing and Process Control (Wiley - IEEE)	2006
2	Semiconductor advanced packaging, John H. Lau, Springer	2021

Equivalent MOOCs courses:

S.No.	**Course Links**	**Offered by**
1	Electronic Manufacturing and Packaging https://nptel.ac.in/courses/112105267	NPTEL
2	Intro to Electronic Packaging https://ep.jhu.edu/courses/525607-intro-to-electronic-packaging/	Johns Hopkins University, United States

Remarks:

Course Name	**Already Existing/New Course**	**If already existing modifications done**	**Institute/Website/other references**
Semiconductor Package Manufacturing	New course	-	• AICTE Model Curriculum for UG Degree Course in Electronics Engineering (VLSI Design and Technology) • IIT Guwahati • IIT Hyderabad

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	H	H						H				H	H
CO2	H	H	H						H				H	H
CO3	H	H	H						H				H	H
CO4	H	H	H						H				H	H

Course Name	**:**	**NEURAL NETWORKS**
Course Code	**:**	**ECO104**
Credits	**:**	**4**
L T P	**:**	**3 1 0**

Course Objectives: The student should be able
● To explore the field of Neural Networks and relate the human neural system to the digital world. ● To explore the computation and dynamic systems using Neural Networks. ● To apply the machine and deep learning algorithms to various applications. ● To explore emerging trends and technologies in Neural Networks.

Total No. of lectures: 42

Lecture wise breakup		**No. of Lectures**
Unit 1	**OVERVIEW OF NEURAL NETWORK** Introduction to Artificial Neural Networks (ANN), Models of a Neuron, Network structure Error–correction learning, Feed-forward Network Functions, Single neuron/ Perceptron networks: Network Training, Gradient descent optimization, Multilayer Perceptron.	10
Unit 2	**NEURAL NETWORK-BASED RULES & ALGORITHMS** Simple Associative Networks- Unsupervised Hebb Rule- Hebb Rule with Decay-Instar Rule-Outstar Rule- Kohonen Rule, Adaline Network- Madaline Network - Mean Square Error- LMS Algorithm- Back Propagation Neural networks – Hopfield Networks.	10
Unit 3	**INTRODUCTION TO DEEP LEARNING** Deep generative models, Deep directed networks, Deep belief networks, Deep neural networks, Deep auto-encoders, and Applications of deep networks.	8
Unit 4	**MACHINE LEARNING** Types of machine learning, Supervised learning, Unsupervised learning, basic concepts in machine learning, K Nearest Neighbours. Kernels, Kernel functions and Dimensionality Reduction: Subset Selection, Principal Component Analysis (PCA).	8
Unit 5	**NEURAL CONTROL APPLICATIONS** Pattern recognition, Object recognition, Pattern classification, Supervised vs Unsupervised Classification, Natural Language Processing.	6

Course Outcomes: By the end of this course, the students will be able to:	
1	Explain the concept of artificial neural networks and describe the various neural network rules and algorithms.
2	Acquire the knowledge of different machine learning techniques.
3	Apply different machine-learning techniques to solve real-time problems.
4	Model the different architectures of Neural Networks.

Suggested Books:

Textbooks

S. No.	Name of Book/Authors/Publisher	Year Of Publication /Reprint
1	Laurene Fausett, "Fundamentals of Neural Networks Architectures, Algorithms, and Applications"	2004
2	Sandro Skansi, "Introduction to Deep Learning: From Logical Calculus to Artificial Intelligence", First Edition, Springer"	2018

Reference Books

S. No.	Name of Book/Authors/Publisher	Year Of Publication /Reprint
1	C. M. Bishop, Pattern Recognition and Machine Learning, Springer, 2013 Hagan Demuth Beale, 'Neural network design', PWS publishing company	1995
2	Freeman, J.A and Skapura, D.M., 'Neural Networks-Algorithms, applications and programming techniques' Addison Wesley	1991
3	Satish Kumar, Neural Networks – A classroom approach', Tata McGraw-Hill Publishing Company Limited	2004
4	Tom M. Mitchell, Machine Learning, McGraw Hill Education (India)	2013
5	Research and review papers in specific area.	

Equivalent MOOCs courses

S. No.	Course Links	Offered by
1	Neural Networks and Applications by Prof. Somnath Sengupta, IIT Kharagpur https://nptel.ac.in/courses/117105084	NPTEL
2	NOC:Deep Learning- Part 1 by Prof. Sudarshan Iyengar, Prof. Sanatan Sukhija, IIT Madras, https://nptel.ac.in/courses/106106184	NPTEL

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO 1	PSO2
CO1	H	M	M						H				H	M
CO2	H	M	M		M				H				M	H
CO3	H	H	H	H	M				H				M	H
CO4	H	H	H	H					H				H	M

MINOR SPECIALIZATION COURSES

Course Name	**:**	**HDL BASED SYSTEM DESIGN**
Course Code	**:**	**VLM101**
Credits	**:**	**4**
L T P	**:**	**3 0 2**

Course Objectives: The student should be able
● To explore the syntax and various constructs of Verilog HDL language and programming. ● To design the digital logic using various programmable logic devices. ● To develop the test benches using system Verilog. ● To execute finite state machine modelling.

Total No. of Lectures – 42

Lecture wise breakup		**No. of Lectures**
Unit 1	**BASIC VERILOG ELEMENTS** Lexical Conventions, Modules, Instances, Design Blocks, Stimulus Blocks, Data Types, Compiler Directives, Ports, Hierarchical Names, Tasks and Functions.	6
Unit 2	**MODELING IN VERILOG HDL** Gate-Level Modelling: Gate Types (And/ Or Gates, Buf/ Not Gates, Bufif/ NotifGates), Gate Delays (Rise, Fall and Turn-Off Delays, Min, Max, and Typical Delays). Data-Flow Modelling: Continuous Assignments, Delay Specification, Expressions, Operators, Operands, Operator Types. Behavioural modelling: Structured Procedures (initial and always), Procedural Assignments (Blocking and Non-Blocking Statements), Timing Controls, Conditional Statements, Multi-way Branching, Loops, Sequential and Parallel Blocks. Generate Blocks. Switch-Level Modelling: Switch modelling Elements. Universal verification methodology (UVM).	10
Unit 3	**ADVANCED FEATURES OF VERILOG HDL** Procedural Continuous Assignments, Overriding Parameters, Conditional Compilation and Execution, Time Scales, Useful System Tasks, Timing and Delays (Delay Model Types, Path Delay modelling, Timing Checks, Delay Back-Annotation), User-Defined Primitives (Basics of UDPs, Combinational UDPs, Sequential UDPs, UDP Shorthand Symbols. Programming Language, Logical Synthesis: Introduction and Impact of Logic Synthesis, Verilog HDL Synthesis	8
Unit 4	**INTRODUCTION TO SYSTEM VERILOG** Introduction, data types, arrays, structures and unions, procedures and functions	8
Unit 5	**MODELING IN SYSTEM VERILOG** Finite state machine modelling, Design hierarchy, Interfaces, behavioral and transaction level modelling.	10

List of Experiments		No. of Turns
1	Write Verilog code to realize all the logic gates and flip-flops.	2
2	Write Verilog codes for combinational designs like encoders and decoders, multiplexers and de-multiplexers.	2
3	Write a Verilog code to describe the functions of a Full Adder using Data flow, gate level and behavioral modeling styles.	2
4	Write a Verilog code to model 8-bit ALU with logical and arithmetical operations.	2
5	Develop the Verilog code for a sequence detector using FSM modeling.	2
6	Design a 4-bit BCD counter (Synchronous reset and Asynchronous reset) using Verilog code.	1
7	Write Verilog code to display messages on an alphanumeric LCD.	1
8	Implement full adder and multiplexer on FPGA kit.	2

Course Outcomes: By the end of this course, the students will be able to	
1	Identify and encode the digital modules using different Verilog HDL modeling styles.
2	Construct various digital logic circuits by using advanced features of Verilog HDL language.
3	Develop synthesizable circuits using logic synthesis tools.
4	Design and verify various circuits using test benches in system Verilog.

Suggested Books:

Text Books		
S.No.	**Name of Book/ Authors/ Publisher**	**Year of Publication / Reprint**
1	Verilog HDL: A Guide to Digital Design and Synthesis, S. Palnitkar, Prentice Hall NJ, USA	2003
2	A SystemVerilog Primer, by J. Bhasker	Latest edition
Reference Books		
S.No.	**Name of Book/ Authors/ Publisher**	**Year of Publication / Reprint**
1	Switching and Finite Automata Theory, ZviKohavi and Niraj K, CambridgeUniversity Press, Third Edition.	2010
2	‘Circuit design with VHDL’ by VoleniA Pedroni, MIT Press.	2011
3	System Verilog For Design: A Guide to Using SystemVerilog for Hardware Design, Stuart Sutherland, Simon Davidmann, Peter Flake, Springer Science	Latest edition

Equivalent MOOCs courses:

S.No.	Course Links	Offered by
1	Hardware modeling using Verilog by Prof.Indranil Sen Gupta https://archive.nptel.ac.in/courses/106/105/106105165/	NPTEL

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	H	H		H				M				H	H
CO2	H	H	H		H				M				H	H
CO3	H	H	H	M	H				M	M			H	H
CO4	H	H	H	M	H				M	M			H	H

Course Name	**:**	**DIGITAL AND ANALOG VLSI DESIGN**
Course Code	**:**	**VLM102**
Credits	**:**	**4**
L T P	**:**	**3-0-2**

Course Objectives:
The student should be able

- To design CMOS digital circuits and analyze its performance.
- To analyze various combinational circuits at transistor level.
- To explain working and design of Analog circuits with given specifications.
- To illustrate and demonstrate working, layout design and characterize different Digital and Analog Circuits using VLSI CAD tools.

Total No. of Lectures – 42

Lecture wise breakup		**No. of Lectures**
Unit 1	CMOS Inverter: CMOS Inverter Analysis and Design, Bi-CMOS Inverters, Latch up in CMOS Circuits, Pass Transistor, Transmission Gate, NMOS Inverter, Various Pull-ups, switching characteristics- delay time calculation.	10
Unit 2	Combinational Logic Circuit, Transistor sizing in static CMOS logic gates, static CMOS logic gate sizing considering method of logical effort, dynamic logic, pass-transistor logic, common mode and other cross-coupled logic families. Building Block, Multiplexer, De multiplexer, Decoder, Encoder, Code Converters.	8
Unit 3	Layout design rules, Lambda based design rule, CMOS Inverter Layout, Intra-Layer Design Rules, Colour Codes, Designing of Interconnects between poly and diffusion.	8
Unit 4	Analog MOS Process (Double Poly Process), fabrication of active devices, passive devices and interconnects, capacitors and resistors, substrate coupling, ground bounce. Single stage amplifiers: Common source stage, source follower, common gate stage, cascode, Folded cascade	6
Unit 5	Differential Amplifier, General considerations, theory and design, performance parameters, Op-Amp characteristics and specifications, concept of virtual ground, Inverting and non-inverting amplifiers, op-amp applications including voltage summer, integrator, differentiator, instrumentation amplifiers, Zero crossing detector, Schmitt trigger	10

List of Experiments:		**No. of Turns**
1	Design CMOS inverters with given specifications such as noise margin, power consumption and propagation delay and analyze these performance parameters from circuit design as well as layout design.	3
2	Design and analysis of the layout of various VLSI circuits such as • Logic gates • Multiplexer • Single stage Amplifier • Two stage Amplifier using 90 nm technology.	5

3	Design of an Operational amplifier circuit with given specifications such as slew rate, gain and output swing etc. analyze these performance parameters from circuit design as well as layout design.	4

Course Outcomes: By the end of this course, the students will be able to	
1	Design CMOS inverters with specified noise margin and propagation delay.
2	Implement efficient techniques at circuit level for improving power and speed of combinational and sequential circuits.
3	Design and analyze various analog circuits, identify suitable topologies of the constituent sub systems and corresponding circuits as per the specifications of the system.
4	Illustrate and demonstrate Analog and Digital VLSI process flow, layout design and analysis of various circuits using VLSI CAD tools.

Suggested Books:

Text books		
S.No.	**Name of Book/ Authors/ Publisher**	**Year of Publication / reprint**
1	Jan M Rabaey, Digital Integrated Circuits, 2nd Edition, Pearson Education	Latest Edition
2	Sung-Mo Kang, CMOS Digital Integrated Circuits, 3rd Edition, McGraw-Hill	Latest Edition
3	P R Gray and R G Meyer, Analysis and Design of Analog Integrated Circuits, 5th Edition, Wiley	Latest Edition
Reference Books		
S.No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	"Design of Analog CMOS Integrated Circuits" by BehzadRazavi, McGraw Hill Education.	2000
2	A. S. Sedra and K. C. Smith, *Microelectronic Circuits: Theory and Applications*, 7th edition. Oxford, 2017.	**2017**

Equivalent MOOCs courses:

S.No.	**Course Links**	**Offered by**
1	CMOS Digital VLSI Design ByProf.SudebDasgupta, IIT Roorkee https://archive.nptel.ac.in/courses/108/107/108107129/	NPTEL
2	Analog IC Design https://www.classcentral.com/course/swayam-analog-ic-design-10032	IIT Madras via swayam

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	H	H										H	H
CO2	H	H	H										H	H
CO3	H	H	H										H	H
CO4	H	H	H		H				H				H	H

Course Name	**:**	**INTRODUCTION TO MICROFABRICATION**
Course Code	**:**	**VLM103**
Credits	**:**	**4**
L T P	**:**	**3 0 2**

Course Objectives :
The student should be able to

- To develop a basic understanding of wafer processing, device fabrication technique, device performance, and intended applications.
- To explore the fundamental concepts of device integration on different substrates, as well as the benefits and drawbacks of emerging technology that will be employed in future devices.
- To characterise new materials, study methods and tools for VLSI devices, circuits, and systems.
- To experience hands-on introduction fabrication of semiconductor devices.

Total No. of Lectures – 42

Lecture wise breakup		**No. of Lectures**
Unit 1	**INTRODUCTION** History of IC's; Operation & Models for Devices of Interest: CMOS and MEMS, Definition, Need of Clean Room, RCA cleaning of wafers, Silicon wafers; Crystallography, Production and Defects: Basic silicon wafer parameters, solid solubility of dopants in silicon, defects, and basic economics of operations.	6
Unit 2	**DIFFUSION** Pre-Deposition and Drive-in Diffusion Modelling, 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 Channelling, Multi Energy Implantation.	8
Unit 3	**LITHOGRAPHY** Basic steps in lithography; lithography techniques-optical lithography, electron beam lithography, x-ray lithography, ion beam lithography; resists and mask preparation of respective lithography techniques, printing techniques-contact, proximity printing and projection printing; merits and demerits of lithography techniques; recent trends in lithography at nanoscale.	6
Unit 4	**ETCHING** Performance metrics of etching; types of etching- wet and dry etching; dry etching techniques-ion beam or ion-milling, sputter ion plasma etching and reactive ion etching (RIE); merits and demerits of etching; etching induced defects; recent trends in etching.	6
Unit 5	**THIN FILM DEPOSITION**	8

	Thermal evaporation, electron beam evaporation, laser ablation, sputtering, chemical vapour deposition (CVD), Different kinds of CVD techniques: APCVD, LPCVD, metal-organic CVD (MOCVD), plasma enhanced CVD etc, physical vapour deposition (PVD), reaction types.	
Unit 6	**CHARACTERIZATION AND MEASUREMENT TECHNIQUES** Optical microscope, Scanning Electron Microscope, X-rays diffraction, Atomic Force Microscopy, Secondary Ion Mass Spectroscopy (SIMS), Electrical measurement techniques, SMU, CVU, Probe Station, two probe and four probe measurement technique.	8

List of Experiments		**No. of Turns**
1	Working in cleanroom environment, protocols, wafer handling.	2
2	Thin film deposition using thermal/ e-beam evaporation.	2
3	Pattern transfer using optical lithography.	2
4	Wet and Dry Etching technique.	3
5	Fabrication of MOS capacitors/schottky diodes.	3
6	Measurement of electrical properties of MOS capacitors/ schottky diodes.	2

Course Outcomes: By the end of this course, the students will be able to	
1	Work in the cleanroom environment for semiconductor device fabrication.
2	Recognize the basic operation principles of semiconductor fabrication equipment.
3	Analyze IC fabrication methodologies and evaluate component effects on IC design for VLSI and ULSI domains.
4	Demonstrate in-depth knowledge in wafer preparation, lithography and etching, diffusion process, material, device characterization and electrical measurement techniques.

Suggested Books:

Text Books		
S.No.	**Name of Book/ Authors/ Publisher**	**Year of Publication / Reprint**
1	S.M. Sze (Ed), VLSI Technology, 2nd Edition, McGraw Hill,	1988
2	Plummer, Deal , Griffin “Silicon VLSI Technology: Fundamentals, Practice & Modelling” PH.	2001
Reference Books		
S.No.	**Name of Book/ Authors/ Publisher**	**Year of Publication / Reprint**
1	Shubham, Kumar, and Gupta, Ankaj. Integrated Circuit Fabrication. United Kingdom, Manakin Press	2021
2	DIETER K. SCHRODER, Semiconductor Material and Device Characterization	2005
3	MOS Device Physics and Technology, Nicloean and Brews	1982

4	Relevant Research Papers	

Equivalent MOOCs courses:

S.No.	Course Links	Offered by
1	https://nptel.ac.in/courses/117106093 VLSI Technology	NPTEL
2	https://nptel.ac.in/courses/108101089 Fabrication of Silicon VLSI Circuits using the MOS technology, IIT Bombay	NPTEL

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	H	H		H				H	H			H	H
CO2	H	H	H		H				H	H			H	H
CO3	H	H	H		H				H	H			H	H
CO4	H	H	H		H				H	H			H	H