MANIPAL UNIVERSITY JAIPUR

School of Electrical, Electronics & Communication Engineering

Department of Electronics & Communication Engineering
Course Hand-out

Analog Electronic Circuits | EC 2102 | 4 Credits | 3 1 0 4

Session: Aug. 22 – Dec. 22 | Faculty: Mr. Ashish Vijay| Class: Core Subject

A. **Introduction:** This course comes in the class of core subject for the undergraduates. This offered course covers very significant topics of electronic devices and Circuits.To impart an in depth knowledge in electronic semiconductor devices & circuits, course give importance to the various aspects of design & analysis of different amplifiers. The subject scope would help students to incorporate these concepts into their electronic designs for other courses and also with industrial applications.

B. **Course Outcomes:** At the end of the course, students will be able to

[EC2102.1]. Develop and analyse various diode and transistor applications.
[EC2102.2]. Apply biasing scheme for transistor circuits;
[EC2102.3]. Prepare BJT and FET amplifier circuits;
[EC2102.4]. Develop High and Low frequency models of Transistors and analyze for research skills.
[EC2102.5]. Understanding of devices would enhance technical as well as employability skills.

C. PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

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[PO.1]. **Engineering knowledge**: Demonstrate and apply knowledge of Mathematics, Science, and Engineering to classical and recent problems of electronic design & communication system.

[PO.2]. **Engineering knowledge**: Demonstrate and apply knowledge of Mathematics, Science, and Engineering to classical and recent problems of electronic design & communication system.

[PO.3]. **Problem analysis**: Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

[PO.4]. **Design/development of solutions**: Designa component, system, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability.

[PO.5]. **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions

[PO.6]. **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations

[PO.7]. **The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice

[PO.8]. **Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development

[PO.9]. **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practices

[PO.10]. **Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings

[PO.11]. **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

[PO.12]. **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

[PO.13]. **Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

PROGRAM SPECIFIC OUTCOMES

[PSO.1]. An ability to understand the concepts of basic Electronics & Communication Engineering and to apply them to various areas like Signal processing, VLSI, Embedded systems, Communication Systems, Digital & Analog Devices, etc.

[PSO.2]. An ability to solve complex Electronics and Communication Engineering problems, using latest hardware and software tools, along with analytical skills to arrive cost effective and appropriate solutions.

[PSO.3]. Wisdom of social and environmental awareness along with ethical responsibility to have a successful career and to sustain passion and zeal for real-world applications using optimal resources as an Entrepreneur.

D. Assessment Plan:

Criteria	Description	Maximum Marks
Internal Assessment (Summative)	Sessional Exam I (Open Book)	20
	Sessional Exam II (Open Book)	20
	In class Quizzes and Assignments , Activity feedbacks (Accumulated and Averaged)	20
End Term Exam (Summative)	End Term Exam (Closed Book)	40
	Total	100
Attendance (Formative)	A minimum of 75% Attendance is required to be maintained by a student to be qualified for taking up the End Semester examination. The allowance of 25% includes all types of leaves including medical leaves.	
Make up Assignments (Formative)	Students who misses a class will have to report to the teacher about the absence. A makeup assignment on the topic taught on the day of absence will be given which has to be submitted within a week from the date of absence. No extensions will be given on this. The attendance for that particular day of absence will be marked blank, so that the student is not accounted for absence. These assignments are limited to a maximum of 5 throughout the entire semester.	
Homework/ Home Assignment/ Activity Assignment (Formative)	There are situations where a student may have to work in home, especially before a flipped classroom. Although these works are not graded with marks. However, a student is expected to participate and perform these assignments with full zeal since the activity/ flipped classroom participation by a student will be assessed and marks will be awarded.	

E. SYLLABUS

Junction Diode Analysis: Built in voltage, Transition and diffusion capacitances. Small-Signal Operation and Models: The Collector Current, Input Resistance at the Base, at the Emitterand the Transconductance, The T and Pie model, Application of the Small-Signal Equivalent Circuits, Analysis the single stage amplifier of CE,CB and CC configurations, The BJT Internal Capacitances and High-Frequency Model, , Multistage amplifiers: Distortion in amplifiers, Frequency response of an amplifier, bandwidth of cascaded amplifiers, frequency response of an RC coupled, direct coupled and transformer coupled stages. Power

amplifiers: Classification of large signal amplifiers, Analysis and design with respect to efficiency, linearity and harmonic distortions of classes of Amplifier. Field Effect Transistor: Structure of JFET and MOSFET, device Characteristics, FET biasing, small signal, Analysis of CS, CD and CG amplifiers at low and high frequencies. Feedback amplifiers: Concept of feedback, types of feedback – their advantages and disadvantages, Determining the Loop Gain, Equivalence of Circuits from a Feedback-Loop Point of View, Effect of Feedback on the Amplifier Poles. Oscillators: Barkhausen criterion for sustained oscillation, Nyquist criterion for stability of amplifier, Types of Oscillators: Hartley and Colpitt's oscillator; Wein bridge oscillator; RC phase shift oscillator; crystal oscillator. Introduction to Power Electronic Devices

F. TEXT BOOKS

T1.J. Millman& C. C. Halkias, "Integrated Electronics", Tata McGraw Hill, New Delhi, 2011

T2. R. L. Boylestad& L. Nashelsky, "Electronic Devices and Circuit Theory", Prentice Hall, 2009

G. REFERENCE BOOKS

R1 .A. S. Sedra, K. C. Smith, *Microelectronic Circuits, Technology and System Applications*, (7e), Oxford University Press, 2014.

R2. S. Salivahanan and N Suresh Kumar, "Electronics Device and circuits", McGraw Hill Publication, 2010

H. Lecture Plan:

Lec. No.	**Topics**	**Session Outcome**	**Mode of Delivery**	**Corresponding CO**	**Mode of Assessing the Outcome**
1,2,	Transport Phenomena in semiconductor	Students would get conceptual knowledge of the transport phenomena in the semiconductor crystal.	Lecture	NA	NA
3,4,5,6	Junction Built in potential	Knowledge of PN junction working principle.	Lecture	2102.1	In Class Quiz Mid Term-01 End Term
7,8	Transition and diffusion capacitances	Knowledge of different capacitive effects develop due to Space Charge Region	Lecture	2102.1 & 2102.2	In Home Assignment Mid Term-01 End Term
9,10,11	Transport Phenomena in BJT	Conceptual working of BJT	Lecture	2102.5	MidTerm-01 End Term
12,13	BJT Configurations	Knowledge of Different configuration of BJT	Lecture	2102.3 & 2102.4	MidTerm-02 End Term
14,15	Transistor Biasing	Requirement & Selection of Biasing circuit	Lecture	2102.3 & 2102.4	MidTerm-02 End Term
16	BJT as CE Amplifier	Understanding of Amplifying action.	Lecture	2102.1	MidTerm-02 End Term
17,18,19	Small-Signal Operation and Models	Transistor at Low Frequency-Two port analysis of CE Amplifier.	Lecture	2102.1	Mid Term-02 End Term
20,21,22	The Collector Current, Input Resistance at the Base, at the Emitterand the Transconductance	Understanding The Collector Current, Input Resistance at the Base, at the Emitterand the Transconductance	Lecture	2102.2, 2102.3 & 2102.4	In Class Quiz End Term
21,22	The T and Pie model , Application of the Small-Signal Equivalent Circuits, Analysis the single stage amplifier of CE,CB and CC configurations	Understanding CE, CB and CC amplifier using T and Pie model	Lecture	2102.2,2102.3 & 2102.4	Mid Term-02 End Term
23,24	multistage amplifiers: Distortion in amplifiers, Frequency response of an amplifier, bandwidth of cascaded amplifiers, and low frequency response of an RC coupled stage;	Understanding of cascading effect and different coupling used for coupling.	Lecture	2102.2,2102.3 & 2102.4	MidTerm-02 End Term m
25,26.27	Transistor at high frequencies: Hybrid – TT model, high frequency limitations;	Transistor at High frequency	Lecture	2102.5	Mid Term-02 End Term
28.29	CE amplifier at high frequencies	Application of pi-model in CE amplifier	Lecture	2102.1	Mid Term-02 End Term
30,31	Classification of large signal amplifiers	Understanding of Power amplifier.	Lecture	2102.2,2102.3 & 2102.4	Mid Term-02 End Term
32,33,34	Structure of JFET and MOSFET, Characteristics	FET & MOSFET working principle	Lecture	2102.1	Mid Term-02 End Term
35	FET biasing	Requirement & Selection of Biasing circuit	Lecture	2102.4 & 2102.5	Mid Term-02 End Term
36	Small signal, Analysis of CS	FET CS configuration working	Lecture	2102.2	End Term

37,38,39	Determining the Loop Gain, Equivalence of Circuits from a Feedback-Loop Point of View, Effect of Feedback on the Amplifier Poles	Circuits in a closed loop environment	Lecture	2102.5	End Term
40,41,42	Types of Oscillators	Circuits with positive feedback	Lecture	2102.4	End Term
End of the session					

I. Course Articulation Matrix: (Mapping of COs with POs)

CO	STATEMENT	CORRELATION WITH PROGRAM OUTCOMES												CORRELATION WITH PROGRAM SPECIFIC OUTCOMES		
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
EC 1306.1	Develop and analyse various diode and transistor applications	3	1	1		1`									3	
EC1306.2	Apply biasing scheme for transistor circuits;	1	1				1								3	
EC 1306.3	Prepare BJT and FET amplifier circuits;	1	0	1	1										3	
EC 1306.4	Analyse High and Low frequency models of Transistors and analyze for research skill		1	2											3	
EC 1306.5	Understanding of devices would enhance technical as well as employability skills	1		1		1								1		

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

MANIPAL UNIVERSITY JAIPUR

School of Electrical, Electronics & Communication Engineering (SEEC)

Department of Electronics & Communication Engineering
Course Hand-out

Digital System Design & Computer Architecture | EC2103 | 3 Credits | 3 0 1 4

Session: July-Nov 22 | Faculty: Dr. Chusen Duari | Class: Core Course

A. **Introduction:** This offered course is designed to provide basic knowledge of Digital circuits and the principles of computer organization with their basic architecture concepts. This course will also impart the core knowledge of combination and sequential circuits which enable student to learn how the design a system can be simulated. The course emphasizes on instruction set design, assembly language programming techniques, CPU instruction sets, addressing modes, computer arithmetic, memory hierarchy, I/O systems, and multi-core/multi-processor systems

B. **Course Outcomes:** At the end of the course, students will be able to :

[EC2103.1]. Define the combinational and arithmetic circuits using logic gates.

[EC2103.2]. Describe all sequential circuits such as flip-flops, counters, shift registers.

[EC2103.3]. Implementation of finite state machine using sequential logic circuit and use Verilog HDL code for enhancing the employability skills in VLSI Domain.

[EC2103.4]. Illustrate functional units of the processor such as the registers, arithmetic logical unit, addressing modes and instructions set.

[EC2103.5]. Analyse the functionality of binary addition, subtraction, multiplication, and division using algorithms.

[EC2103.6]. Explain the organization of control unit, memory unit and the I/O unit

C. PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

[PO.1]. **Engineering knowledge:** Demonstrate and apply knowledge of Mathematics, Science, and Engineering to classical and recent problems of electronic design & communication system.

[PO.2]. **Problem analysis**: Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

[PO.3]. **Design/development of solutions**: Designa component, system, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability.

[PO.4]. **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions

[PO.5]. **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations

[PO.6]. **The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice

[PO.7]. **Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development

[PO.8]. **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practices

[PO.9]. **Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings

[PO.10]. Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions

[PO.11]. Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments

[PO.12]. Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

[PSO.1]. An ability to understand the concepts of basic Electronics & Communication Engineering and to apply them to various areas like Signal processing, VLSI, Embedded systems, Communication Systems, Digital & Analog Devices, etc.

[PSO.2]. An ability to solve complex Electronics and Communication Engineering problems, using latest hardware and software tools, along with analytical skills to arrive cost effective and appropriate solutions.

[PSO.3]. Wisdom of social and environmental awareness along with ethical responsibility to have a successful career and to sustain passion and zeal for real-world applications using optimal resources as an Entrepreneur.

D. Assessment Plan:

Criteria	Description	Maximum Marks
Internal Assessment (Summative)	Sessional Exam I	20
	Sessional Exam II	20
	In class Quizzes and Assignments , Activity feedbacks (Accumulated and Averaged)	20
End Term Exam (Summative)	End Term Exam (Close Book)	40
	Total	100
Attendance (Formative)	A minimum of 75% Attendance is required to be maintained by a student to be qualified for taking up the End Semester examination. The allowance of 25% includes all types of leaves including medical leaves.	
Make up Assignments (Formative)	Students who misses a class will have to report to the teacher about the absence. A makeup assignment on the topic taught on the day of absence will be given which has to be submitted within a week from the date of absence. No extensions will be given on this. The attendance for that particular day of absence will be marked blank, so that the student is not accounted for absence. These assignments are limited to a maximum of 5 throughout the entire semester.	
Homework/ Home Assignment/ Activity Assignment (Formative)	There are situations where a student may have to work in home, especially before a flipped classroom. Although these works are not graded with marks. However, a student is expected to participate and perform these assignments with full zeal since the activity/ flipped classroom participation by a student will be assessed and marks will be awarded.	

E. SYLLABUS

Introduction to Combinational logic circuits. Design of arithmetic circuits: code convertors, multiplexers, demultiplexers, encoders, decoders & comparators, Parity generators and checker. Introduction to Sequential Logic: Binary cell, Latches and flip-flops. RS, JK, Master-Slave JK, D & T flip flops, Registers, Shift Registers.Sequential circuit design: Binary Counters, Finite State Machines, Moore and Mealy Machines.Overview of typical computer architecture: Accumulator based, General Register based and Stack based. Data Path and Control Unit Design: Basic concepts, Types of Bus structures, Control Unit design methods-Hardwired and micro programmed. Computer Arithmetic: Fast adders, subtractors, Multiplication of signed and unsigned integers, Booths Multiplication algorithm, Division, Floating Point Arithmetic Operation.
Memory Organization: Memory hierarchies- types of ROMs, Main memory- SRAM and DRAM, Memory Address Map; Cache memory- mapping functions – associative, direct and set-associative. Sequential circuit design: Introduction to Verilog programming.

F. TEXT BOOKS

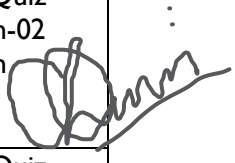
1. S. Brown and Z. Vranesic, Fundamentals of Digital logic with Verilog Design, (3e), McGraw Hill, 2014.
2. M. Mano and M. Ciletti, Digital Design: With an introduction to Verilog HDL, (5e), Pearson, 2012.
3. Z. Navabi, Verilog Digital System Design, (2e), McGraw Hill, 2008.
4. M. Morris Mano, Computer System Architecture, (3e), Pearson, 2008.

G. REFERENCE BOOKS

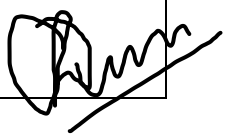
1. John P. Hayes, Computer Architecture and Organization, (3e), TMH, 1998.
2. 6. C. Hamacher, Z. Vranesic, S. Zaky, Computer Organization, (5e), TMH, 2002.

H. Lecture Plan:

Lec. No.	Topics	Session Outcome	Mode of Delivery	Corresponding CO	Mode of Assessing the Outcome
1,2	Introduction to Combinational logic circuits: adders & subtractors	Students will be able to design various combinational circuit and their application	Online Lecture	EC2103.1	In Class Quiz Mid Term-01 End Term
3, 4,	Design of arithmetic circuits: code convertors,	Students will be able to design various combinational circuit and their application	Online Lecture	EC2103.1	In Class Quiz Mid Term-01 End Term
5,6	Design of arithmetic circuits: multiplexers, demultiplexers,	Students will be able to design various combinational circuit and their application	Online Lecture	EC2103.1	In Class Quiz Mid Term-01 End Term
7,8	Encoders & decoders	Students will be able to design various combinational circuit and their application	Online Lecture	EC2103.1	In Class Quiz Mid Term-01 End Term
9,10	comparators & Parity generators and checker	Students will be able to design various combinational circuit and their application	Online Lecture	EC2103.1	In Class Quiz Mid Term-01 End Term
11	Introduction to Sequential Logic: Binary cell, Latches and flip-flops.	Students will learn about memory cell.	Online Lecture	EC2103.2	In Class Quiz
12,13	RS, JK, Master-Slave JK, D & T flip flops.	Students will identify various memory elements and their characteristics used in sequential circuit	Online Lecture	EC2103.2	In Class Quiz Mid Term-02 End Term
14,15	Sequential circuit design: Registers, Shift Registers,	Students will learn to design various registers and their uses	Online Lecture	EC2103.2	In Class Quiz Mid Term-02 End Term
16,17, 18	Sequential circuit design: Binary Counters,	Students will learn to design various counters and their uses.	Online Lecture	EC2103.3	In Class Quiz
19,20, 21	Finite State Machines: Moore and Mealy Machines.	Students will learn to design various finite state machines and their uses	Online Lecture	EC2103.3	In Class Quiz Mid Term-02 End Term
22,23	Overview of typical computer architecture	Students would get acquainted with basic understanding computer architecture and its developmental stages.	Online Lecture	EC2103.4	In Class Quiz Mid Term-02 End Term
24-27	Overview of typical computer architecture: Accumulator based, General Register based and Stack based.	Basic understanding of computer architecture fundamentals.	Online Lecture	EC2103.4	In Class Quiz Mid Term-02 End Term
28	Data Path and Control Unit Design: Basic concepts	Understanding of control unit design fundamentals.	Online Lecture	EC2103.4	In Class Quiz Mid Term-02 End Term



29	Types of Bus structures	Understanding of control unit design fundamentals.	Online Lecture	EC2103.4	In Class Quiz Mid Term-02
30-33	Control Unit design methods- Hardwired and micro programmed	Understanding of various micro-operations.	Online Lecture	EC2103.4	In Class Quiz Mid Term-02
34,35	Computer Arithmetic: Fast adders, subtractors	Knowledge of arithmetic operations.	Online Lecture	EC2103.5	In Class Quiz Mid Term-02 End Term
36,37, 38	Computer Arithmetic: Multiplication of signed and unsigned integers	Knowledge of arithmetic operations.	Online Lecture	EC2103.5	In Class Quiz Mid Term-02 End Term
39,40, 41	Booths Multiplication algorithm, Division	Knowledge of arithmetic operations.	Online Lecture	EC2103.5	In Class Quiz End Term
42	Floating Point Arithmetic Operation.	Understanding of floating point numbers and their fundamentals.	Online Lecture	EC2103.5	End Term
43,44	Memory Organization: Memory hierarchies- types of ROMs, Main memory- SRAM and DRAM, Memory Address Map	Basic understanding of memory mapping,	Online Lecture	EC2103.6	End Term
45,46	Cache memory-mapping functions – associative, direct and set-associative.	Knowledge of cache and its basics.	Online Lecture	EC2103.6	End Term
47,48	Introduction to Verilog programming.	Students will be familiarised with HDL language and software.	Online Lecture	EC2103.3	End Term



I. Course Outcome Attainment Level Matrix:

CO	STATEMENT	ATTAINMENT OF PROGRAM OUTCOMES **THRESHOLD VALUE: 40%**												ATTAINMENT OF PROGRAM SPECIFIC OUTCOMES		
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
EC 2103.1	Define the combinational and arithmetic circuits using logic gates.	1	1	0	0	0	0	0	0	0	0	1	1	2	2	0
EC 2103.2	Describe all sequential circuits such as flip-flops, counters, shift registers.	3	1	1	2	2	1	2	0	0	2	2	2	3	3	1
EC 2103.3	Implementation of finite state machine using sequential logic circuit and use Verilog HDL code for enhancing the employability skills in VLSI Domain.	2	1	1	2	2	1	2	0	0	2	2	2	3	3	1
EC 2103.4	Illustrate functional units of the processor such as the registers, arithmetic logical unit, addressing modes and instructions set.	2	1	1	2	1	1	2	0	0	1	2	2	3	3	1
EC 2103.5	Analyse the functionality of binary addition, subtraction, multiplication, and division using algorithms.															
EC 2103.6	Explain the organization of control unit, memory unit and the I/O unit															

0-No Attainment; 1- Low Attainment; 2- Moderate Attainment; 3- Substantial Attainment

MANIPAL UNIVERSITY JAIPUR

School of Electrical, Electronics & Communication Engineering

Department of Electronics & Communication Engineering

COURSE HAND OUT

Electromagnetic Field Theory | EC 2104 | 3 Credits | 3 1 0 4

Session: Aug 2022 – Nov. 2022 | **Faculty**: Dr. Abhishek Shrivastava|

Class: Core Subject; Course **for Semester**: III[rd]

A. **Introduction:** This course comes in the class of core course for the undergraduates. The course will provide basic skills, required to understand, develop, and design various engineering applications involving electromagnetic fields. The topics of the course are thoughtfully designed to lay the foundations of the application of electromagnetic fields in Antenna and Wave propagation, Transmission lines, Wireless Communications etc.

B. **Course Outcomes:** Course outcomes are goals for student learning that you, as the instructor, set for your course. Course outcomes demonstrate what you want students to know, do, or value by the end of the course. A typical course outcomes may start with - At the end of the course, students will be able to

[2104.1] Recall the fundamentals of Vector Calculus.
[2104.2] Outline the difference between Electrostatic and Magnetostatic fields using concepts and their behaviours in changed mediums.
[2104.3] Solve Electric and Magnetic fields concept related and boundary conditions problems.
[2104.4] Analyze the Electric and Magnetic field using Maxwell's Equations.
[2104.5] Estimate the phenomena of wave propagation in different media.
[2104.6] Formulate Electromagnetic Field Theory applications

C. **Program Outcomes (POs) and Program Specific Outcomes(PSOs)**

[PO.1]. **Engineering knowledge**: Demonstrate and apply knowledge of Mathematics, Science, and Engineering to classical and recent problems of electronic design & communication system.

[PO.2]. **Problem analysis**: Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

[PO.3]. **Design/development of solutions**: Design a component, system, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability.

[PO.4]. **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions

[PO.5]. **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations

[PO.6]. **The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice

[PO.7]. **Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development

[PO.8]. **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practices

[PO.9]. **Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings

[PO.10]. **Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions

[PO.11]. **Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments

[PO.12]. **Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

Program Specific Outcomes

[PSO.1]. An ability to understand the concepts of basic Electronics & Communication Engineering and to apply them to various areas like Signal processing, VLSI, Embedded systems, Communication Systems, Digital & Analog Devices, etc.

[PSO.2]. An ability to solve complex Electronics and Communication Engineering problems, using latest hardware and software tools, along with analytical skills to arrive cost effective and appropriate solutions.

[PSO.3]. Wisdom of social and environmental awareness along with ethical responsibility to have a successful career and to sustain passion and zeal for real-world applications using optimal resources as an entrepreneur.

D. Assessment Plan:

Criteria	Description	Maximum Marks
Internal Assessment (Summative)	Sessional Exam I (probably Online/ or as per directions)	20
	Sessional Exam II (probably Online/ or as per directions)	20
	Online quizzes and Activity feedbacks (Accumulated and Averaged)	20
End Term Exam (Summative)	End Term Exam (as per directions)	40 (80 scaled down to 40)
	Total	100
Attendance (Formative)	A minimum of 75% Attendance is required to be maintained by a student to be qualified for taking up the End Semester examination. The allowance of 25% includes all types of leaves including medical leaves. (as per Academic policy 2020)	

Homework/ Home Assignment/ Activity Assignment (Tutorials) (Formative)	Student is expected to participate and perform in online assignments given via MS team with full zeal timely submission of the assignment. The participation by a student will be assessed and marks will be awarded.

E. Syllabus

Review of Vector Calculus: Cartesian coordinates, Circular, Cylindrical and Spherical co-ordinates. **Electrostatics:** Coulomb's law and its applications, Electric field intensity and Electrostatic potential due to point charges, Field due to continuous charge distribution. Electric flux and electric flux density, Gauss's law, Gauss's Law – Maxwell's equation, Electric dipole and flux lines, energy density in electrostatic fields. **Electric field in material space:** convection and conduction currents, conductors, polarization in dielectrics, continuity equation and relaxation time; **Electrostatic boundary condition:** dielectric-dielectric, dielectric-conductor. Poisson's and Laplace's equations. **Magnetostatics**: Magnetic field intensity, Biot-Savart's law, magnetic flux and magnetic flux density, Ampere's law, Maxwell's equation, application of Ampere's law, magnetic flux density- Maxwell's equation, Maxwell's equation for static fields, magnetic scalar and vector potential, magnetic boundary conditions, magnetic energy. **Electromagnetic Waves & Applications:** Maxwell's equation, Faraday's Law, transformer and motional electromotive forces, displacement current, Maxwell's equation in final form. Maxwell's equations in integral and point form for free space and material media. **Electromagnetic wave propagation**: Wave propagation in lossy dielectrics, plane waves in lossless dielectrics, plane wave in free space, plane waves in good conductors, power and the pointing vector, reflection of a plain wave in a normal incidence. **Introduction to Transmission Lines and waveguides**.

F. Reference Books

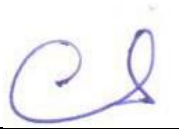
1) Jr. Hayt and Bucker, Engineering Electromagnetics, 7th Edition, McGraw Hill, 2006.
2) M. A. Plonus, Applied Electromagnetics, McGraw Hill 1978.
3) J. D. Kraus, Electromagnetics, 4th Edition, McGraw Hill 1992.
4) Cheng, Fields, Waves and Electromagnetics, 2nd Edition, Addison Wesley, 2004.
5) M. N. O. Sadiku, "Principles of Electromagnetics", 4th Ed, Oxford University Press, 2006.
6) S. Ramo, J.R. Whinnery and T. Van Duzer, Fields and Waves in Communication Electronics, Wiley, 3rd edition, 1994.
7) S.M. Wentworth, Fundamentals of Electromagnetics with Engineering Applications, Wiley, 2005.

G. E-Resources

1) www.dannex.se/theory/1.html
2) https://nptel.ac.in/courses/108/104/108104087/
3) https://nptel.ac.in/courses/115/101/115101005/

H. Lecture Plan:

Lec. No.	Topics	Session Outcome	Mode of Delivery	Corresponding CO/(s)/POs	Mode of Assessing the Outcomes
1	**Introduction** to the Course "Electromagnetic Waves"	Students would get acquainted with basic understanding of the electromagnetic waves, and its applications.	Online	NA	NA
2-4	Review of **Vector analysis:** Cartesian, Cylindrical co-ordinate systems, Spherical co-ordinate systems, Differential Length, area, and volume,	Students get acquainted with representation of point and vectors and their transformation from one coordinate system to another, and differential length, area, and volume elements in three coordinate systems	Online	2104.1/PO.1/PSO.1	In Class Quiz Mid Term-01 End Term
5-8	**Vector Calculus**: Del operator, Gradient of a scalar, Divergence of a Vector and Divergence theorem, Curl of a vector and Stokes's theorem, Laplacian of a scalar	Students can apply gradient, divergence (divergence theorem), curl (stokes theorem) and Laplacian to problems of electrostatics	Online	2104.1/ PO.1/ PSO.1	In Class Quiz Mid Term-01 End Term
9-11	**Electrostatics:** Coulomb's law and its applications, Electric field intensity and Electrostatic potential due to point charges	Students can evaluate the electric field intensity and electrostatic potential using coulomb's law for point charges.	Online	2104.2/ PO.2/ PSO.1	In Class Quiz MidTerm-01 End Term
12,13	Electric field intensity and Electrostatic potential due to line, surface, volume charge distribution.	Students can evaluate the electric field intensity and electrostatic potential using coulomb's law for charge distributions.	Online	2104.2 and / PO.2 / PSO.1	In Class Quiz MidTerm-01 End Term
14,15	Electric flux and electric flux density, Gauss's law - Maxwell's equation & its applications	Students can evaluate the electric flux and electric flux density using gauss's law for standard configurations (point charges & charge distributions).	Online	2104.2/ PO.2 / PSO.1	In Class Quiz MidTerm-01 End Term
16-17	Electric dipole and flux lines, energy density in electrostatic fields, **Electric field in material space:** convection and conduction currents, conductors, polarization in dielectrics, continuity equation and relaxation time.	Students would get acquainted with basic understanding of the concept of electric fields in materials & energy density of electrostatic field.	Online	2104.2/ PO.2/ PSO.1	In Class Quiz End Term
18-21	**Electrostatic boundary condition**: dielectric-dielectric, dielectric-conductor, Poission's and Laplace's equations.	Students understand the Laplace and Poisson's equation & can apply boundary conditions to problems of electrostatics.	Online	2104.2, 2104.3/ PO.2, PO.4 and PO.5/ PSO.1	In Class Quiz Mid Term-01 End Term

22	**Magnetostatic**s: Magnetic field intensity, Biot-Savart's law,	Students can evaluate the magnetic field intensity for a current carrying conductor using Biot-Savart law.	Online	2104.2/ PO.2/ PSO.1	In Class Quiz MidTerm-02 End Term
23-25	Magnetic flux and magnetic flux density, Ampere's law (Maxwell's equation) & its application	Students can evaluate the magnetic field intensity for standard current distributions using Ampere's law.	Online	2104.4/ PO.2/ PSO.1	In Class Quiz MidTerm-02 End Term
26,27	**Maxwell's equation** for static fields, magnetic scalar, and vector potential,	Students would be able to understand the Maxwell's equations and their significance, and compute magnetic scalar and vector potential.	Online	2104.2, 2104.4/ PO.2 / PSO.1	In Class Quiz MidTerm-02 End Term
28	Magnetic boundary conditions, magnetic energy;	Students can apply magnetic boundary conditions to problems of magnetostatics and have a basic understanding of concept of magnetic energy.	Online	2104.3/ PO.2/ PSO.1	In Class Quiz MidTerm-02 End Term
29-32	**Electromagnetic Waves & Applications**: Maxwell's equation, Faraday's Law, transformer and motional electromotive forces, displacement current.	Students understand Faraday's law and the connection between electric and magnetic fields, and the concept of transformer, EMF, and displacement current.	Online	2104.5/ PO.2/ PSO.1	In Class Quiz MidTerm-02 End Term
33,34	Maxwell's equation in final form, Maxwell's equations in integral and point form for free space and material media.	Students would be able to understand the Maxwell's equations for free space & material media and their significance.	Online	2104.4,2014.5/ PO.2 & PO.3/ PSO.1	MidTerm-02 End Term
35,36	**Electromagnetic wave propagation**: Wave propagation in lossy dielectrics, plane waves in lossless dielectrics,	Students can understand and analyse the wave propagation phenomenon in lossy and lossless dielectrics.	Online	2104.5/PO.4/ PSO.1	End Term
37,38	Plane wave in free space, plane waves in good conductors,	Students can understand and analyse the wave propagation phenomenon in free space and good conductors.	Online	2104.5/PO.4/ PSO.1 and PSO.2	In Class Quiz End Term
39	Power and the pointing vector	Students can compute the power using pointing vector theorem.	Online	2104.5/PO.4	In Class Quiz End Term
39,40	reflection of a plane wave in a normal incidence.	Students can analyse the reflection of a plane wave in a normal incidence.	Online	2104.5/PO.4 and PO.5/ PSO.1 and PSO.2	In Class Quiz End Term
41	Introduction to Transmission Lines and waveguides.	Students can understand basics of transmission lines and waveguides.	Online	2104.6/PO.3, PO.4 and PO.5/ PSO.1 and PSO.2	In Class Quiz End Term 

42	Course Summary and Conclusion	Students are familiar with the applications of electromagnetics.	Online	NA	NA

I. Course Articulation Matrix: (Mapping of COs with POs)

Course Outcomes (Cos)	Statements	Correlation with Program Outcomes (POs)												Correlation with Program Specific Outcomes (PSOs)		
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
EC 2104.1	Recall the fundamentals of Vector Calculus.	3	1											2		
EC 2104.2	Outline the difference between Electrostatic and Magnetostatic fields using concepts and their behaviours in changed mediums.	1	3	2	1	1								2		
EC 2104.3	Solve Electric and Magnetic fields concept related and boundary conditions problems.	1	3	2	1	1								2		
EC 2104.4	Analyze the Electric and Magnetic field using Maxwell's Equations.	3	3	2										2	1	
EC 2104.5	Estimate the phenomena of wave propagation in different media.		2	1	1	1								2	1	
EC 2104.6	Formulate Electromagnetic Field Theory applications.			2	1	1										

1. Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Dr. Abhishek Shrivastava

Course Coordinator

MANIPAL UNIVERSITY JAIPUR

School of Electrical, Electronics & Communication Engineering (SEEC)

Department of Electronics & Communication Engineering
Course Hand-out

Signals & Circuits Lab| EC2130| 1 Credits | 0 0 2 1

Session: Aug 22 – Dec 22 | Faculty: Dr Ankur Saharia, Mr. Ashish Vijay | Class: III sem Lab course

A. **Introduction:** This course is offered by Dept. of Electronics & Communication Engineering as a Lab course in III semester with theory course EC2102 Analog Electronics. This course aims to help the students understand practical use and implementation of the theoretical concepts of semiconductor devices and circuits. The students are exposed to different analog electronic components and circuits, their practical feasibility, capability and limitations regarding their best utilization in a specific situation. The course emphasizes circuit design and analysis skills that require the student to create circuits that meet customer/user specifications as industry professional or entrepreneur.

B. **Course Outcomes:** At the end of the course, students will be able to

[EC2130.1]. Understand semiconductor device characteristics
[EC2130.2]. Analyze device characteristics to determine important device and circuit parameters
[EC2130.3]. Implement circuits with diodes
[EC2130.4]. Implement circuits with BJT and FET
[EC2130.5]. Understand the effect of input frequency on amplifier circuits

C. PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

PROGRAM OUTCOMES

[PO.1]. **Engineering knowledge**: Demonstrate and apply knowledge of Mathematics, Science, and Engineering to classical and recent problems of electronic design & communication system.

[PO.2]. **Problem analysis**: Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

[PO.3]. **Design/development of solutions**: Design a component, system, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability.

[PO.4]. **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions

[PO.5]. **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations

[PO.6]. **The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice

[PO.7]. **Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development

[PO.8]. **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practices

[PO.9]. **Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings

[PO.10]. **Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions

[PO.11]. **Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments

[PO.12]. **Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

PROGRAM SPECIFIC OUTCOMES

[PSO.1]. An ability to understand the concepts of basic Electronics & Communication Engineering and to apply them to various areas like Signal processing, VLSI, Embedded systems, Communication Systems, Digital & Analog Devices, etc.

[PSO.2]. An ability to solve complex Electronics and Communication Engineering problems, using latest hardware and software tools, along with analytical skills to arrive cost effective and appropriate solutions.

[PSO.3]. Wisdom of social and environmental awareness along with ethical responsibility to have a successful career and to sustain passion and zeal for real-world applications using optimal resources as an Entrepreneur.

D. Assessment Plan:

Criteria	Description	Maximum Marks
Internal Assessment (Summative)	Each lab experiment is evaluated for performance, lab record maintenance and knowledge and viva during the entire semester. The score is scaled to a maximum of 6**0 marks**.	60
End Term Exam (Summative)	End Term Exam	40
	Total	100
Attendance (Formative)	A minimum of 75% Attendance is required to be maintained by a student to be qualified for taking up the End Semester examination. The allowance of 25% includes all types of leaves including medical leaves.	
Make up Lab sessions (Formative)	A student who misses a class will have to report to the teacher about the absence. He/ She has to perform the experiment issued on the missed date in extra time during the same week. If the student fails to carry out the experiment in the same week, he will be marked absent with zero marks for attendance in evaluation.	
Lab record	The students need to maintain lab-records of the experiment they carry out in the lab. It is expected from the student that he completes the experiment details in the record within the week of issue of the experiment and get it corrected in the next lab-class itself. Delay in submission of work will attract penalty of marks. A separate Lab-notebooks is to be maintained by individual student to take down observations during lab. The students should get their observations approved by faculty.	

E. SYLLABUS

Experiments of this lab are implemented at Hardware as well as software level.

- Device characteristics of BJT and JFET
- Applications of diode: clippers and clampers
- Applications of BJT and FET: amplifiers with feedback and without feedback, single and two stage RC coupled amplifiers and Oscillators.

F. TEXT BOOKS

Not Applicable

G. REFERENCE BOOKS

[1] R. L. Boylestad & L. Nashelsky, "Electronic Devices and Circuit Theory", Prentice Hall, 2009
[2] S. Salivahanan and N. Suresh Kumar, "Electronics Device and circuits", McGraw Hill Publication, 2010

H. Lecture Plan:

Lab No.	Name of the experiment	Experiment Outcome	Type of Expt	Corresponding CO	Mode of Assessing the Outcome
1	Measurement of the following parameters for given DC voltage, sine wave, square wave and triangular wave using Cathode Ray Oscilloscope (CRO) (a) DC Voltage, (b) Peak & RMS Value of AC Voltage, and (c) Time Period and Frequency of Periodic signals.	To acquaint students with laboratory equipment and take readings	Hands-on	NA	NA
2	To plot the diode characteristics and find its dynamic resistance & cut-in voltage.	To understand working of pn diodes	Hands-on	EC2130.1 EC2130.2	Observational Data, Viva-Voce
3	To plot the characteristics of Zener diode and find its dynamic resistance under reverse biased condition.	To understand working of zener diodes	Hands-on	EC2130.1 EC2130.2	Observational Data, Viva-Voce
4	To use Zener diode for voltage regulation (i) Plot the Line-Regulation curve and (ii) Plot the Load-Regulation curve.	To analyze use of Zener diodes for regulation	Hands-on	EC2130.3	Observational Data, Viva-Voce
5	To implement a diode clipper circuit and observe its output waveform.	To analyze use of pn diodes for waveshaping circuits	Hands-on	EC2130.3	Observational Data, Viva-Voce
6	To implement a diode clamper circuit which clamps the positive and negative peak of input voltage to (a) Zero voltage and (b) at a given voltage.	To analyze use of pn diodes for waveshaping circuits	Hands-on	EC2130.3	
7	To find the bandwidth of emitter follower circuit.	To analyze application of BJT for amplification	Hands-on	EC2130.4 EC2130.5	Observational Data, Viva-Voce
8	To plot the frequency response of a single stage RC coupled transistor amplifier and determine its bandwidth	To analyze application of BJT for amplification	Hands-on	EC2130.4 EC2130.5	Observational Data, Viva-Voce
9	To plot the frequency response of a Common Source (CS) Amplifier.	To analyze application of FET for amplification	Hands-on	EC2130.4 EC2130.5	Observational Data, Viva-Voce
10	To observe the frequency of oscillation of phase shift oscillator.	To analyze application of BJT for amplification	Hands-on	EC2130.4	Observational Data, Viva-Voce

Online additional experiment (Multisim)

To plot the input and output characteristics of NPN transistor in CE configuration and determine the h-parameters. (EC2130.1, EC2130.2)

To plot the drain and transfer characteristics of a JFET in CS configuration. (EC2130.1, EC2130.2)

I. Course Articulation Matrix: (Mapping of COs with POs)

CO	STATEMENT	CORRELATION WITH PROGRAM OUTCOMES												CORRELATION WITH PROGRAM SPECIFIC OUTCOMES		
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
[EC2130.1].	Understand semiconductor device characteristics	1											1	1		
[EC2130.2].	Analyze device characteristics to determine important device and circuit parameters		1		1	3							1	2		
[EC2130.3].	Implement circuits with diodes		2	1	2	3			1	1			1	1	2	1
[EC2130.4].	Implement circuits with BJT and FET		2	1	2	3			1	1			1	1	2	1
[EC2130.5].	Understand the effect of input frequency on amplifier circuits	1	1						1	1	1		1	1		

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

MANIPAL UNIVERSITY JAIPUR
School of Electrical, Electronics & Communication Engineering

Department of Electronics & Communication Engineering
Course Hand-out

Microprocessor & Microcontroller | EC 2202 | 4 Credits | 3 1 0 4

Session: Jan 22 – May 22 | Faculty: Dr. Abhishek Shrivastava, Dr. Rohit Mathur & Dr. Himanshu Choudhary| Class: Core Subject

A. **Introduction:** This course aims to introduce the architecture, programming of microprocessors (8086), interfacing devices and, microcontroller (8051) basic operational procedures. The course incorporates, basic understanding of the device working environment including its basic programming in assembly language. The course gives the conceptual orientation about how programs work, other important parameters involved.

B. **Course Outcomes:** At the end of the course, students will be able to
[2202.1]. Describe problems related to the device architectural design.
[2202.2]. Categorize problems based on the mathematical reasoning.
[2202.3]. Demonstrate Logical and Conditional programming skills.
[2202.4] Differentiate microprocessor and microcpntroller.
[2202.5]. Justify the conceptual details of the devices through programming problems.
[2202.6]. Devise device interfacing concepts.

C. PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

[PO.1]. **Engineering knowledge**: Demonstrate and apply knowledge of Mathematics, Science, and Engineering to classical and recent problems of electronic design & communication system.

[PO.2]. **Problem analysis**: Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

[PO.3]. **Design/development of solutions**: Design a component, system, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability.

[PO.4]. **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions

[PO.5]. **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations

[PO.6]. **The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice

[PO.7]. **Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development

[PO.8]. **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practices

[PO.9]. **Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings

[PO.10]. **Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions

[PO.11]. **Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments

[PO.12]. **Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

PROGRAM SPECIFIC OUTCOMES

[PSO.1]. An ability to understand the concepts of basic Electronics & Communication Engineering and to apply them to various areas like Signal processing, VLSI, Embedded systems, Communication Systems, Digital & Analog Devices, etc.

[PSO.2]. An ability to solve complex Electronics and Communication Engineering problems, using latest hardware and software tools, along with analytical skills to arrive cost effective and appropriate solutions.

[PSO.3]. Wisdom of social and environmental awareness along with ethical responsibility to have a successful career and to sustain passion and zeal for real-world applications using optimal resources as an Entrepreneur.

D. Assessment Plan:

Criteria	Description	Maximum Marks
Internal Assessment (Summative)	Sessional Exam I	20
	Sessional Exam II	20
	Three Assignments each of 05 marks Two Quizzes each of 05 marks Software based Assignment	05 10 05
End Term Exam (Summative)	End Term Exam	40
	Total	**100**
Attendance	A minimum of 75% attendance is required to be maintained by a student to be qualified for taking up the End Semester examination. The allowance of 25% includes all types of leaves including medical leaves.	
Make up Assignments for Academic absence in the class.	Students who miss any assessment procedure will have to report to his/her faculty about the absence (with reason). Respective faculty as per the reason will, (with consent of the course coordinator) decide his/her eligibility for the reassessment. Date and time of the reassessment will be informed with prior notice.	
Homework/ Home Assignment/ Activity Assignment (Formative)	This is flipped classroom activity. Although these works are not graded with marks. However, a student is expected to participate and perform these assignments with full zeal since the activity/ flipped classroom participation by a student will be assessed at the faculty level and might reflect in the internal marks.	

E. SYLLABUS

8086 Microprocessor: Introduction and history of microprocessors and microcontrollers, RISC and CISC Architectures. **8086 Architecture**: Bus Interface Unit and Execution Unit, Instruction pipeline, Data and Address Bus Configuration, Memory Segmentation, Memory Address generation, I/O Port addressing. 8086 Signals: Functions of all signals, Minimum and Maximum Mode signals, Bus Cycles, Bus Arbitration, Bus driver 8288. **8086 Instruction Set:** Types of Instructions and Addressing Modes, assembler and assembler directives, Programming. Basic Peripherals and their interfacing with **8086: Memory interfacing**, Types of I/O - Isolated I/O, memory mapped I/O, programmed I/O, Interrupt driven I/O, Interfacing I/O ports, PIO 8255, Programmable Interval Timer 8254, Interrupts, Programmable Interrupt Controller 8259, Keyboard/Display Controller, DMA Controller, DMA transfer and operations, Multiprocessor Systems. **8051 Microcontroller**: Architectural features, Programming model, I/O Ports, Special Function Registers, Addressing Modes, Instruction set and Programming.

References:

1. N. Senthil Kumar, M. Saravanan, S. Jeevananthan, *Microprocessors and Microcontrollers,* (1e), Oxford University Press, 2010.
2. K. M . Bhurchandi, A K Ray, *Advanced Microprocessors and Peripheral Devices*, (3e), McGraw Hill Education (India) Private Ltd, 2018.
3. M. A. Mazidi, J. G. Mazidi, R. D. McKinlay, *The 8051 Microcontroller and Embedded Systems using Assembly and C*, (2e), Pearson, 2008.
4. D. V. Hall and S. S. S. P. Rao, *Microprocessors and Interfacing*, (3e), McGraw Hill, 2012.

F. Lecture Plan:

Lec. No.	**Topics**	**Session Outcome**	**Mode of Delivery**	**Corresponding CO**	**Mode of Assessing the Outcome**
1,2,3	Introduction and history of microprocessors and microcontrollers, RISC and CISC Architectures	Students would get acquainted with basic understanding of the microprocessors and its developmental stages.	PPT	2202.1	NA
4,5,6	8086 Architecture: Bus Interface Unit and Execution Unit, Instruction pipeline, Data and Address Bus Configuration.	Knowledge of architectural view of 8086 & it's working principle.	PPT	2202.1	In Class Quiz Mid Term-01 End Term
7,8,9,10	Memory Segmentation, Memory Address generation, I/O Port addressing	Students would be able to understand 8086 memory structure and its operational details.	PPT	2202.1 & 2202.2	In Home Assignment Mid Term-01 End Term
11,12,13	8086 Signals: Functions of all signals, Minimum and Maximum Mode signals	Understanding of 8086 mode operations & pin details.	PPT	2202.5	In Class Quiz MidTerm-01 End Term
14,15,16	Bus Cycles, Bus Arbitration, Bus driver 8288	Basic Understanding Bus functioning.	PPT	2202.3 & 2202.4	MidTerm-02 End Term
17,18,19	8086 Instruction Set: Types of Instructions and Addressing Modes	Basic understanding of programming fundamentals	PPT	2202.3 & 2202.4	MidTerm-02 End Term
20,21	Assembler and assembler directives	Basic understanding of programming instructions	PPT	2202.1	NA
22,23,24	Programming. Basic Peripherals and their interfacing with 8086	Interfacing concepts	PPT	2202.1	In Class Quiz Mid Term-02 End Term
25,26,27,28	Memory interfacing, Types of I/O - Isolated I/O, memory mapped I/O, programmed I/O, Interrupt driven I/O, Interfacing I/O ports	Interfacing types and fundamentals	PPT	2202.2,2202.3 & 2202.4	In Class Quiz End Term
29,30	PIO 8255	Interfacing device fundamentals	PPT	2202.2,2202.3 & 2202.4	End Term
30,31,32	Programmable Interval Timer 8254,	Interfacing device fundamentals	PPT	2202.2,2202.3 & 2202.4	End Term
33,34	Interrupts, Programmable Interrupt Controller 8259	Interfacing device fundamentals	PPT	2202.5	End Term
35,36,37	Keyboard/Display Controller	Interfacing device fundamentals	PPT	2202.1	End Term
38,39,40	DMA Controller,	Interfacing device fundamentals	PPT	2202.2,2202.3 & 2202.4	End Term
41,42	8051 Microcontroller, Architectural features	Basics of 8051 Microcontroller	PPT	2202.1	End Term
43,44	Addressing Modes, Instruction set and Programming	Knowledge of 8051 programming basics	PPT	2202.4 & 2202.5	End Term

G. Course Articulation Matrix: (Mapping of COs with POs)

CO	STATEMENT	CORRELATION WITH PROGRAM OUTCOMES												CORRELATION WITH PROGRAM SPECIFIC OUTCOMES		
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
EC 2202.1	Categorize problems related to the device architectural design;	3												3		
EC 2202.2	Estimate problems based on the mathematical reasoning;	3	3		2									1	1	1
EC 2202.3	Devise Logical and Conditional programming skills;	3	3	1	3									3	1	1
EC 2202.4	Outline the conceptual details of the devices through programming problems; and	3	2	1	3									3	1	1
EC 2202.5	Devise device interfacing concepts	1	1	3											2	3

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Dr. Abhishek Shrivastava

Course Coordinator

MANIPAL UNIVERSITY JAIPUR

School of Electrical, Electronics & Communication Engineering (SEEC)

Department of Electronics & Communication Engineering
Course Hand-out

DIGITAL SIGNAL PROCESSING | EC 2203 | 4 Credits | 3 1 0 4

Session: Jan– May 2023| Faculty: Dr. Suddhendu DasMahapatra | Class: B.Tech ECE (IV Sem)

A. Introduction: This course is offered by Dept. of Electronics & Communication Engineering as core Course, targeting students who wish to pursue research & development in industries or higher studies in field of Electronics & Communication Engineering, Including Digital Signal Processing, Image Processing, and Communication Systems. Offers in depth knowledge of DSP by covering Signals, Sampling, Z-Transform, Discrete Fourier transform, Implementation of discrete time systems, Design of IIR filters and digital FIR filters, and Power spectrum estimation for a better learning. Students are expected to have background knowledge on signals & systems for a better learning.

B. Course Outcome: At the end of the course, students will be able to

[EC2203.1] Recall the concepts of signals, systems and Z transform and analysis of signals in time and frequency domain

[EC2203.2] Classify and analyse response of LTI system

[EC2203.3] Relate and apply the concepts of Discrete Fourier Transform to diverse engineering problems

[EC2203.4] Understand and implement discrete time systems such as FIR and IIR structures

[EC2203.5] Acquire the skills to design IIR filters and FIR filters using multiple techniques

[EC2203.6] Understand and interpret frequency domain sampling, signal reconstruction and multi-rate DSP

C. Program Outcomes and Program Specific Outcomes

[PO.1]. Engineering knowledge: Demonstrate and apply knowledge of Mathematics, Science, and Engineering to classical and recent problems of electronic design & communication system.

[PO.2]. Problem analysis: Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

[PO.3]. Design/development of solutions: Design a component, system, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability.

[PO.4]. Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions

[PO.5]. Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations

[PO.6]. The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice

[PO.7]. Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development

[PO.8]. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practices

[PO.9]. Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings

[PO.10]. Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions

[PO.11]. Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments

[PO.12]. Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

PROGRAM SPECIFIC OUTCOMES

[PSO.1]. An ability to understand the concepts of basic Electronics & Communication Engineering and to apply them to various areas like Signal processing, VLSI, Embedded systems, Communication Systems, Digital & Analog Devices, etc.

[PSO.2]. An ability to solve complex Electronics and Communication Engineering problems, using latest hardware and software tools, along with analytical skills to arrive cost effective and appropriate solutions.

[PSO.3]. Wisdom of social and environmental awareness along with ethical responsibility to have a successful career and to sustain passion and zeal for real-world applications using optimal resources as an Entrepreneur.

D. Assessment Plan:

Criteria	Description	Maximum Marks
Internal Assessment (Summative)	Sessional Exam I (Closed Book)	20
	Sessional Exam II (Closed Book)	20
	In class Quizzes and Assignments , Activity feedbacks (Accumulated and Averaged)	20
End Term Exam (Summative)	End Term Exam (Closed Book)	40
	Total	100
Attendance (Formative)	A minimum of 75% Attendance is required to be maintained by a student to be qualified for taking up the End Semester examination. The allowance of 25% includes all types of leaves including medical leaves.	
Make up Assignments (Formative)	Students who miss a class will have to report to the teacher about the absence. A makeup assignment on the topic taught on the day of absence will be given which has to be submitted within a week from the date of absence. No extensions will be given on this. The attendance for that particular day of	

	absence will be marked blank, so that the student is not accounted for absence. These assignments are limited to a maximum of 3 throughout the entire semester.
Homework/ Home Assignment/ Activity Assignment (Formative)	There are situations where a student may have to work in home, especially before a flipped classroom. A student is expected to participate and perform these assignments with full zeal since the activity/ flipped classroom participation by a student will be assessed and marks will be awarded.

E. Syllabus

Review of signals and systems: Time and frequency analysis of signals and systems. Transform Analysis of LTI Systems: The frequency Response of LTI systems, Inverse system, All- Pass system, Minimum Phase system, Linear systems with Generalized Linear Phase. Frequency domain sampling and reconstruction of discrete time signals: Discrete-Time Processing of continuous- Time Signals, Continuous- Time Processing of Discrete-Time Signals, Changing the Sampling Rate Using DiscreteTime Processing. Discrete Fourier transform: Introduction, properties of the DFT, use of DFT in linear filtering, filtering of long data sequences, DFT as linear transformation, Computation of DFT, Decimation-in-Time and Decimation–in–frequency Algorithms. Implementation of discrete time systems: Structures for FIR systems – Direct form, cascade form, Frequency sampling and lattice structures. Structures for IIR systems – Direct form, cascade and parallel form. Design of IIR filters and digital FIR filters: Classical design by impulse invariance, bilinear transformation and matched Z- transform, characteristics and design of commonly used filters – butterworth. Chebyshev, elliptical.

F. Text Books

T1. A.V. Oppenheim & R.W. Schafer, Discrete-Time Signal Processing, Pearson education 2003.

T2. S. Salivahanan, C. Gnanpriya, Digital Signal Processing, 2e, Tata McGraw-Hill Education, 2011.

G. Reference Books

R1. J.G. Proakis, D.G. Manolakis, D. Mimitris, Introduction to Digital Signal Processing, Prentice Hall, India 2003.

R2. Sanjit K. Mitra, Digital Signal Processing A Computer Based Approach, 4e, Mc Graw Hill Education, 2013

R3. I. feachar & Jervis, Digital Signal Processing: A Practical approach, Pearson education, Asia, 2003.

R4. L.R. Rabiner & D.J. Gold, Theory and applications of digital signal processing Prentice Hall, India 1988.

R5. Anand Kumar, Signals and Systems, Prentice Hall, India.

R6. Tarun Kumar Rawat, Signals and Systems, Oxford University Press, 2010.

H. Lecture Plan:

Lec No	**Topics**	**Session Outcome**	**Mode of Delivery**	**Corresponding CO**	**Mode of Assessing the Outcome**
1	Introduction and Course Hand-out briefing	To acquaint and clear teachers expectations and understand student expectations	Lecture	NA	NA
2	Review of signals and systems	Recall signal characterization in various domains	Flipped Classroom	2203.1	In Class Quiz
3	Time and frequency analysis of signals and systems	Analyze signals and systems in time and frequency domain	Lecture	2203.1	In Class Quiz Home Assignment
4,5	Transform Analysis of LTI Systems: The frequency Response of LTI systems, magnitude and phase response	Analyze the LTI systems in frequency domain and plot their magnitude and phase response	Lecture	2203.2	Mid-term I End Term In Class Quiz
6,7	Inverse system, All- Pass system,	Define and characterize an inverse system, and all pass system and their relevance	Lecture	2203.2	In Class Quiz End Term
8	Minimum Phase system.	Identify and characterize a minimum-phase system.	Lecture	2203.2	Class Quiz Mid Term I End Term
9,10	Linear systems with Generalized Linear Phase.	Characterize linear systems with linear phase and to identify various types	Lecture	2203.2	Class Quiz Mid Term 1 End term
11,12,13	Discrete Fourier transform: Introduction, properties of the DFT,	To compute the discrete fourier transform of a signal	Flipped Class	2203.3	Home Assignment Class Quiz Mid Term 1 End Term
14	Use of DFT in linear filtering, filtering of long data sequences,	Application of DFT in linear filtering	Lecture	2203.3	Mid Term 1 End Term
15,16	DFT as linear transformation; Computation of DFT,	To compute DFT as a linear transformation	Lecture	2203.3	Class Quiz Mid Term I End Term
17,18	FFT: Decimation-in-Time Fast-fourier transform (DIT-FFT) algorithm and application.	To apply DIT-FFT algorithm for fast computation of DFT(FFT)	Lecture	2203.3	Class Quiz Mid Term I End Term
19,20	Decimation-in-frequency Fast-fourier transform (DIF-FFT) algorithm and application.	To apply DIT-FFT algorithm for fast computation of DFT(FFT)	Flipped Class	2203.3	Class Quiz Mid Term I End Term
21,22	Implementation of discrete time systems: Structures for FIR systems – Direct form, cascade form,	Describe the various structures for implementation of FIR filters- Direct form & cascade form	Lecture	2203.4	Class Quiz Mid Term II End Term

23,24	Structures for FIR systems – Frequency sampling and lattice structures.	Describe the various structures for implementation of FIR filters- Frequency sampling and lattice structures.	Flipped Class	2203.4	Class Quiz Mid Term II End Term
24	Structures for IIR systems – Direct form,	Describe the Direct form structures for implementation of IIR filters.	Flipped Class	2203.4	Class Quiz Mid Term II End term
25,26	Structures for IIR systems – Cascade and parallel form.	Describe the various structures for implementation of IIR filters- Cascade and parallel form.	Flipped Class	2203.4	Class Quiz Mid Term II End term
27	Design of IIR filters: Classical design by impulse invariance,	Design of IIR filters using impulse invariant method	Lecture	2203.5	Class Quiz Mid Term II End Term
28,29	Design of IIR filters: Bilinear transformation and matched Z transform,	Design of IIR filters using Bilinear transformation and matched Z transform,	Flipped Classroom	2203.5	Class Quiz Mid Term II End Term
30,33	Design of FIR filters -characteristics and design of commonly used filters – butter worth, chebychev.	Design of commonly used FIR filters- butter worth, chebychev.	Lecture	2203.5	Class Quiz Mid Term II End Term
34, 35	Frequency domain sampling and reconstruction of discrete-time signals,	To sample a signal in frequency domain and reconstruct it, aliasing	Lecture	2203.6	Class Quiz Mid Term II End Term
36,37	Discrete-Time Processing of continuous- time Signals, Continuous- Time Processing of Discrete-Time Signals ,	Discrete-time processing of continuous-time signals & Continuous- Time Processing of Discrete-Time Signals.	Lecture	2203.6	End Term
38	Decimation and application.	Describe the relevance and process of decimation.	Lecture	2203.6	Class Quiz End Term
39	Interpolation and application.	Describe the relevance and process of interpolation.	Flipped Class	2203.6	Class Quiz End Term
40-42	Changing the Sampling Rate Using Discrete-Time Processing.	Describe the changing of sampling by a non-integer factor(I/D)	Lecture	2203.6	Class Quiz End Term

I. Course Articulation Matrix: (Mapping of COs with POs)

CO	STATEMENT	CORRELATION WITH PROGRAM OUTCOMES												CORRELATION WITH PROGRAM SPECIFIC OUTCOMES		
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
EC2203.1	Recall the concepts of signals, systems and Z transform and analysis of signals in time and frequency domain	3	2	1	1									2	2	2
EC2203.2	Classify and analyse response of LTI system	2	3	1	2									1	2	1
EC2203.3	Relate and apply the concepts of Discrete Fourier Transform to diverse engineering problems	3	3	3	2	1								1	2	1
EC2203.4	Understand and implement discrete time systems such as FIR and IIR structures	2	3	1	1									1	2	1
EC2203.5	Acquire the skills to design IIR filters and FIR filters using multiple techniques	3	1	1	1									1	2	1
EC2203.6	Understand and interpret frequency domain sampling, signal reconstruction and multi-rate DSP	2	2	1	1	1								1	2	1
	EC2203	3	3	3	2	1								2	2	2

Program Outcomes- Competencies-Performance Indicators.

	PO1: Engineering Knowledge: apply knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of complex engineering problems.			**CO1**	**CO2**	**CO3**	**CO4**	**CO5**	**CO6**
	Competency	**Performance Indicators**							
1.1	Demonstrate competence in mathematical modeling	1.1.1	Apply mathematical techniques such as linear algebra, differential calculus, differential equations and integral calculus to solve problems	Yes	Yes	Yes	Yes	Yes	Yes
1.2	Demonstrate competence in basic sciences	1.2.1	Apply laws of natural science to an engineering problem	Yes		Yes		Yes	
1.3	Demonstrate competence in engineering fundamentals	1.3.1	Apply engineering fundamentals	Yes	Yes	Yes	Yes	Yes	Yes
1.4	Demonstrate competence in specialized engineering knowledge to the program	1.4.1	Apply electronics engineering concepts tosolve engineering problems	Yes	Yes	Yes	Yes	Yes	Yes

	PO2: 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			**CO1**	**CO2**	**CO3**	**CO4**	**CO5**	**CO6**
	Competency	**Performance Indicators**							
2.1	Demonstrate an ability to identifyand formulate complex engineering problem	2.1.3	Identify the mathematical, engineering andother relevant knowledge that applies to a given problem	Yes	Yes	Yes	Yes	Yes	Yes
2.2	Demonstrate an ability to formulate a solution plan and methodology for an engineering problem	2.2.3	Identify existing solution/methods for solving the problem, including forming justified approximations and assumptions	Yes	Yes	Yes	Yes	Yes	Yes
2.3	Demonstrate an ability to formulate and interpret a model	2.3.1	Combine scientific principles and engineering concepts to formulate model/s (mathematicalor otherwise) of a system or process that is appropriate in terms of applicability and required accuracy.	Yes	Yes	Yes	Yes		Yes
2.4	Demonstrate an ability to executea solution process and analyze results	2.4.1	Apply engineering mathematics to implement solution	Yes	Yes	Yes	Yes		

	PO3: Design & Development of Solutions: design solutions for complex engineering problems anddesign system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.			**CO1**	**CO2**	**CO3**	**CO4**	**CO5**	**CO6**
	Competency	**Performance Indicators**							
3.1	Demonstrate an ability to define a complex/open-ended problem in engineering terms	3.1.1	Recognize that need analysis is key to good problem definition		Yes	Yes	Yes	Yes	Yes
		3.1.6	Determine design, objectives, functional requirements and arrive at specifications	Yes	Yes	Yes			
3.2	Demonstrate an ability to generate a diverse set of alternative design solutions	3.2.3	Identify suitable criteria for evaluation of alternate design solutions			Yes	Yes	Yes	Yes
3.3	Demonstrate an ability to select optimal design scheme for further development	3.3.1	Ability to perform systematic evaluation of the degree to which several design concepts meet the criteria.	Yes		Yes			

	PO4: Conduct Investigation of Complex Problems: Use research-based knowledge and researchmethods including design of experiments, analysis and interpretation of data, and synthesis of information to provide valid conclusions.			**CO1**	**CO2**	**CO3**	**CO4**	**CO5**	**CO6**
	Competency	**Performance Indicators**							
4.1	Demonstrate an ability to conduct investigations of technical issues consistent with their level of knowledge and understanding	4.1.1	Define a problem for purpose of investigation, its scope and importance	Yes	Yes	Yes	Yes	Yes	Yes
4.2	Demonstrate an ability to design experiments to solve open ended problems	4.2.1	Design and develop experimental approach, specify appropriate equipment and procedures	Yes	Yes	Yes	Yes	Yes	Yes
4.3	Demonstrate an ability to analyzedata and reach a valid conclusion	4.3.2	Critically analyze data for trends and correlations, stating possible errors and limitations			Yes			
		4.3.3	Represent data (in tabular and/or graphicalforms) so as to facilitate analysis and explanation of the data, and drawing of conclusions		Yes				

	PO5: Modern Tools Usage: create, select and apply appropriate techniques, resources, andmodern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations			**CO1**	**CO2**	**CO3**	**CO4**	**CO5**	**CO6**
	Competency	**Performance Indicators**							
5.1	Demonstrate an ability to identify/create modern engineering tools, techniques and resources	5.1.2	Create/adapt/modify/extend tools and techniques to solve engineering problems			Yes			Yes
5.2	Demonstrate an ability to select and apply discipline specific tools,techniques and resources	5.2.1	Identify the strengths and limitations of toolsfor (i) acquiring information (ii) modeling andsimulating (iii) monitoring system performance, and (iv) creating engineering designs						
		5.2.2	Demonstrate proficiency in using discipline specific tools						
5.3	Demonstrate an ability to evaluatethe suitability and limitations of tools used to solve an engineering problem	5.3.1	Discuss limitations and validate tools, techniques and resources						

	PO6: 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.			**CO1**	**CO2**	**CO3**	**CO4**	**CO5**	**CO6**
	Competency	**Performance Indicators**							
6.1	Demonstrate an ability to describeengineering roles in a broader context, e.g. pertaining to the environment, health, safety, legal and public welfare	6.1.1	Identify and describe various engineering roles; particularly as pertains to protection ofthe public and public interest at global, regional and local level.						
6.2	Demonstrate an understanding of professional engineering regulations, legislation and standards	6.2.1	Interpret legislation, regulations, codes, and standards relevant to professional engineering practice and explain its contribution to the protection of the public.						

	PO7: Environment & Sustainability: understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.			**CO1**	**CO2**	**CO3**	**CO4**	**CO5**	**CO6**
	Competency	**Performance Indicators**							
7.1	Demonstrate an understanding ofthe impact of engineering and industrial practices on social, environmental and in economic contexts	7.1.1	Identify risks/impacts in the life-cycle of an engineering product or activity						
		7.1.2	Understand the relationship between the technical, socioeconomic and environmental dimensions of sustainability						
7.2	Demonstrate an ability to applyprinciples of sustainable designand development	7.2.1	Describe management techniques for sustainable development						
		7.2.2	Apply principles of preventive engineering and sustainable development to an engineering activity or product relevant to the discipline						

	PO8: Ethics: apply ethical principles and commit to professional ethics and responsibilities and norms of engineering practice.			**CO1**	**CO2**	**CO3**	**CO4**	**CO5**	**CO6**
	Competency	**Performance Indicators**							
8.1	Demonstrate an ability to recognize ethical dilemmas	8.1.1	Identify situations of unethical professional conduct and propose ethical alternatives						
		8.2.1	Identify tenets of code of ethics given by the professional bodies like IEEE.						
8.2	Demonstrate an ability to applythe code of ethics	8.2.2	Examine and apply moral & ethical principles to known case studies						

	PO9: Individual & Team work: function effectively as an individual and as a member or leader in diverse teams, and in multidisciplinary settings			**CO1**	**CO2**	**CO3**	**CO4**	**CO5**	**CO6**
	Competency	**Performance Indicators**							
9.1	Demonstrate an ability to form a team and define a role for each member	9.1.1	Recognize a variety of working and learning preferences; appreciate the value of diversity on a team						
9.2	Demonstrate effective individual and team operations--- communication, problem solving,conflict resolution and leadershipskills	9.2.1	Demonstrate effective communication, problem solving, conflict resolution and leadership skills						
9.3	Demonstrate success in a teambased project	9.3.1	Present results as a team, with smooth integration of contributions from all individual efforts						

	PO10: 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.			**CO1**	**CO2**	**CO3**	**CO4**	**CO5**	**CO6**
	Competency	**Performance Indicators**							
10.1	Demonstrate an ability to comprehend technical literature and document project work	10.1.1	Read, understand and interpret technical and non-technical information						
		10.1.2	Produce clear, well-constructed, and well-supported written engineering documents						
		10.1.3	Create flow in a document or presentation- alogical progression of ideas so that the main point is clear						
10.3	Demonstrate the ability to integrate different modes ofcommunication	10.3.1	Create engineering-standard figures, reports and drawings to complement writing and presentations						

	PO11: Project management & 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			**CO1**	**CO2**	**CO3**	**CO4**	**CO5**	**CO6**
	Competency	**Performance Indicators**							
11.1	Demonstrate an ability to evaluatethe economic and financial performance of an engineering activity	11.1.1	Describe various economic and financial costs/benefits of an engineering activity						
		11.1.2	Analyze different forms of financial statements to evaluate the financial status of an engineering project						
11.2	Demonstrate an ability to compare and contrast the costs/benefits of alternate proposals for an engineering activity	11.2.1	Analyze and select the most appropriate proposal based on economic and financial considerations						
11.3	Demonstrate an ability to plan/manage an engineering activity within time and budgetconstraints	11.3.1	Identify the tasks required to complete an engineering activity and the resources required to complete the tasks						
		11.3.2	Use project management tools to schedule an engineering project so it is completed on time and on budget						

	PO12: 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			**CO1**	**CO2**	**CO3**	**CO4**	**CO5**	**CO6**
	Competency	**Performance Indicators**							
12.1	Demonstrate an ability to identify gaps in knowledge and a strategyto close these gaps	12.1.1	Describe the rationale for requirement for continuing professional development						
		12.1.2	Identify deficiencies or gaps in knowledge and demonstrate an ability to source information to close this gap						
12.2	Demonstrate an ability to identifychanging trends in engineering knowledge and practice	12.2.2	Recognize the need and be able to clearly explain why it is vitally important to keep current regarding new developments in your field.						
12.3	Demonstrate an ability to identifyand access sources for new information	12.3..2	Analyze sourced technical and popular information for feasibility, viability, sustainability etc.						

	PSO1: An ability to understand the concepts of basic Electronics & Communication Engineering and to apply them to various areas like Signal processing, VLSI, Embedded systems, Communication Systems, Digital & Analog Devices, etc.			**CO1**	**CO2**	**CO3**	**CO4**	**CO5**	**CO6**
	Competency	**Performance Indicators**							
13.1	Ability to identify errors in circuits, systems and products	13.1.1	Select and use the suitable tools and methodology for identification of faults	Yes	Yes	Yes	Yes	Yes	Yes
		13.1.2	Able to locate and classify the fault						
13.2	Ability to rectify faults in circuits,systems and products	13.2.1	Select and use the suitable tools and methodology for rectification of faults	Yes	Yes	Yes	Yes	Yes	Yes
		13.2.2	Able to eliminate fault with optimum efforts for proper functioning of circuits, systems and products.	Yes					

	PSO2: An ability to solve complex Electronics and Communication Engineering problems, using latest hardware and software tools, along with analytical skills to arrive cost effective and appropriate solutions.			**CO1**	**CO2**	**CO3**	**CO4**	**CO5**	**CO6**
	Competency	**Performance Indicators**							
14.1	Ability to use open source tools	14.1.1	Recognize need of open source tools	Yes	Yes	Yes	Yes	Yes	Yes
		14.1.2	Identify and use the available open source tool for a given task			Yes	Yes	Yes	Yes
		14.1.3	Develop or modify open source tool for custom applications	Yes	Yes				

	PSO3: Wisdom of social and environmental awareness along with ethical responsibility to have a successful career and to sustain passion and zeal for real-world applications using optimal resources as an entrepreneur			**CO1**	**CO2**	**CO3**	**CO4**	**CO5**	**CO6**
	Competency	**Performance Indicators**							
15.1	Ability to identify social and environmental awareness	15.1.1	Comprehend literature, carry out background search & prior art, create a flowchart or diagram to bring clarity in invention and summarize the invention.	Yes		Yes	Yes	Yes	Yes
15.2	Ability to utilize minimum resources	15.2.1	Identify and use the available sources to be utilized for a given task		Yes				
15.3	Ability to have essential features of entrepreneur	15.3.1		Yes					

MANIPAL UNIVERSITY JAIPUR

School of Electrical, Electronics & Communication Engineering (SEEC)

Department of Electronics & Communication Engineering
Course Hand-out

Electronic Sub-System Design Lab| EC2230| 1 Credits | 0 0 2 1

Session: Jan 23 – May 23 | Faculty: Dr. Neha Singh | Class: IV sem Lab course

A. Introduction: This course is offered by Dept. of Electronics & Communication Engineering as a Lab course in IV semester. The course aims to help the students understand practical use and implementation of the theoretical concepts of operational amplifiers and Timer IC. The students are required to design op-amp and time IC based circuits to expose them to practical feasibility, capability and limitations of these IC regarding their best utilization in a specific situation.

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

[2230.1] Understand and analyse the characteristics of an op-amp.
[2230.2] Apply the knowledge of op-amp to design various electronic circuits in linear domain.
[2230.3] Understand the non-linear operation of op-amp and solve various problems in non-linear domain and designing of problems as well.
[2230.4] Understand the principle and applications of IC 555 to develop employability and entrepreneur skills.

C. PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

[PO.1]. **Engineering knowledge**: Demonstrate and apply knowledge of Mathematics, Science, and Engineering to classical and recent problems of electronic design & communication system.

[PO.2]. **Problem analysis**: Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

[PO.3]. **Design/development of solutions**: Design a component, system, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability.

[PO.4]. **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions

[PO.5]. **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations

[PO.6]. **The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice

[PO.7]. **Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development

[PO.8]. **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practices

[PO.9]. **Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings

[PO.10]. **Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions

[PO.11]. **Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments

[PO.12]. **Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

PROGRAM SPECIFIC OUTCOMES

[PSO.1]. An ability to understand the concepts of basic Electronics & Communication Engineering and to apply them to various areas like Signal processing, VLSI, Embedded systems, Communication Systems, Digital & Analog Devices, etc.

[PSO.2]. An ability to solve complex Electronics and Communication Engineering problems, using latest hardware and software tools, along with analytical skills to arrive cost effective and appropriate solutions.

[PSO.3]. Wisdom of social and environmental awareness along with ethical responsibility to have a successful career and to sustain passion and zeal for real-world applications using optimal resources as an Entrepreneur.

D. Assessment Plan:

Criteria	Description	Maximum Marks
Internal Assessment (Summative)	Each lab experiment is evaluated for performance, lab record maintenance and knowledge based on viva during the entire semester.	60
End Term Exam (Summative)	End Term Exam	40
	Total	100
Attendance (Formative)	A minimum of 75% Attendance is required to be maintained by a student to be qualified for taking up the End Semester examination. The allowance of 25% includes all types of leaves including medical leaves.	
Make up Lab sessions (Formative)	A student who misses a class will have to report to the teacher about the absence. He/ She has to perform the experiment issued on the missed date in extra time during the same week. The attendance for that particular day of absence will be marked blank, so that the student is not accounted for absence for the week. If the student fails to carry out the experiment in the same week, he will be marked absent with penalty of one mark for attendance in evaluation.	
Lab record	The students need to maintain lab-records of the experiment they carry out in the lab. It is expected from the student that he completes the experiment details in the record within the week of issue of the experiment and get it corrected in the next lab-class itself. Delay in submission of work attracts penalty of marks.	

E. SYLLABUS

Experiments of this lab are implemented at Hardware as well as software level.

- Device characteristics of BJT and JFET
- Applications of diode: clippers and clampers
- Applications of BJT and FET: amplifiers with feedback and without feedback, single and two stage RC coupled amplifiers and Oscillators.

F. TEXT BOOKS

Not Applicable

G. REFERENCE BOOKS

[1] R. L. Boylestad & L. Nashelsky, "Electronic Devices and Circuit Theory", Prentice Hall, 2009

[2] S. Salivahanan and N Suresh Kumar, "Electronics Device and circuits", McGraw Hill Publication, 2010

H. Lecture Plan:

Lab No.	Name of the experiment	Experiment Outcome	Type of Expt	Corresponding CO	Mode of Assessing the Outcome
1	(a) Design and implement an inverting amplifier using op-amp 741 for the given gain. (b) Design and implement a non-inverting amplifier using op-amp 741 for the given gain.	To design amplifier using op-amp	Hands-on	EC2230.1 EC2230.2	Observational Data, Viva-Voce
2	(a) Implement a voltage follower circuit using op-amp 741 and calculate its voltage gain. (b) Design and implement a summing amplifier (adder circuit) for at least three inputs using op-amp 741 for the given gain.	To use op-amp as voltage follower and design adder circuit	Hands-on	EC2230.2	Observational Data, Viva-Voce
3	(a) Design and implement a scaler circuit using op-amp 741. (b) Design and implement an averager circuit using op-amp 741 for the given gain.	To design an average and scalar circuit using op-amp	Hands-on	EC2230.2	Observational Data, Viva-Voce
4	(a) Design and implement a difference amplifier circuit using op-amp 741 for the given gain. (b) Design and implement a comparator using op-amp 741 and verify the output.	To design difference amplifier and comparator using op-amp	Hands-on	EC2230.2	Observational Data, Viva-Voce
5	Design and implement an integrator using op-amp 741 and verify the output for the given waveshapes: (i) triangular (ii) square (iii) sinusoidal.	To design integrator using op-amp	Hands-on	EC2230.2	Observational Data, Viva-Voce
6	Design and implement a differentiator using op-amp 741 and verify the output for the given waveshapes: (i) triangular (ii) square (iii) sinusoidal.	To design differentiator using op-amp	Hands-on	EC2230.2	Observational Data, Viva-Voce
7	(a) Design and implement a second order Butterworth Low Pass Filter using op-amp 741 for the given cut-off frequency and obtain its frequency response. (b) Design and implement a second order Butterworth High Pass Filter using op-amp 741 for the given cut-off frequency and obtain its frequency response.	To design filters using op-amp	Hands-on	EC2230.3	Observational Data, Viva-Voce
8	Design and implement a Butterworth Band Pass Filter using op-amp 741 for the given cut-off frequencies and obtain its frequency response.	To design filters using op-amp	Hands-on	EC2230.3	Observational Data, Viva-Voce
9	Design a Schmitt Trigger using op-amp 741 and verify its output.	To design Schmitt trigger using op-amp	Hands-on	EC2230.3	Observational Data, Viva-Voce
10	Design and implement a square wave generator using op-amp 741 forgiven frequency.	To design a generator using op-amp	Hands-on	EC2230.3	Observational Data, Viva-Voce
11	Design and implement Astable Multivibrator using Timer IC 555 for the given time period.	Design AMV using IC 555	Hands-on	EC2230.4	Observational Data, Viva-Voce
12	Design and implement Monostable Multivibrator using Timer IC 555 for the given pulse width.	Design MMV using IC 555	Hands-on	EC2230.4	Observational Data, Viva-Voce

13	Design and implementation of a Phase shift oscillator using IC 741.	Design oscillator using op-amp	Hands-on	EC2230.3	Observational Data, Viva-Voce

H. Course Articulation Matrix: (Mapping of COs with POs)

CO	STATEMENT	CORRELATION WITH PROGRAM OUTCOMES												CORRELATION WITH PROGRAM SPECIFIC OUTCOMES		
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
1432.1	Understand and analyse the characteristics of all individual blocks of an op-amp.	2	1											3		
1432.2	Apply the knowledge of op-amp to design various electronic circuits in linear domain.			3	3					3				3	1	
1432.3	Understand the non-linear operation of op-amp and solve various problems in non-linear domain and designing of problems as well.									3				3		
1434.4	Understand the principle and applications of Phase Locked Loop in various modulation techniques			3						3		2		3	1	

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

MANIPAL UNIVERSITY JAIPUR

School of Electrical, Electronics & Communication Engineering (SEEC)

Department of Electronics & Communication Engineering
Course Hand-out

DIGITAL SIGNAL PROCESSING LAB | EC2231 | 1 Credits | 0 0 2 1

Session: Jan – May 2023 | Faculty: Dr. Suddhendu DasMahapatra | Class: B.Tech (IV Sem)

A. Introduction: This course is offered by Dept. of Electronics & Communication Engineering as core Lab Course, targeting students who wish to pursue research & development in industries or higher studies in field of Electronics & Communication Engineering, Including Digital Signal Processing, Image Processing, and Communication Systems. Offers in depth knowledge of DSP by covering Signals, Sampling, Z-Transform, Discrete Fourier transform, Implementation of discrete time systems, Design of IIR filters and digital FIR filters, and Power spectrum estimation for a better learning. Students are expected to have background knowledge on signals & systems for a better learning.

B. Course Outcome: At the end of the course, students will be able to

[EC1634.1] Characterize and Analyse the signals and systems in time domain, frequency domain, Z-domain and Illustrate and interpret the Discrete Fourier Transform, FFT and acquire the skills to apply them to diverse engineering problems.

[EC1634.2] Demonstrate and Implementation of discrete time systems such as structures for FIR and IIR systems.

[EC1634.3] Apply the skills to design IIR filters and FIR filters using various techniques and Illustrate and interpret the frequency domain sampling and signal reconstruction, and multi-rate processing.

[EC1634.4] Apply the skills to apply system response of LTI system & power spectral density estimation.

C. Program Outcomes and Program Specific Outcomes

[PO.1]. **Engineering knowledge**: Demonstrate and apply knowledge of Mathematics, Science, and Engineering to classical and recent problems of electronic design & communication system.

[PO.2]. **Problem analysis**: Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

[PO.3]. **Design/development of solutions**: Design a component, system, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability.

[PO.4]. **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions

[PO.5]. **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations

[PO.6]. **The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice

[PO.7]. **Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development

[PO.8]. **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practices

[PO.9]. **Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings

[PO.10]. **Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions

[PO.11]. **Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments

[PO.12]. **Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

PROGRAM SPECIFIC OUTCOMES

[PSO.1]. An ability to understand the concepts of basic Electronics & Communication Engineering and to apply them to various areas like Signal processing, VLSI, Embedded systems, Communication Systems, Digital & Analog Devices, etc.

[PSO.2]. An ability to solve complex Electronics and Communication Engineering problems, using latest hardware and software tools, along with analytical skills to arrive cost effective and appropriate solutions.

[PSO.3]. Wisdom of social and environmental awareness along with ethical responsibility to have a successful career and to sustain passion and zeal for real-world applications using optimal resources as an Entrepreneur.

D. Assessment Plan:

Criteria	Description	Maximum Marks
Internal Assessment	Laboratory Sessions and Assignments	60
End Term Exam	End Term Exam : Practical Lab	40
	Total	100
Attendance (Formative)	A minimum of 75% Attendance is required to be maintained by a student to be qualified for taking up the End Semester examination. The allowance of 25% includes all types of leaves including medical leaves.	
Make up Assignments (Formative)	Students who misses a lab session will have to report to the teacher about the absence. The missed experiment can be performed as a makeup experiment in the next lab session or any time before the laboratory exam	
Laboratory Guidelines	Students are expected to maintain an observation book and a laboratory record notebook. The experimental data should be noted in the observation book on the day of performance and the same should be transferred to the record notebook before the next lab. No students are allowed to enter the lab without the observation book and record book and attendance will be marked absent	

E. Syllabus

Review of signals and systems: Time and frequency analysis of signals and systems. Transform Analysis of LTI Systems: The frequency Response of LTI systems; Frequency domain sampling and reconstruction of discrete time signals: Discrete-Time Processing of continuous- Time Signals, Continuous- Time Processing of Discrete-Time Signals; Discrete Fourier transform Analysis of Signals; Computation of DFT, Decimation-in- Time and Decimation–in–frequency Algorithms(FFT). Design of filters with window Techniques and Power spectrum estimation.

F. Reference Books

1. A.V. Oppenheim & R.W. Schafer, Discrete-Time Signal Processing, Pearson education 2003.
2. S. Salivahanan, C. Gnanpriya, Digital Signal Processing, 2e, Tata McGraw-Hill Education, 2011.
3. J.G. Proakis, D.G. Manolakis, D. Mimitris, Introduction to Digital Signal Processing, Prentice Hall, India 2003.
4. Sanjit K. Mitra, Digital Signal Processing A Computer Based Approach, 4e, Mc Graw Hill Education, 2013.
5. Anand Kumar, Signals and Systems, Prentice Hall, India.
6. Tarun Kumar Rawat, Signals and Systems, Oxford University Press, 2010.

G. Lab Experiment List:

Lab No	**Name of the Experiment**	**Experiment Outcome**	**Type of Expt**	**Corresponding CO**	**Mode of Assessing the Outcome**
1	Introduction to Digital Signal Processing Lab, Introduction to MATLAB Simulation Software for DSP Lab, Important MATLAB Commands.	To acquaint and clear teachers expectations and understand student expectations	Hands On MATLAB Software	NA	NA
2	To develop elementary signal function modules (m-files) for Continuous and Discrete-Time Signals (Time-domain representation) namely, Unit-Impulse signal, Unit step, Exponential and Unit ramp Signal.	Students learn the basic signals with simulation and understands their expectations	Hands On with MATLAB Software	EC1634.1	Observational Data and plots, Viva-Voce
3	To develop program for basic equation in continuous - time domain.	Students learn the basic mathematical equations with simulation and understands their expectations	Hands On with MATLAB Software	EC1634.1	Observational resulted Data, Viva-Voce
4	To develop program for discrete convolution sum. To develop program for discrete correlation.	Students learn the Convolution with simulation and understands students expectations	Hands On with MATLAB Software	EC1634.2, EC1634.3	Observational resulted Data, Viva-Voce
5	To develop program for computing DFT using inbuilt functions. To develop program for computing IDFT using inbuilt functions	Students learn the Convolution with simulation and understands students expectations	Hands On with MATLAB Software	EC1634.1-EC1634.3	Observational resulted Data, Viva-Voce
6	To develop program for computing DFT using formula- Matrix Form (Mathematical formula). To develop program for computing IDFT using formula- Matrix Form (Mathematical formula).	Students learn the Convolution with simulation and understands students expectations	Hands On with MATLAB Software	EC1634.3	Observational resulted Data, Viva-Voce
7	To develop program for computing Circular Convolution using inbuilt function. To develop program for computing Circular Convolution using Formula (Mathematical Formula).	Students learn the Convolution with simulation and understands students expectations	Hands On with MATLAB Software	EC1634.3	Observational resulted Data, Viva-Voce

8	To develop program for designing Band pass FIR filter using windowing techniques (Rectangular window, Hamming window, Hanning window).	Students learn the Band stop FIR Filters with simulation and understands students expectations	Hands On with MATLAB Software	EC1634.4	Observational resulted Data, Viva-Voce
9	To develop program for designing Band pass FIR filter using windowing techniques (Rectangular window, Hamming window, Hanning window).	Students learn the Band Pass FIR Filters with simulation and understands students expectations	Hands On with MATLAB Software	EC1634.4	Observational resulted Data, Viva-Voce
10	To develop program for designing low pass FIR filter using windowing techniques (Rectangular window, Hamming window, Hanning window).	Students learn the Low Pass FIR Filters with simulation and understands students expectations	Hands On with MATLAB Software	EC1634.4	Observational resulted Data, Viva-Voce
11	To develop program for designing High pass FIR filter using windowing techniques (Rectangular window, Hamming window, Hanning window).	Students learn the High Pass FIR Filters with simulation and understands students expectations	Hands On with MATLAB Software	EC1634.4	Observational resulted Data, Viva-Voce

H. Course Articulation Matrix: (Mapping of COs with POs)

CO	STATEMENT	CORRELATION WITH PROGRAM OUTCOMES												CORRELATION WITH PROGRAM SPECIFIC OUTCOMES		
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
ECEC1634.1	Characterize and Analyse the signals and systems in time domain, frequency domain, Z-domain and Illustrate and interpret the Discrete Fourier Transform, FFT and acquire the skills to apply them to diverse engineering problems.	3	2	3				2						3	3	
ECEC1634.2	Demonstrate and Implementation of discrete time systems such as structures for FIR systems and IIR systems.	2	2	3												
ECEC1634.3	Apply the skills to design IIR filters and FIR filters using various techniques and Illustrate and interpret the frequency domain sampling and signal reconstruction, and multi-rate processing.		2	3	3			2					2	3	3	
ECEC1634.4	Apply the skills to system response of LTI system & power spectral density estimation	2	2										2	3		

I- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

MANIPAL UNIVERSITY JAIPUR

School of Electrical, Electronics & Communication Engineering (SEEC)

Department of Electronics & Communication Engineering
Course Hand-out

Antennas | EC3101 | 4 Credits | 3 1 0 4

Session: Aug. 2022 – Dec 2022 | Faculty: Dr. Sanyog Rawat, Dr. Dinesh Yadav | Class: Core Course

A. Introduction: This course is offered by Dept. Electronics and Communication Engineering as a Core Course, targeting students who wish to pursue a career in the field of Antenna Engineering, including designing antennas for various applications and analysing the performance in free space.

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

[EC3101.1] Explain radiation phenomena and need of antenna theory for wireless applications to promote sustainable development in RF field.
[EC3101.2] Define and understand fundamental antenna parameters.
[EC3101.3] Analyse radiation characteristics and designing techniques of different antenna structures and hence develop employability skills.
[EC3101.3] Illustrate techniques for antenna parameter measurements.
[EC3101.5] Understand the propagation of electromagnetic waves in different propagation modes.
[EC3101.6] Recognize the effect involved in free space propagation.

C. PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

[PO.1]. **Engineering knowledge:** Demonstrate and apply knowledge of Mathematics, Science, and Engineering to classical and recent problems of electronic design & communication system.

[PO.2]. **Problem analysis:** Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

[PO.3]. **Design/development of solutions:** Design a component, system, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability.

[PO.4]. **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions

[PO.5]. **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations

[PO.6]. **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice

[PO.7]. **Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development

[PO.8]. **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practices

[PO.9]. **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings

[PO.10]. **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions

[PO.11]. **Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments

[PO.12]. **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

[PSO.1]. An ability to understand the concepts of basic Electronics & Communication Engineering and to apply them to various areas like Signal processing, VLSI, Embedded systems, Communication Systems, Digital & Analog Devices, etc.

[PSO.2]. An ability to solve complex Electronics and Communication Engineering problems, using latest hardware and software tools, along with analytical skills to arrive cost effective and appropriate solutions.

[PSO.3]. Wisdom of social and environmental awareness along with ethical responsibility to have a successful career and to sustain passion and zeal for real-world applications using optimal resources as an Entrepreneur.

D. Assessment Plan:

Criteria	Description	Maximum Marks
Internal Assessment (Summative)	Sessional Exam I (Close Book)	20
	Sessional Exam II (Close Book)	20
	In class Quizzes and Assignments , Activity feedbacks (Accumulated and Averaged)	20
End Term Exam (Summative)	End Term Exam (Close Book)	40
	Total	100
Attendance (Formative)	A minimum of 75% Attendance is required to be maintained by a student to be qualified for taking up the End Semester examination. The allowance of 25% includes all types of leaves including medical leaves.	
Make up Assignments (Formative)	Students who misses a class will have to report to the teacher about the absence. A makeup assignment on the topic taught on the day of absence will be given which has to be submitted within a week from the date of absence. No extensions will be given on this. The attendance for that particular day of absence will be marked blank, so that the student is not accounted for absence. These assignments are limited to a maximum of 5 throughout the entire semester.	
Homework/ / Activity Assignment (Formative)	There are situations where a student may have to work in home, especially before a flipped classroom. Although these works are not graded with marks. However, a student is expected to participate and perform these assignments with full zeal since the activity/ flipped classroom participation by a student will be assessed and marks will be awarded.	

E. SYLLABUS

Introduction: Radiation Mechanism, current distribution, Antenna parameters; Vector potentials: Electric and magnetic vector potentials, solutions for wave equations, far-field radiation, Duality theorem, Reciprocity theorem; Linear wire Antennas: Infinitesimal, small and finite dipole Antennas, Region separation, Half wave length dipole; Loop Antennas: Small circular loop Antenna, circular loop with constant current, Ferrite loop; Antenna Arrays and other types of antennas: Two element array, N-element array – uniform, broadside, ordinary end-fire, Non-uniform Amplitude Arrays, planar and circular arrays; Qualitative study of Folded dipole, long wire, V, Rhombic, Helical, Yagi Uda, log-periodic, Aperture antennas, and horn Antennas, Babinet's principle, Huygens's principle, Rectangular and Circular Microstrip Patch antenna, Quality Factor, Bandwidth, Efficiency; Antenna Measurements: Radiation Pattern measurement, Distance requirement for uniform phase, uniform field amplitude requirement, Introduction to phase measurement; Gain Measurement: Comparison method, Near field method, Introduction to current distribution measurement, Measurement of antenna efficiency, measurement of Noise figure and noise temperature of an antenna polarization measurement; Propagation of EM waves: Ground wave Propagation, Space Wave Propagation, Troposphere and ionosphere propagation and its effect on Radio Waves.

F. TEXT BOOKS

1. *C. A. Balanis, "Antenna Theory" 3e, John Wiley & Sons, New Delhi, 2010*
2. *K. D. Prasad "Antenna and Wave Propagation", 3E, Satya Prakashan, New Delhi, 2009*

G. REFERENCE BOOKS

1. *J. Kraus "Antenna and wave Propagation", 4e, Tata McGraw – Hill, New Delhi, 2010*
2. *F. E. Termen "Radio Engineering" Tata McGraw – Hill, New Delhi, 1995*

H. Lecture Plan:

Lec No	Topics	Session Outcome	Mode of Delivery	Corresponding CO	Mode of Assessing the Outcome
1	Introduction and Course Hand-out briefing	To acquaint and clear teachers expectations and understand student expectations	Lecture	NA	NA
2	Introduction: Types of Antennas, Radiation Mechanism, current distribution;,	Describes basics radiation mechanism of antenna radiation	Lecture	EC3101.1	In Class Quiz
3	Vector potentials: Electric and magnetic vector potentials,	Understanding of electric and magnetic potentials	Lecture	EC3101.1	In Class Quiz
4	Solutions for wave equations	Understanding of wave equation of EM radiation	Lecture	EC3101.1	In Class Quiz End Term
5	Near field far-field radiation,	Describes various radiating fields	Lecture	EC3101.1	In Class Quiz
6	Duality theorem, Reciprocity theorem;	Understanding of theorems applicable to antenna system	Lecture	EC3101.1	Class Quiz Mid Term I End Term
7-8	Antenna Parameters	Define & derive expressions for key parameters of antenna	Lecture	EC3101.2	Class Quiz Mid Term I End Term
9	Tutorial	Understanding of numerical problem solving	Question Sheet	EC3101.1 & EC31012	Class Quiz
10	Linear wire Antennas: Infinitesimal, small and finite dipole Antennas,	Describes wire antennas and its type	Lecture	EC3101.3	Class Quiz Mid Term I End Term
11	Region separation, Half wave length dipole,	Describes wavelength dependent antennas	Lecture	EC3101.3	Class Quiz Mid Term I End Term
12	Image theory, vertical and horizontal antenna on perfect conductor, effect of earth curvature	Understanding of antenna orientation and external effects on radiation	Lecture	EC3101.3	Class Quiz Mid Term I End Term
13	Tutorial	Understanding of numerical problem solving	Question Sheet	EC3101.3	Class Quiz
14	Loop Antennas: Small circular loop Antenna	Understanding loop antenna's radiation	Lecture	EC3101.3	Class Quiz Mid Term II End Term
15	Circular loop with constant current, Ferrite loop;	Describes various loop antennas and their applications	Lecture	EC3101.3	Class Quiz Mid Term II End Term
16	Arrays and other types of antennas: Two element array	Describes the need of Array and its advantages	Lecture	EC3101.3	Class Quiz
17	Tutorial	Understanding of numerical problem solving	Question Sheet	EC3101.3	Class Quiz

18	N-element array – uniform, broadside,	Describes various types of antenna arrays	Lecture	EC3101.3	Class Quiz
19	ordinary end-fire, Non-uniform Amplitude Arrays	Describes various types of antenna arrays and their applications	Lecture	EC3101.3	Class Quiz Mid Term II End Term
20	planar and circular arrays,	Describes various types of antenna arrays and their applications	Lecture	EC3101.3	Class Quiz Mid Term II End Term
21	Tutorial	Understanding of numerical problem solving	Question Sheet	EC3101.3	Class Quiz
22	Qualitative study of Folded dipole	Describes the advantages of folded dipole over dipole	Lecture	EC3101.3	Class Quiz Mid Term II End Term
23	Long wire antenna	Understanding of long wire antennas and their applications	Lecture	EC3101.3	Class Quiz
24	V, Rhombic,	Understanding of various types of extended long wire antennas	Lecture	EC3101.3	Class Quiz
25	Tutorial	Understanding of numerical problem solving	Question Sheet	EC3101.3	Class Quiz
26	Helical Antenna	Understanding of radiation in helical antenna	Lecture	EC3101.3	Mid Term II End Term
27	Yagi-UDA	Understanding of radiation in Yagi-UDA antenna	Lecture	EC3101.3	Class Quiz Mid Term II End Term
28	Log-periodic,	Understanding of of radiation in log periodic antenna	Lecture	EC3101.3	Class Quiz Mid Term II End Term
29	Tutorial	Understanding of numerical problem solving	Question Sheet	EC3101.3	Class Quiz
30	Aperture Antennas	Understanding of radiation in aperture antenna	Lecture	EC3101.3	Mid Term II End Term
31	Horn Antennas	Describes the radiation in horn antenna and its types	Lecture	EC3101.3	Mid Term II End Term
32	Babinet‘s principle.	Understanding of babinet’s principle.	Lecture	EC3101.3	Mid Term II End Term
33	Tutorial	Understanding of numerical problem solving	Question Sheet	EC3101.3	Class Quiz
34	Huygens‘s principle	Understanding of Huygens’s principle in aperture antennas	Lecture	EC3101.3	Class Quiz End Term
35	Micro Strip Antenna: Rectangular and Circular Patch,	Describes the radiation in patch antenna and its types	Lecture	EC3101.3	Mid Term II End Term
36	Antenna Measurement	Understanding of antenna measurement techniques	Lecture	EC3101.4	Class Quiz Mid Term II End Term

37	Tutorial	Understanding of numerical problem solving	Question Sheet	EC3101.4	Class Quiz
38	Antenna Measurement Quality Factor, Bandwidth, Efficiency;	Understanding of measurement of antenna parameters	Lecture	EC3101.4	Mid Term II End Term
39	Propagation of EM waves	Describes the wave propagation in different medium	Lecture	EC3101.5	Mid Term II End Term
40	Ground wave Propagation,	Understanding of ground wave propagation	Lecture	EC3101.5	Mid Term II End Term
41	Tutorial	Understanding of numerical problem solving	Question Sheet	EC3101.5	Class Quiz
42	Sky Wave Propagation	Understanding of sky wave propagation	Lecture	EC3101.5	Mid Term II End Term
43	Space Wave Propagation	Understanding of space wave propagation	Lecture	EC3101.5	Mid Term II End Term
44	Troposphere and structure of ionosphere	Understanding of structure of ionosphere	Lecture	EC3101.5	Class Quiz Mid Term II End Term
45	Tutorial	Understanding of numerical problem solving	Question Sheet	EC3101.5	Class Quiz
46	Ionosphere propagation and its effect on Radio Waves	Understanding of ionosphere propagation	Lecture	EC3101.5	Mid Term II End Term
47	Ionosphere Layers	Describes various ionosphere layers	Lecture	EC3101.5	Mid Term II End Term
48	Virtual Height	Understanding of free space parameters	Lecture	EC3101.6	Mid Term II End Term
49	Maximum usable Frequency	Understanding of free space parameters	Lecture	EC3101.6	Class Quiz End Term
50	Critical Frequency	Understanding of free space parameters	Lecture	EC3101.6	Class Quiz End Term
51	Refractive Index Ionosphere	Understanding of free space parameters	Lecture	EC3101.6	Class Quiz End Term
52	Tutorial	Understanding of numerical problem solving	Question Sheet	EC3101.6	Class Quiz
53	Effect of Earth Curvature	Understanding of earth's surface in wave propagation	Lecture	EC3101.6	Class Quiz End Term
54	Ground Effects and Fading	Understanding of earth's surface in wave propagation	Lecture	EC3101.6	Class Quiz End Term

I. Course Articulation Matrix: (Mapping of COs with POs)

CO	STATEMENT	CORRELATION WITH PROGRAM OUTCOMES												CORRELATION WITH PROGRAM SPECIFIC OUTCOMES		
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
EC 3101.1	Explain radiation phenomena and need of antenna theory for wireless applications to promote sustainable development in RF field.	2	2	0	0	0	0	0	0	0	0	0	3	2	1	2
EC 3101.2	Define and understand fundamental antenna parameters.	2	1	2	1	1	0	0	0	0	0	0	2	3	3	2
EC 3101.3	Analyse radiation characteristics and designing techniques of different antenna structures and hence develop employability skills.	1	2	2	1	1	0	0	0	0	0	0	2	3	3	2
EC 3101.4	Illustrate techniques for antenna parameter measurements.	1	1	1	1	1	0	0	0	0	0	0	2	2	3	2
EC 3101.5	Understand the propagation of electromagnetic waves in different propagation modes.	2	2	2	2	1	0	0	0	0	0	0	2	2	3	2
EC 3101.6	Recognize the effect involved in free space propagation.	2	2	2	2	1	0	1	0	0	0	0	2	2	3	2
	Maximum Correlation	2	2	2	2	1	-	1	-	-	-	-	3	3	3	2

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

MANIPAL UNIVERSITY JAIPUR

School of Electrical, Electronics & Communication Engineering (SEEC)

Department of Electronics & Communication Engineering
Course Hand-out

Analog & Digital Communication | EC 3103 | 4 Credits | 3 1 0 4

Session: July 22 – December 22| Faculty: Madhuri Sahal | Class: Core

A. Introduction:

This course offers a detailed impression to the basic principles and techniques used in analog and digital communications. The course presents analog and digital modulation methods, communication transmitter and receiver, baseband and bandpass communication techniques, and noise analysis. The course also introduces logical techniques to assess the performance of communication systems.

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

[EC 3103.1] Demonstrate the use of Fourier transform to represent amplitude modulation scheme in time and frequency domain (Application)

[EC 3103.2] Compute various parameters & compare different angle modulation schemes in time and frequency domain (Analysis)

[EC 3103.3] Demonstrate use of sampling theorem for baseband signals to mitigate aliasing (Application)

[EC 3103.4] Analyse baseband communication techniques in time domain (Analysis)

[EC 3103.5] Represent baseband pulse signals into signals using appropriate line coding technique (Comprehension)

[EC 3103.6] Calculate error probability & compare different binary modulated digital passband signals and develop the skills to analyse the performance of various bandpass techniques (Analysis)

C. PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

[PO.1]. **Engineering knowledge**: Demonstrate and apply knowledge of Mathematics, Science, and Engineering to classical and recent problems of electronic design & communication system.

[PO.2]. **Problem analysis**: Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

[PO.3]. **Design/development of solutions**: Design a component, system, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability.

[PO.4]. **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

[PO.5]. **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

[PO.6]. **The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

[PO.7]. **Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

[PO.8]. **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practices.

[PO.9]. **Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

[PO.10]. **Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

[PO.11]. **Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

[PO.12]. **Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

[PSO.1]. An ability to understand the concepts of basic Electronics & Communication Engineering and to apply them to various areas like Signal processing, VLSI, Embedded systems, Communication Systems, Digital & Analog Devices, etc.

[PSO.2]. An ability to solve complex Electronics and Communication Engineering problems, using latest hardware and software tools, along with analytical skills to arrive cost effective and appropriate solutions.

[PSO.3]. Wisdom of social and environmental awareness along with ethical responsibility to have a successful career and to sustain passion and zeal for real-world applications using optimal resources as an Entrepreneur.

D. Assessment Plan:

Criteria	Description	Maximum Marks
Internal Assessment (Summative)	Sessional Exam I (Close Book)	20
	Sessional Exam II (Close Book)	20
	In class Quizzes and Assignments, Activity feedbacks (Accumulated and Averaged)	20
End Term Exam (Summative)	End Term Exam (Close Book)	40
	Total	100

Attendance (Formative)	A minimum of 75% Attendance is required to be maintained by a student to be qualified for taking up the End Semester examination. The allowance of 25% includes all types of leaves including medical leaves.
Make up Assignments (Formative)	Students who misses a class will have to report to the teacher about the absence. A makeup assignment on the topic taught on the day of absence will be given which has to be submitted within a week from the date of absence. No extensions will be given on this. These assignments are limited to a maximum of 5 throughout the entire semester.
Homework/ Home Assignment/ Activity Assignment (Formative)	There are situations where a student may have to work in home, especially before a flipped classroom. Although these works are not graded with marks. However, a student is expected to participate and perform these assignments with full zeal since the activity/ flipped classroom participation by a student will be assessed and marks will be awarded.

E. SYLLABUS

Introduction to Analog Communication: Amplitude Modulation, Frequency Modulation, Phase Modulation, Representation of Band Pass signals and systems Relationship between PM& FM. **Radio Receivers:** Superheterodyne Receiver. **Noise Theory:** Noise Performance of Analog Communication Systems. **Introduction to Digital Communication:** Line coding, Review of Sampling theorem, uniform and non-uniform quantization, companding, μ-Law and A-Law compressors, Concept and Analysis of PCM, DPCM, DM and ADM modulators and demodulators. M-ary waveforms, S/N ratio for all modulation, probability of error for PCM in AWGN Channel and other modulation techniques, Duo Binary pulse. **Digital modulation schemes:** Coherent Binary Schemes, Coherent M-ary Schemes, Incoherent Schemes (DPSK and DEPSK), Calculation of average probability of error for different modulation schemes, Power spectra of digitally modulated signals, Performance comparison of different digital modulation schemes.

F. TEXT BOOKS

1. Simon Haykin, Communication Systems, (4e), John Wiley, 2009.

G. REFERENCE BOOKS

1. B. P. Lathi & Z. Ding, Modern Digital and Analog Communication Systems, Oxford, 2010.
2. Taub & Schilling, Principles of Communication Systems, (3e), McGraw Hill, 2008.
3. G. Kennedy, Electronic Communication Systems, (4e), McGraw-Hill, 2008.
4. John G Proakis, M.Salehi and G.Bauch, Modern Communication System Using MATLAB, (3e), Cengage Learning, 2013.
5. R.P.Singh & S.D. Sapre, Communication System-Analog and Digital, (2e), McGraw Hill, 2007.
6. D. Roddy & J. Coolen, Electronic Communications, Fourth Edition, PHI 2001.
7. H.P. Hsu, Analog and Digital Communications, Schaum's outline series TMH 2006.

Lecture Plan:

Lecture No.	Topic	Mode of Delivery	Corresponding CO	Mode of Assessing the Outcome
1.	Introduction to course & Communication Systems	Flipped Classroom	EC1508.1	Assignment/Quiz/Mid-term-1
2.	Review of Fourier Transform	Lecture	EC1508.1	Assignment/Quiz/Mid-term-1
3.	Spectral analysis	Lecture	EC1508.1	Assignment/Quiz/Mid-term-1

4.	Tutorial			
5.	Introduction to Analog Communication	Lecture	EC1508.1	Assignment/Quiz/Mid-term-1
6.	Amplitude modulation: General Equation of single tone AM	Lecture	EC1508.1	Assignment/Quiz/Mid-term-1
7.	Amplitude modulation: Representation of Band Pass signals (Time and Frequency domain analysis of single tone AM)	Lecture	EC1508.1	Assignment/Quiz/Mid-term-1
8.	Tutorial			
9.	Amplitude modulation: Generation (Square Law Modulator) & Detection (Square Law De-Modulator & Envelope Detector) of single tone AM	Lecture	EC1508.1	Assignment/Quiz/Mid-term-1
10.	Time and Frequency domain analysis of Multi tone AM	Lecture	EC1508.2	Assignment/Quiz/Mid-term-1
11.	DSB-SC, SSB, VSB & Frequency Division Multiplexing (FDM)	Lecture	EC1508.2	Assignment/Quiz/Mid-term-1
12.	Introduction Angle modulation (PM & FM)	Lecture	EC1508.2	Assignment/Quiz/Mid-term-1
13.	Tutorial			
14.	Angle modulation: General Equation of single tone NBFM & WBFM	Lecture	EC1508.2	Assignment/Quiz/Mid-term-1
15.	Angle modulation: Representation of Band Pass signals (Time and Frequency domain analysis of single tone FM)	Lecture	EC1508.2	Assignment/Quiz/Mid-term-1
16.	Calculation of modulation index for NBFM, average power for FM, transmission bandwidth	Lecture	EC1508.2	Assignment/Quiz/Mid-term-1
17.	Tutorial			
18.	Generation (Armstrong Method) & Detection (detuned resonant circuit) of single tone FM, Systems Relationship between PM & FM	Lecture	EC1508.2	Assignment/Quiz/Mid-term-1
19.	Angle modulation: Representation of Band Pass signals (Time and Frequency domain analysis of single tone PM)	Lecture	EC1508.2	Assignment/Quiz/Mid-term-1

20.	Tutorial			
21.	Radio Receivers	Lecture	EC1508.2	Assignment/Quiz/Mid-term-2
22.	Superheterodyne Receiver	Lecture	EC1508.2	Assignment/Quiz/Mid-term-2
23.	Noise Theory: Thermal Noise, Shot Noise Signal to Noise ratio	Lecture	EC1508.2	Assignment/Quiz/Mid-term-2
24.	Noise Performance of Amplitude & Angle modulation schemes	Lecture	EC1508.2	Assignment/Quiz/Mid-term-2
25.	Tutorial			
26.	Introduction to Digital Communication System,	Lecture	EC1508.3	Assignment/Quiz/Mid-term-2
27.	Review of Sampling theorem	Lecture	EC1508.3	Assignment/Quiz/Mid-term-2
28.	Quantization (uniform and non-uniform quantization)	Lecture	EC1508.3	Assignment/Quiz/Mid-term-2
29.	Non-Uniform Quantization: companding, μ-Law and A-Law compressors	Lecture	EC1508.3	Assignment/Quiz/Mid-term-2
30.	Tutorial			
31.	Baseband digital communication systems: Pulse Code Modulation (PCM): modulators and demodulators	Lecture	EC1508.3	Assignment/Quiz/Mid-term-2
32.	Signal-to-Noise Ratio (SNR) & probability of error (Pe) of in PCM (AWGN Channel)	Lecture	EC1508.3	Assignment/Quiz/Mid-term-2
33.	Tutorial			
34.	Differential Pulse Code Modulation (DPCM): modulators and demodulators	Lecture	EC1508.3	Assignment/Quiz/Mid-term-2
35.	Delta Modulation (DM): modulators and demodulators	Lecture	EC1508.4	Assignment/Quiz/Mid-term-2
36.	Signal-to-Noise Ratio (SNR) & probability of error (Pe) of in DM (AWGN Channel)	Lecture	EC1508.4	Assignment/Quiz/Mid-term-2
37.	Adaptive Delta Modulation (ADM): modulators and demodulators	Lecture	EC1508.4	Assignment/Quiz/Mid-term-2
38.	Tutorial			
39.	Time Division Multiplexing (TDM)	Lecture	EC1508.3	Assignment/Quiz/Mid-term-2
40.	Line coding	Lecture	EC1508.5	Assignment/Quiz/Mid-term-2
41.	Eye Diagram	Lecture	EC1508.4	Assignment/Quiz/Mid-term-2
42.	Duo Binary pulse	Lecture	EC1508.4	Assignment/Quiz/Mid-term-2
43.	Digital modulation schemes, Coherent Binary & M-ary Schemes: Amplitude Shift Keying (ASK)	Lecture	EC1508.6	Assignment/Quiz/ETE

44.	Tutorial			
45.	Coherent Binary Schemes: Phase Shift Keying (PSK)	Lecture	EC1508.6	Assignment/Quiz/End term
46.	Coherent Binary Schemes: Frequency Shift Keying (FSK)	Lecture	EC1508.6	Assignment/Quiz/End term
47.	Incoherent Binary Schemes: Differential Phase Shift Keying (DPSK)	Lecture	EC1508.6	Assignment/Quiz/End term
48.	Tutorial			
49.	Incoherent Binary Schemes: Differentially Encoded Phase Shift Keying (DEPSK)	Lecture	EC1508.6	Assignment/Quiz/End term
50.	Geometric interpretation of signals: Calculation of average probability of error for modulation schemes	Lecture	EC1508.6	Assignment/Quiz/End term
51.	Power spectra of digitally modulated signals, Performance comparison of different digital modulation schemes	Lecture	EC1508.6	Assignment/Quiz/End term
52.	Tutorial			
53.	Revision			

A. Course Articulation Matrix: (Mapping of COs with POs)

CO	STATEMENT	CORRELATION WITH PROGRAM OUTCOMES												CORRELATION WITH PROGRAM SPECIFIC OUTCOMES		
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
[EC3103.1].	Demonstrate the use of Fourier transform to represent amplitude modulation scheme in time and frequency domain	2	2	2	1	0	0	0	0	0	1	1	1	2	2	0
[EC3103.2].	Compute various parameters & compare different angle modulation schemes in time and frequency domain	2	1	2	1	0	0	0	0	0	0	0	1	2	1	0
[EC3103.3].	Demonstrate use of sampling theorem for baseband signals to mitigate aliasing	2	2	1	1	0	1	0	0	0	0	1	0	2	2	0
[EC3103.4]	Analyse baseband communication techniques in time domain	2	1	1	1	0	0	0	0	0	1	0	0	2	2	0
[EC3103.5]	Represent baseband pulse signals into signals using appropriate line coding technique	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0
[EC3103.6]	Calculate error probability & compare different binary modulated digital passband signals and develop the skills to analyse the performance of various bandpass techniques	1	2	1	1	0	1	0	0	0	0	1	1	2	2	0
		2	2	2	1	0	0	0	0	0	0	1	1	2	2	0

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

MANIPAL UNIVERSITY JAIPUR

School of Electrical, Electronics & Communication Engineering (SEEC)

Department of Electronics & Communication Engineering
Course Hand-out

CMOS VLSI Design EC3104 | 4 Credits | 3 1 0 4

Session: August 22– December 22 | Faculty: Dr. Kulwant Singh, Dr. Deepika Bansal, Mr. Vikas Boradak | Class: Core

A. Introduction: This course is offered by Dept. of Electronics & Communication Engineering as a Core Course, to introduce the field of VLSI design for pursuing research & development in the field of VLSI Design, Nano-devices and its applications, Low Power VLSI Design. This course offers in depth knowledge of MOSFET working & characteristics, CMOS circuit fabrication, static and timing analysis and gives an introductory level knowledge on low power techniques. Students are expected to have background knowledge of Analog Electronic and Digital Electronics for better understanding of the course and this course is a prerequisite for Low Power VLSI Design Course.

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

[EC3104.1] Illustrate fabrication and working of MOS device for calculating current and voltages
[EC3104.2] Analyze CMOS circuits in behavioral, structural and geometrical domain for CMOS implementation
[EC3104.3] Compute noise margin for CMOS circuits using mathematical calculations
[EC3104.4] Compute propagation delays for CMOS circuits using mathematical calculations
[EC3104.5] Design combinational and sequential logic circuits using different implementation strategies for digital circuits

C. PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

PROGRAM OUTCOMES

[PO.1]. Engineering knowledge: Demonstrate and apply knowledge of Mathematics, Science, and Engineering to classical and recent problems of electronic design & communication system.

[PO.2]. Problem analysis: Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

[PO.3]. Design/development of solutions: Design a component, system, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability.

[PO.4]. Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions

[PO.5]. Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations

[PO.6]. The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice

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[PO.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

[PO.12]. **Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

PROGRAM SPECIFIC OUTCOMES

[PSO.1]. An ability to understand the concepts of basic Electronics & Communication Engineering and to apply them to various areas like Signal processing, VLSI, Embedded systems, Communication Systems, Digital & Analog Devices, etc.

[PSO.2]. An ability to solve complex Electronics and Communication Engineering problems, using latest hardware and software tools, along with analytical skills to arrive cost effective and appropriate solutions.

[PSO.3]. Wisdom of social and environmental awareness along with ethical responsibility to have a successful career and to sustain passion and zeal for real-world applications using optimal resources as an Entrepreneur.

D. Assessment Plan:

Criteria	Description	Maximum Marks
Internal Assessment (Summative)	Sessional Exam I (Close Book)	20
	Sessional Exam II (Close Book)	20
	In class Quizzes and Assignments	20
End Term Exam (Summative)	End Term Exam (Close Book)	40
	Total	100
Attendance (Formative)	A minimum of 75% Attendance is required to be maintained by a student to be qualified for taking up the End Semester examination. The allowance of 25% includes all types of leaves including medical leaves.	
Make up Assignments (Formative)	Students who miss the class will have to report to the teacher about the absence. A makeup assignment on the topic taught on the day of absence will be given. These assignments are limited to a maximum of 5 throughout the entire semester.	
Activity Assignment & Quiz (Summative)	Minimum 3 Quiz will be given.	

E. SYLLABUS

Introduction: VLSI technology trends, performance measures and Moore's law. **MOS devices and circuits:** MOS transistors, Study of depletion and enhancement mode operations, Threshold Voltage. Second order effects in MOSFETs. **Fabrication of ICs:** Lithographic process of MOS and CMOS fabrication, N-well, P-well and twin tub processes, Latch-up in CMOS, SOI process, VLSI Yield and economics. **MOS Circuit design & layouts**: Implementation of Boolean functions and combinational circuits using switch logic & gate logic, Pass transistors and transmission gates, Pseudo NMOS inverter, Dynamic and clocked CMOS inverters, Clocking strategies. **Basic circuit concepts and performance estimation:** Sheet resistance, Standard unit of capacitance, Estimation of delay in NMOS and CMOS inverters. **Sub system design:** Design strategies, Design issues and structured approach, Design examples such as Adders, ALUs and Shifters, Design of sequential circuits. **Memory Arrays:** SRAM, DRAM. **Current trends:** BiCMOS devices and circuits.

F. TEXT BOOK

T1. S. M. Kang & Y. Leblebici, CMOS digital Integrated circuits design and analysis, Tata McGraw Hill, 3rd edition, 1996.

G. REFERENCE BOOKS

1. Jan. M. Rabaey, Anantha Chandrakasan, Borivoje Nikolic, Digital Integrated Circuits, (2e), Pearson, 2003.

2. Neil H. E. Weste & Kamran Eshraghian, Principles of CMOS VLSI Design, (2e), Addison Wesley, 1993.

H. Lecture Plan:

Lecture No.	*Topics to be Covered.*	**Session Outcome**	**Mode of Delivery**	**Corresponding CO**	**Mode of Assessing the Outcome**
1	Overview of the Course	To acquaint and clear teachers expectations and understand student expectations	Lecture	[3104.1]	NA
2-4	VLSI technology trends, performance measures and Moore's law.	Interpret VLSI technology trends	Lecture	[3104.1]	Class Quiz
5	MOS structure	Recall the operation of JFET and MOSFET	Lecture	[3104.1]	Class Quiz
6-7	**Fabrication of ICs:** Lithographic process of MOS and CMOS fabrication, N-well, P-well and twin tub processes, Latch-up in CMOS, SOI process, VLSI Yield and economics.	understand fabrication of MOS	Lecture	[3104.1]	Class Quiz Mid-term-I
8	**MOS devices and circuits:** MOS transistors, Study of depletion and enhancement mode operations	understand modes of operation for the MOS	Lecture	[3104.1]	Class Quiz Mid-term-I
9, 10	Energy band diagram and Fermi level	Recall Energy band diagram for semiconductors and extend it for MOS	Lecture	[3104.1]	Class Quiz Mid-term-I End-term
11	MOSFET working and its region of operation	Analyze MOSFET operating region	Lecture	[3104.1]	Class Quiz Mid-term-I
12	Threshold Voltage & Derivation	Determine the components of Threshold voltage for MOS	Lecture	[3104.1]	Class Quiz Mid-term-I End-term
13	Threshold Voltage	Calculating threshold voltage for a device	Tutorial	[3104.1]	Class Quiz Mid-term-I End-term
14	MOS current Derivation	Estimate MOS current based on applied voltage	Lecture Tutorial	[3104.1]	Class Quiz Mid-term-I End-term
15	Body Bias Effect, Channel Length Modulation	Evaluate effect of body bias and channel length modulation on MOS current	Lecture	[3104.1]	Class Quiz Mid-term-I End-term
16	MOS Scaling, Second order effects in MOSFETs	Interpret effect of scaling on capacitance, current and power density of MOS	Lecture Tutorial	[3104.2]	Class quiz Mid-term-I
17-18	Resistive Load Inverter	Sketch Voltage Transfer Characteristics for Inverter and identify device operation	Lecture	[3104.2]	Class Quiz Mid-term-I End-term

19-20	Analysis of NMOS and CMOS inverter circuits (Noise Margin)	Analyze the circuit to find Noise Margin	Lecture	[3104.2]	Class Quiz Mid-term-I End-term
21	Noise Margin	Calculation of Noise Margin for a circuit	Tutorial	[3104.3]	Class Quiz Mid-term-I End-term
22	Power dissipation in CMOS	Determine the power requirements of the circuit	Lecture	[3104.3]	Class Quiz Mid-term-I
23-25	Estimation of delay in NMOS and CMOS inverters	Analysis of circuits for delay calculations	Lecture	[3104.3]	Class Quiz Mid-term-II End-term
26	**Delay calculations**	Solving numerical to calculate delay in circuits	Tutorial	[3104.4]	Class Quiz Mid-term-II End-term
27	**Basic circuit concepts and performance estimation:** Sheet resistance, Standard unit of capacitance,	Understand parasitic resistance and capacitance	Lecture	[3104.4]	Class Quiz Mid-term-II End-term
28	**calculation of circuit parasitic**	Solve problems for calculating parasitic capacitances	Tutorial	[3104.4]	Class Quiz Mid-term-II End-term
29-30	Implementation of Boolean functions and combinational circuits using CMOS logic	Implementation of Boolean functions and combinational circuits using different circuits studied	Lecture Tutorial	[3104.5]	Class Quiz Mid-term-II End-term
31-32	Stick diagrams, Design rules and layouts	Implementation of circuits using stick diagrams and layouts	Lecture Tutorial	[3104.5]	Class Quiz, Mid-term-II End-term
33-34	Pass transistors and transmission gates	Explain TG operation and implementation of circuits	Lecture	[3104.5]	Class Quiz Mid-term-II End-term
35	Implement circuits using TG and pass transistor	Implement circuits using TG and pass transistor	Tutorial	[3104.5]	Class Quiz Mid-term-II End-term
36	Pseudo NMOS inverter	Implementation of Boolean functions and combinational circuits using different circuits studied	Lecture	[3104.5]	Class Quiz Mid-term-II End-term
37, 38	Dynamic and clocked CMOS inverters, Clocking strategies	Explain the working of dynamic CMOS circuits and understand its limitations	Lecture	[3104.5]	Class Quiz Mid-term-II End-term
39, 40	Domino Logic	Explain the working of domino CMOS circuits	Lecture Tutorial	[3104.5]	Class Quiz Mid-term-II End-term
41-42	Flip flops and sequential circuits using various logic families	Recall flip-flops operation and implement them using CMOS circuits	Lecture Tutorial	[3104.5]	Class Quiz End-term

43-44	**Sub system design:** Design strategies, Design issues and structured approach, Design examples such as Adders, ALUs and Shifters,	Understand sub-system design strategies	Lecture	[3104.5]	Class Quiz End-term
45-46	**Memory Arrays:** SRAM, DRAM.	Understand working of memories	Lecture	[3104.5]	Class Quiz End-term
47	**Current trends:** BiCMOS devices and circuits.	Give exposure to latest devices and circuits	Lecture	[3104.5]	Class Quiz
48	**Summary for the course**	Quick summary of important concepts	Lecture	NA	NA

I. Course Articulation Matrix: (Mapping of COs with POs)

CO	STATEMENT	CORRELATION WITH PROGRAM OUTCOMES												CORRELATION WITH PROGRAM SPECIFIC OUTCOMES		
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
[3104.1]	Illustrate fabrication and working of MOS device for calculating current and voltages	2												1	2	1
[3104.2]	Analyze CMOS circuits in behavioral, structural and geometrical domain for CMOS implementation	2	2	1	1									2	2	
[3104.3]	Compute noise margin for CMOS circuits using mathematical calculations	1	3	1	1									2	1	
[3104.4]	Compute propagation delays for CMOS circuits using mathematical calculations	2	2	3										2	2	1
[3104.5]	Design combinational and sequential logic circuits using different implementation strategies for digital circuits	2	2	3										2	2	1

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

MANIPAL UNIVERSITY JAIPUR

School of Electrical, Electronics and Communication Engineering (SEEC)

Department of Electronics and Communication Engineering
Course Hand-out

VLSI Lab EC 4143 | 1 Credits | 0 0 2 1

Session: Aug 2022– Dec 2022 | Faculty: Dr Shilpi Birla, Dr Neha Singh, Dr Amit Kumar Singh, Ms. Deepika Bansal | Class: Practical Course

A. **Introduction:** This course is offered by Dept. of Electronics & Communication Engineering as a Core Course, targeting students who wish to pursue research & development in the field of VLSI Design, Nano-devices and its applications, Low Power VLSI Design. This course offers in depth knowledge of CMOS fabrication flow, MOSFET working & characteristics, Noise margin & delays and gives an introductory level knowledge on low power techniques. Students are expected to have background knowledge on Analog Electronic and Digital Electronics for better understanding of the course and this course is a prerequisite for Low Power VLSI Design Course.

B. **Course Outcomes:** At the end of the course, students will be able to

EC3130.1 Demonstrate VLSI EDA software using SPICE coding and schematic
EC3130.2 Demonstrate current-voltage characteristics for MOS for understanding device working
EC3130.3 Calculate delays and noise margin for CMOS circuits
EC3130.4 Observe DC and transient response of CMOS logic gates
EC3130.5 Design and analyse combinational circuits using CMOS
EC3130.6 Design and analyse sequential circuits using CMOS

C. PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

PROGRAM OUTCOMES

[PO.1]. **Engineering knowledge**: Demonstrate and apply knowledge of Mathematics, Science, and Engineering to classical and recent problems of electronic design & communication system.

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[PSO.3]. Wisdom of social and environmental awareness along with ethical responsibility to have a successful career and to sustain passion and zeal for real-world applications using optimal resources as an Entrepreneur.

D. List of Experiment:

S.	Experiment List	CO		
1.	Verify the Input and output characteristic of MOS Transistors using HSPICE.	Understand device working	**Practical**	**EC3130.1**
2.	Analyse a resistive load inverter for Transient and DC Analysis using HSPICE.	Analyze resistive load inverter	**Practical**	**EC3130.4**
3.	Simulate CMOS inverter to perform DC and transient response. Also analyse the effects of different width, length, supply voltage and capacitance on the responses using HSPICE.	Analyze MOS inverter	**Practical**	**EC3130.4**
4.	Simulate CMOS inverter to perform transient response and obtain the rise time, fall time and propagation delays on inverters.	Study transient response	**Practical**	**EC3130.3**
5.	Design a CMOS inverter using Schematic and analyse the different responses.	Make entry as schematic	**Practical**	**EC3130.1**
6.	Design the schematic of 2-input NAND and NOR gate and simulate it to observe the DC and transient response using HSPICE.	Make entry as schematic	**Practical**	**EC3130.2, EC3130.3**
7.	Design sub circuits for gates and analyse different circuits using HSPICE	Understand sub-circuit design	**Practical**	**EC3130.2, EC3130.4**
8.	Design & Simulate Combinational Circuits (higher order adder) using HSPICE.	Simulate combinational circuit	**Practical**	**EC3130.4**
9.	Design & Simulate Combinational Circuits (higher order MUX) using HSPICE.	Simulate combinational circuit	**Practical**	**EC3130.4**
10.	Design and simulate Multiplexers using Transmission Gate using HSPICE.	Simulate combinational circuit	**Practical**	**EC3130.4**
11.	Design and simulate schematic of Decoder using Transmission Gate.	Simulate combinational circuit	**Practical**	**EC3130.4**

12.	Design and simulate Combinational Circuit using Dynamic logic family and calculate power using HSPICE.	Simulate combinational circuit	**Practical**	**EC3130.4**
13.	Design and simulate Sequential Circuit using Domino logic family and calculate power using HSPICE.	Simulate sequential circuit	**Practical**	**EC3130.5**

E. Course Articulation Matrix: (Mapping of COs with POs)

CO	STATEMENT	CORRELATION WITH PROGRAM OUTCOMES												CORRELATION WITH PROGRAM SPECIFIC OUTCOMES		
		PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
EC3130.1	Illustrate MOS fabrication and its working for skilled employability	1		1	1									1	2	1
EC3130.2	Analyze CMOS circuits in behavioral, structural and geometrical domain to have better skill set		1	2	2	1						1	1	2	2	
EC3130.3	Design and discuss CMOS circuits for delays and noise margin	1	1	2	1	1								2	1	
EC3130.4	Design and analyze different combinational logic circuits and systems using CMOS and other logic families to promote entrepreneurship	2	2	2	2	2		1				1	1	2	2	1
EC3130.5	Implement sequential circuits using CMOS and other logic families	1	2			1	1		1			1	1	2	2	1

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Dr Neha Singh

MANIPAL UNIVERSITY JAIPUR

School of Electrical, Electronics & Communication Engineering

Department of Electronics & Communication Engineering
Course Hand-out

Microwave Engineering | EC 3201 | 3 Credits | 3 0 0 3

Session: Jan 2022 – May 2022 | Faculty: Dr. Neetu, Dr. Madhuri Sahal | Class: Core Subject

A. Introduction: This course comes in the class of core subject for the undergraduates targeting who wish to pursue research & development in industries or higher studies in field of Microwave Engineering. Offers in depth knowledge of microwave transmission line analysis, electromagnetic field analysis inside a waveguide, microwave generators, scattering parameter analysis of microwave components and microwave devices. Students are expected to have background knowledge on electromagnetics for a better learning.

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

[EC3201.1]. Recall the concepts and fundamentals of electromagnetic field theory
[EC3201.2]. Understand the concepts of guided structures like transmission line and apply the concepts to calculate various parameters of transmission Line using Smith Chart
[EC3201.3]. Explain different types of waveguides and their respective modes of propagation
[EC3201.4]. Understand the working of ferrite and non-ferrite based microwave passive components and apply knowledge to form scattering matrix
[EC3201.5] Understand the performance of specialized microwave tubes such as klystron, reflex klystron, magnetron and Travelling wave tube
[EC3201.6] Recognize the limitations of existing vacuum tubes and understand the operation of solid state devices at various microwave frequencies

C. PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

[PO.1]. **Engineering knowledge:** Demonstrate and apply knowledge of Mathematics, Science, and Engineering to classical and recent problems of electronic design & communication system.

[PO.2]. **Problem analysis:** Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

[PO.3]. **Design/development of solutions:** Design a component, system, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability.

[PO.4]. **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions

[PO.5]. **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations

[PO.6]. **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice

[PO.7]. **Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development

[PO.8]. **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practices

[PO.9]. **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings

[PO.10]. **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions

[PO.11]. **Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments

[PO.12]. **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

[PSO.1]. An ability to understand the concepts of basic Electronics & Communication Engineering and to apply them to various areas like Signal processing, VLSI, Embedded systems, Communication Systems, Digital & Analog Devices, etc.

[PSO.2]. An ability to solve complex Electronics and Communication Engineering problems, using latest hardware and software tools, along with analytical skills to arrive cost effective and appropriate solutions.

[PSO 3] Wisdom of social and environmental awareness along with ethical responsibility to have a successful career and to sustain passion and zeal for real-world applications using optimal resources as an Entrepreneur.

D. Assessment Plan:

Criteria	Description	Maximum Marks
Internal Assessment (Summative)	Sessional Exam I (Close Book)	20
	Sessional Exam II (Close Book)	20
	In class Quizzes and Activity feedbacks (Accumulated and Averaged)	20
End Term Exam (Summative)	End Term Exam (Close Book)	40
	Total	100
Attendance (Formative)	A minimum of 75% Attendance is required to be maintained by a student to be qualified for taking up the End Semester examination. The allowance of 25% includes all types of leaves including medical leaves.	
Make up Assignments (Formative)	Students who misses a class will have to report to the teacher about the absence. A makeup assignment on the topic taught on the day of absence will be given which has to be submitted within a week from the date of absence. No extensions will be given on this. The attendance for that particular day of absence will be marked blank, so that the student is not accounted for absence. These assignments are limited to a maximum of 5 throughout the entire semester.	
Homework/ Home Assignment/ Activity Assignment (Formative)	There are situations where a student may have to work in home, especially before a flipped classroom. Although these works are not graded with marks. However, a student is expected to participate and perform these assignments with full zeal since the activity/ flipped classroom participation by a student will be assessed and marks will be awarded.	

E. SYLLABUS

Introduction to Transverse Electric, Transverse Magnetic and Transverse Electromagnetic waves in conducting planes, characteristics of TE, TM and TEM waves, wave impedance, attenuation, TE, TM and TEM waves. Transmission line equations & solutions, reflection and transmission coefficient, standing wave and standing wave ratio, line impedance and admittance, impedance matching, using stub line, application of smith chart in solving transmission line problems. Rectangular and circular waveguides-theory and analysis, characteristics of TE and TM mode and excitation of wave guides. Passive components: Resonators, Directional Couplers, E-plane Tee, H-plane Tee and Hybrid Tee, Hybrid ring, Attenuators, Circulator, Faraday rotation principle, Isolators. Microwave active Devices: Limitations of conventional vacuum tube devices. Two cavity klystron: Re-entrant cavities, velocity modulation process, bunching process. Reflex klystron: Velocity modulation, power output and efficiency and electronic admittance. Traveling wave tube: Slow wave structure, amplification process, convection current, axial electric field, wave modes and gain consideration. Magnetron: Mode of oscillation, Types of Magnetron, Strapping and Rising Sun Magnetron. Microwave diodes and transistors: Tunnel diode, Varactor diode, Gunn diode, IMPATT diode, Microwave transistors and FETs.

F. TEXT BOOKS

1) S. Y. Liao, Microwave Devices and Circuits, Prentice Hall, 2004.

2) D. M. Pozar, Microwave Engineering, John Wiley & Sons, 2004.

G. REFERENCE BOOKS

1) J. Ryder, Network lines and Fields, Prentice Hall, 1999.

2) Jordan & Balmain, Electromagnetic waves and Radiating System, Prentice Hall, 1968.

H. Lecture Plan:

Lec No	**Topics**	**Session Outcome**	**Mode of Delivery**	**Corresponding CO**	**Mode of Assessing the Outcome**
1	Introduction and Course Hand-out briefing	To acquaint and clear teachers expectations and understand student expectations	Lecture	NA	NA
2	Recall the fundamentals of electromagnetic field theory,	Describes the fundamentals of transmission line	Lecture	3201.1	In Class Quiz
3	Introduction of Transmission Line and Characteristic impedance,	Understanding of line parameters	Lecture	3201.2	In Class Quiz
4	Transmission lines at high frequencies	Understanding of the operation of line at high frequency	Lecture	3201.2	Home Assignment In Class Quiz End Term
5	Reflection coefficient, standing waves on transmission line for different loads,	Understanding of line parameters	Lecture	3201.2	In Class Quiz
6	SWR, eighth, quarter and half wave line, impedance matching	Understanding of line parameters	Lecture	3201.2	Class Quiz Mid Term I End Term
7	Smith chart: Construction single and double stub matching;	Describes smith chart and measurement of unknown parameters	Lecture	3201.2	Home Assignment Class Quiz Mid Term I End Term
8	Guided waves: Transverse electric,	Describes applications of wave guides and its propagation modes	Lecture	3201.3	Class Quiz Mid Term I End Term Home Assignment
9	Transverse magnetic	Describes applications of wave guides and its propagation modes	Lecture	3201.3	Class Quiz Mid Term I End Term
10	Transverse electromagnetic waves in conducting planes	Describes applications of wave guides and its propagation modes	Lecture	3201.3	Class Quiz Mid Term II End Term Home Assignment
11	Characteristics of TE TM and TEM waves	Describes characterises various modes	Lecture	3201.3	Class Quiz Mid Term II End Term Home Assignment
12	wave impedance, attenuation;	Describes various guide parameters	Lecture	3201.3	Class Quiz Home Assignment
13	Rectangular wave guides: TE, TM and TEM waves in rectangular wave guide,	Describes various rectangular wave guide and its modes	Lecture	3201.3	Class Quiz Home Assignment
14	circular wave guides: TE, TM and TEM waves in circular wave guide	Describes various circular wave guide and its modes	Lecture	3201.3	Class Quiz Mid Term II End Term Home Assignment
15	characteristics of TE and TM mode and excitation of wave guides;	Describes modes characterises and excitation modes in waveguide	Lecture	3201.3	Class Quiz Mid Term II End Term Home Assignment

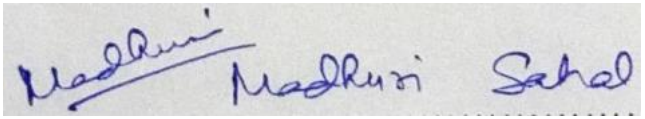
16	Strip lines and micro strip lines: Characteristic impedance, losses and quality factor Q of micro strip lines,	Describes various planer lines and their transmission parameters	Lecture	3201.3	Class Quiz Mid Term II End Term Home Assignment
17	Coplanar strip lines and shielded strip lines	Describes various planer lines and their transmission parameters	Lecture	3201.3	Class Quiz Home Assignment
18	Strip line parameters and its properties;	Describes various planer lines and their transmission parameters	Lecture	3201.3	Mid Term II End Term Home Assignment
19	Passive components: Resonators, Directional Couplers,	Understanding of microwave components	Lecture	3201.4	Mid Term II End Term Home Assignment
20	E-plane Tee, H-plane Tee	Understanding of microwave components	Lecture	3201.4	Class Quiz Mid Term II End Term Home Assignment
21	Hybrid Tee,	Understanding of microwave components	Lecture	3201.4	Class Quiz Mid Term II End Term
22	Hybrid ring, Attenuators,	Understanding of microwave components	Lecture	3201.4	Home Assignment
23	Circulator, Faraday rotation principle,	Understanding of microwave components	Lecture	3201.4	Mid Term II End Term Home Assignment
24	Isolators, Gyrators, Phase Shifters, their applications;	Understanding of microwave components	Lecture	3201.4	Class Quiz End Term
25	Microwave active Devices: Limitations of conventional vacuum tube devices;	Understanding of microwave active devices	Lecture	3201.5	Class Quiz Home Assignment End Term
26	Two cavity klystron: Reentrant cavities,	Understanding of microwave two cavity klystron generators	Lecture	3201.5	Mid Term II End Term Home Assignment
27	Velocity modulation process	Describes velocity modulation process in microwave signal generator	Lecture	3201.5	Mid Term II End Term Home Assignment
28	Bunching process, output power and beam loading;	Understanding of signal generator parameters	Lecture	3201.5	Class Quiz Mid Term II End Term
29	Reflex klystron: Velocity modulation,	Describes of microwave single cavity generator	Lecture	3201.5	Class Quiz Mid Term II End Term Home Assignment
30	Power output and efficiency and electronic admittance;	Understanding of signal generator parameters	Lecture	3201.5	Class Quiz Mid Term II End Term Home Assignment
31	Traveling wave tube: Slow wave structure,	Understanding of TWT and slow wave structures	Lecture	3201.5	Class Quiz Mid Term II End Term
32	Amplification process, convection current,	Understanding of TWT parameters	Lecture	3201.5	Class Quiz Mid Term II End Term Home Assignment

33	Axial electric field, wave modes and gain consideration;	Understanding of TWT parameters	Lecture	3201.5	Class Quiz Mid Term II End Term Home Assignment
34	Magnetron: Mode of oscillation,	Understanding of Magnetron signal generator	Lecture	3201.5	Class Quiz Mid Term II End Term
35	Strapping and Rising Sun Magnetron;	Describes various types of magnetron	Lecture	3201.5	Class Quiz Mid Term II End Term Home Assignment
36	Parametric amplifiers: Physical structure, nonlinear reactance	Understanding of magnetron parameters	Lecture	3201.6	Class Quiz Mid Term II End Term Home Assignment
37	Manley Rowe relations, applications;	Understanding of magnetron parameters	Lecture	3201.6	Class Quiz Mid Term II End Term
38	Microwave diodes and transistors: Tunnel diode	Understanding of diodes and transistor at high frequency	Lecture	3201.6	Class Quiz End Term Home Assignment
39	Varactor diode, Gunn diode	Understanding of diodes and transistor at high frequency	Lecture	3201.6	Class Quiz End Term Home Assignment
40	IMPATT diode	Understanding of IMPATT diodes at high frequency	Lecture	3201.6	Class Quiz End Term Home Assignment
41	Microwave transistors and FETs	Understanding of transistor and FETs at high frequency	Lecture	3201.6	Class Quiz End Term Home Assignment

A. Course Articulation Matrix: (Mapping of COs with POs)

CO	STATEMENT	CORRELATION WITH PROGRAM OUTCOMES												CORRELATION WITH PROGRAM SPECIFIC OUTCOMES		
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
[EC3201 .1]	Recall the concepts and fundamentals of electromagnetic field theory	3												1		
[EC3201 .2]	Understand the concepts of guided structures like transmission line and apply the concepts to calculate various parameters of transmission Line using Smith Chart	3	3		1			1		1			1	1	2	
[EC3201 .3]	Explain different types of waveguides and their respective modes of propagation	2	3					1		1				1	2	
[EC3201 .4]	Understand the working of ferrite and non-ferrite based microwave passive components and apply knowledge to form scattering matrix	1						1						1		
[EC3201 .5]	Understand the performance of specialized microwave tubes such as klystron, reflex klystron, magnetron and Travelling wave tube	1			1			1		1			1	1	2	
[EC3201 .6]	Recognize the limitations of existing vacuum tubes and understand the operation of solid state devices at various microwave frequencies	1	2		1			1					1	1		

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation



MANIPAL UNIVERSITY JAIPUR

School of Electrical, Electronics & Communication

Department of Electronics & Communication Engineering

Course Hand-out

EMBEDDED & REAL TIME OPERATING SYSTEMS | EC 3202 | 4 Credits | 3 1 0 4

Session: January 23 – May 23 | Faculty: Dr. Abhishek Shrivastava, Dr. Rohit Mathur, Mr. Ashish Vijay | Class: Dep. Core (6th Sem)

A. Introduction: This course aims at providing the students with the knowledge and understanding of Embedded systems, Operating systems, and Real time systems. The course focus in developing related programming skills of the students to make them employable in Embedded & IoT industries.

B. Course Outcomes: On successful completion of this course, students shall be able to

[EC 3202.1] Outline the concepts of embedded systems design and analysis.

[EC 3202.2] Understand the concepts of interrupt handling and communication interface protocols in embedded systems.

[EC 3202.3] Outline the concepts of Operating systems in Embedded systems.

[EC 3202.4] Explain the basic concepts of real time operating system design

[EC3202.5] Model real-time applications using embedded-system concepts

C. Program Outcomes (POs) and Program Specific Outcomes (PSOs)

[PO.1]. **Engineering knowledge**: Demonstrate and apply knowledge of Mathematics, Science, and Engineering to classical and recent problems of electronic design & communication system.

[PO.2]. **Problem analysis**: Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

[PO.3]. **Design/development of solutions**: Design a component, system, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability.

[PO.4]. **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions

[PO.5]. **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations

[PO.6]. **The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice

[PO.7]. **Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development

[PO.8]. **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practices

[PO.9]. **Individual and teamwork**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings

[PO.10]. **Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions

[PO.11]. **Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments

[PO.12]. **Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

Program Specific Outcomes

[PSO.1]. An ability to understand the concepts of basic Electronics & Communication Engineering and to apply them to various areas like Signal processing, VLSI, Embedded systems, Communication Systems, Digital & Analog Devices, etc.

[PSO.2]. An ability to solve complex Electronics and Communication Engineering problems, using latest hardware and software tools, along with analytical skills to arrive cost effective and appropriate solutions.

[PSO.3]. Wisdom of social and environmental awareness along with ethical responsibility to have a successful career and to sustain passion and zeal for real-world applications using optimal resources as an entrepreneur.

D. Assessment Plan:

Criteria	Description	Maximum Marks
Internal Assessment (Summative)	Sessional Exam I (probably Online/ or as per directions)	20
	Sessional Exam II (probably Online/ or as per directions)	20
	Online quizzes and Activity feedbacks (Accumulated and Averaged)	20
End Term Exam (Summative)	End Term Exam (as per directions)	40 (80 scaled down to 40)
	Total	100
Attendance (Formative)	A minimum of 75% Attendance is required to be maintained by a student to be qualified for taking up the End Semester examination. The allowance of 25% includes all types of leaves including medical leaves. (as per Academic policy 2020)	
Homework/ Home Assignment/ Activity Assignment (Tutorials) (Formative)	Student is expected to participate and perform in online assignments given via MS team with full zeal timely submission of the assignment. The participation by a student will be assessed and marks will be awarded.	

E. Syllabus

Embedded Systems: Introduction, Classification, Elements of Embedded Systems, Hardware units, devices, Software, Embedded SOC (System on Chip), Design Process, Process of Embedded system development. Interrupts, Devices and Device Drivers: Interrupts, Interrupt Handling Mechanism, Interrupt Controllers, Interrupt Latency, Timers, Counters, Device Drivers. Buses and Communication Interfaces and protocols. Operating System: Process Management: Processes, Threads, Process Synchronization, Process Scheduling, Deadlock. Inter-process Communication and synchronization of processes, threads and tasks: Semaphores, Synchronization with semaphores and Mutex, Shared data, Signal function, Message function, Mailbox, Pipe. Real Time Operating Systems (RTOS): Introduction, Classification, Services, Process Management, Timer function, Memory Management, Task Scheduling modules, Interrupt latency.

F. Reference Books

- Rajkamal, *Embedded Systems: Architecture, Programming and Design*, (2e), McGraw Hill publication, 2008.

- Frank Vahid, Tony Givargis, *Embedded System Design: A unified Hardware/Software approach*, (3e), John Wiley and Sons, 2009.
- 3. Abraham Silberschaltz, Peter Baer Galvin, Greg Gagne, *Operating System Concepts*, (9e), John Wiley and Sons, 2013.

G. Lecture Plan:

Lec. No.	Topics	Session Outcome	Mode of Delivery	Corresponding CO/(s)/POs	Mode of Assessing the Outcomes
1	**Introduction** to Embedded Systems:	Students would get acquainted with basic understanding of the Embedded Systems.	PPT/Board Teaching	3202.1/PO.1/PSO.1	In Class Quiz Mid Term-01 End Term
2-5	Classification, Elements of Embedded Systems, Hardware units, devices, Software, Embedded SOC (System on Chip),	Students get acquainted with various design components of Embedded systems.	PPT/Board Teaching	3202.1/PO.1/PSO.1	In Class Quiz Mid Term-01 End Term
6-9	Design Process, Process of Embedded system development.	Students would learn about the design process involved in development of Embedded systems.	PPT/Board Teaching	3202.1/PO.1/PSO.1	In Class Quiz Mid Term-01 End Term
10-13	Interrupts, Interrupt Handling Mechanism, Interrupt Controllers, Interrupt Latency	Interrupts and handling of interrupts in Embedded systems	PPT/Board Teaching	3202.2/PO.1/PSO.1	In Class Quiz MidTerm-01 End Term
13-15	Timers/Counters in Embedded systems	Timing and counting mechanism in embedded systems	PPT/Board Teaching	3202.1/PO.1/PSO.1	In Class Quiz MidTerm-01 End Term
14,15	Buses and Communication Interfaces and protocols	Students would be able to understand the Communication concepts in Embedded systems.	PPT/Board Teaching	3202.1/PO.1/PSO.1	In Class Quiz MidTerm-01 End Term
16-22	Operating System, Process Management: process concepts, process scheduling, operations on processes and Inter-Process Communications (IPC)	Students would be able to understand the concept of operating systems and associated phenomena	PPT/Board Teaching	3202.3/PO.1/PSO.1	In Class Quiz End Term
22-25	Threads: overview, multicore programming, multithreading models, thread libraries, implicit threading and threading issues.	Students would be able to understand the concept of Threads in operating systems and associated phenomena	PPT/Board Teaching	3202.3/PO.1/PSO.1	In Class Quiz Mid Term-01 End Term
25-28	Process Synchronization, background, mutex locks, semaphores, and critical problems.	Students would be able to understand the concept of Synchronization in operating systems and associated phenomena	PPT/Board Teaching	3202.3/PO.1/PSO.1	In Class Quiz MidTerm-02 End Term
28-31	Deadlocks system models, characterization, methods of handling the deadlocks, preventions, avoidance, detections, and recovery	Students would be able to understand the concept of deadlocks in operating systems and associated phenomena	PPT/Board Teaching	3202.3/PO.1/PSO.1	In Class Quiz MidTerm-02 End Term
31- 35	Real Time Operating Systems (RTOS): Introduction, Classification, Services, Process Management, Timer function, Memory Management, Task Scheduling modules, Interrupt latency.	Students would be able to understand the concept of RTOS systems and associated phenomena	PPT/Board Teaching	3202.4/3202.5/PO.1/PSO.1	In Class Quiz MidTerm-02 End Term

H. Course Articulation Matrix: (Mapping of COs with POs)

CO	STATEMENT	CORRELATION WITH PROGRAM OUTCOMES												CORRELATION WITH PROGRAM SPECIFIC OUTCOMES		
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
[EC 3202.1]	Outline the concepts of embedded systems design and analysis.	3		1										3		
EC 3202.2]	Understand the concepts of interrupt handling and communication interface protocols in embedded systems.	3	3	2			2				1			3		2
EC 3202.3]	Outline the concepts of Operating systems in Embedded systems	3	3	3	3	3				2	1	1	1	2	3	1
EC 3202.4]	Explain the basic concepts of real time operating system design	3	3	3	2	1				1				3	2	
EC 3202.5]	Model real-time applications using embedded-system concepts	3		2	2									3		

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Dr. Abhishek Shrivastava

Course Coordinator

MANIPAL UNIVERSITY JAIPUR

School of Electrical, Electronics & Communication Engineering (SEEC)

Department of Electronics & Communication Engineering
Course Hand-out

OPTICAL COMMUNICATION | EC3203 | 4 Credits | 3 1 0 4

Session: Jan-May 2023 | Faculty: Dr. Amit Rathi | Class: Compulsory (Core)

A. **Introduction:** The course is aimed at equipping undergraduate Engineering students with the basic understanding of optical fibers and optical fiber communication. The course provides knowledge of optical fiber waveguides at the fundamental level, essentials of an optical fiber communication system and understanding of various components of an optical fiber telecommunication system.

B. **Course Outcomes:** At the end of the course, students will be able to :

[3203.1] Understand basic laws of optical physics for lifelong learning and encouraging entrepreneurship. Distinguish between the various modes of operation of Optical fibres.
[3203.2] Identify the various causes for signal degradation. Calculate the various types of losses occurring in transmission of energy.
[3203.3] Learn and Classify the construction and characteristics of optical sources and their various performance parameters .
[3203.4] Develop the experimental skills needed for optical fibre communication with learn the operation of optical detectors, optical receiver and their noise analysis.
[3203.5] Calculate the link budget analysis for performance analysis and hence result in scope of entrepreneurship.
[3203.6] Understand the use of analogue and digital links. Describe the various criteria viz. power loss wavelength, SNR, BER analysis, EYE-diagram to be considered for point-to-point link system and power penalty.

C. **PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES**

[PO.1]. **Engineering knowledge:** Demonstrate and apply knowledge of Mathematics, Science, and Engineering to classical and recent problems of electronic design & communication system.

[PO.2]. **Problem analysis**: Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

[PO.3]. **Design/development of solutions**: Design a component, system, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability.

[PO.4]. **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions

[PO.5]. **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations

[PO.6]. **The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice

[PO.7]. **Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development

[PO.8]. **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practices

[PO.9]. **Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings

[PO.10]. **Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions

[PO.11]. **Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments

[PO.12]. **Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

[PSO.1]. An ability to understand the concepts of basic Electronics & Communication Engineering and to apply them to various areas like Signal processing, VLSI, Embedded systems, Communication Systems, Digital & Analog Devices, etc.

[PSO.2]. An ability to solve complex Electronics and Communication Engineering problems, using latest hardware and software tools, along with analytical skills to arrive cost effective and appropriate solutions.

[PSO.3]. Wisdom of social and environmental awareness along with ethical responsibility to have a successful career and to sustain passion and zeal for real-world applications using optimal resources as an Entrepreneur.

D. Assessment Plan:

Criteria	Description	Maximum Marks
Internal Assessment (Summative)	Sessional Exam I	20
	Sessional Exam II	20
	In class Quizzes and Assignments , Activity feedbacks (Accumulated and Averaged)	20
End Term Exam (Summative)	End Term Exam	40
	Total	100
Attendance (Formative)	A minimum of 75% Attendance is required to be maintained by a student to be qualified for taking up the End Semester examination. The allowance of 25% includes all types of leaves including medical leaves.	
Makeup Assignments (Formative)	Students who miss a class will have to report to the teacher about the absence. A makeup assignment on the topic taught on the day of absence will be given which has to be submitted within a week from the date of absence. No extensions will be given on this. The attendance for that particular day of absence will be marked blank so that the student is not accounted for absence. These assignments are limited to a maximum of 5 throughout the entire semester.	
Homework/ Home Assignment/ Activity Assignment (Formative)	There are situations where a student may have to work in home, especially before a flipped classroom. Although these works are not graded with marks. However, a student is expected to participate and perform these assignments with full zeal since the activity/ flipped classroom participation by a student will be assessed and marks will be awarded.	

E. SYLLABUS

Introduction to optical communication: Basic principles of light propagation, Propagation of Light in an Optical Fiber: Ray Model, Numerical aperture, phase-front (wavefront) based study of Total Internal Reflection, Wave Model and its Analysis, V number of an Optical fiber. **Signal distortion on optical fibers:** Material Dispersion, Intermodal Dispersion, Intermodal Dispersion, Material Attenuation, Microbending, Macrobending, Analysis of Signal distortion in optical fibers using OTDR, Practical issues in implementation of fiber link**. Optical Sources:** Introduction of Optical sources. Light Emitting Diode: Quantum Efficiency, material, electrical and spectral characteristics, modulation. Lasers: Introduction to Laser, Spontaneous emission, Absorption, Stimulated emission, Different type of lasers: ruby laser, He-Ni laser, semiconductor laser**. Optical Receiver:** Photon detector, Photo Diodes, Photo detector and its noise Analysis, Optical Receiver, Digital data transmission in optical domain, SNR, BER analysis, Performance Analysis and the EYE-diagram, Receiver Sensitivity Degradation, Fiber Optic link Design, power penalty.

F. Text books/ Reference books:

1. G.P Agrawal , "*Fiber optics communication"*, third edition, John Wiley & sons,2002 .

2. Keiser, "*Optical Fiber Communication"*, fourth edition, Mc Graw Hill, 2017.

3. M.N. Islam (Ed), "*Raman Amplifiers for communications"*, Springer-verlag, New York, 2003.
4. J.Senior, "Optical Communication, Principles and Practice", Prentice Hall of India, 3rd Edition, 2008.

A. Lecture Plan:

Lec No	Topics	Session Outcome	Mode of Delivery	Corresponding CO	Mode of Assessing the Outcome
1,2	Introduction: History of fiber optic communication	Interaction with students and give basic about subject	Lecture	EC3203.1	NA
2,3,4,5	Elements of an optical fibre communication system	Describes basics	Lecture	EC3203.1	In Class Quiz Mid Term I End Term
6,7,8,9	Optical fiber, the nature of light, basic optical laws and definitions	Understanding of nature and laws of optical fibre	Lecture	EC3203.1	In Class Quiz Mid Term I End Term
10,11,12,13	fiber types, step index and graded index fiber, overview of modes, key modal concepts, single mode fiber, mode field diameter,	Understanding of various type of fiber	Lecture	EC3203.2	Home Assignment In Class Quiz End Term
14,15	Optical fiber modes, v-number	Understanding of field propagation	Lecture	EC3203.2	In Class Quiz
16, 17,18,19,20,21	Signal degradation in optical fiber: Fiber losses, dispersion, distortion, design optimization principles.	Understanding about losses in fibre and communication through fiber	Lecture	EC3203.2	Class Quiz Mid Term I End Term Home Assignment
22,23,24,25	Optical sources and detectors: LED, structure of LED, LED materials, types of LEDs,	Understanding of various optical source and its principle	Lecture	EC3203.3	Class Quiz
26,27,28,29, 30	LASER, principle of LASER, structure of LASER diode and radiation pattern, Different type of lasers: ruby laser, He-Ni laser, semiconductor laser	Understanding of various optical source and its principle	Lecture	EC3203.3	Home Assignment Class Quiz Mid Term 1 End Term
31,32,33,34	Photon detector, Photo Diodes, Photo detector and its noise Analysis,	Understanding of various optical detector and its principle	Lecture	EC3203.4, EC3203.5	Class Quiz Mid Term 1 End Term Home Assignment
35,36,37,38,39	Optical Receiver, Digital data transmission in optical domain, SNR, BER analysis	Understanding of optical receiver, SNR, BER.	Lecture	EC3203.4, EC3203.5	Class Quiz Mid Term I End Term
40,41,42,43,44	Performance Analysis and the EYE-diagram, Receiver Sensitivity Degradation, Fiber Optic link Design, power penalty.	Understanding of EYE diagram and power penalty of link design.	Lecture	EC3203.4, EC3203.5	Class Quiz Mid Term II End Term Home Assignment

G. Course Outcome Attainment Level Matrix:

CO	STATEMENT/JUSTIFICATION	ATTAINMENT OF PROGRAM OUTCOMES **THRESHOLD VALUE: 40%**												ATTAINMENT OF PROGRAM SPECIFIC OUTCOMES		
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
[3203.1]	Understand basic laws of optical physics for lifelong learning and encouraging entrepreneurship. Distinguish between the various modes of operation of Optical fibres.	3	3	1	1	1	0	0	0	0	0	0	0	3	0	2
[3203.2]	Identify the various causes for signal degradation. Calculate the various types of losses occurring in transmission of energy.	3	3	1	1	1	0	0	0	0	0	0	0	3	0	2
[3203.3]	Learn and Classify the construction and characteristics of optical sources and their various performance parameters.	2	3	2	1	1	1	0	0	0	0	0	0	3	0	2
[3203.4]	Develop the experimental skills needed for optical fibre communication with learn the operation of optical detectors, optical receiver and their noise analysis. Calculate the link budget analysis for performance analysis and hence result in scope of entrepreneurship.	2	3	2	1	1	2	0	0	0	0	0	0	3	0	2
[3203.5]	Understand the use of analogue and digital links. Describe the various criteria viz. power loss wavelength, SNR, BER analysis, EYE-diagram to be considered for point-to-point link system and power penalty.	3	3	1	2	1	0	1	0	0	1	0	0	2	1	2

0-No Attainment; 1- Low Attainment; 2- Moderate Attainment; 3- Substantial Attainment

MANIPAL UNIVERSITY JAIPUR

School of Electrical, Electronics & Communication Engineering (SEEC)

Department of Electronics & Communication Engineering
Course Hand-out

VLSI TESTING & TESTABILITY EC3242 | 3 Credits | 3 0 0 3

Session: Jan 23– May 23 | Faculty: Dr. Neha Singh | Class: Program Elective Course

A. Introduction: This course is offered by Dept. of Electronics & Communication Engineering as a program elective Course. The course is mandatory for minor specialization in VLSI. It targets the students interested in the domain of VLSI design to introduce them to the field of Design for Testability. The course covers techniques for efficient testing and the technique of automated test pattern generation for digital system design. Students are expected to have background knowledge of Digital Electronics for better understanding of the course.

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

[EC3242.1] Apply the concepts of testing by modelling different faults for fault free simulation in digital circuits
[EC3242.2] Apply various test generation methods for fault detection in digital circuits
[EC3242.3] Apply various test methods for fault testing in memories and PLA
[EC3242.4] Apply different methods for test response compaction for fault detection
[EC3242.5] Understand Built-in Self-Test methods for improving testability of digital circuits

C. PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

PROGRAM OUTCOMES

[PO.1]. **Engineering knowledge**: Demonstrate and apply knowledge of Mathematics, Science, and Engineering to classical and recent problems of electronic design & communication system.

[PO.2]. **Problem analysis**: Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

[PO.3]. **Design/development of solutions**: Design a component, system, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability.

[PO.4]. **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions

[PO.5]. **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations

[PO.6]. **The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice

[PO.7]. **Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development

[PO.8]. **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practices

[PO.9]. **Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings

[PO.10]. **Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions

[PO.11]. **Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments

[PO.12]. **Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

PROGRAM SPECIFIC OUTCOMES

[PSO.1]. An ability to understand the concepts of basic Electronics & Communication Engineering and to apply them to various areas like Signal processing, VLSI, Embedded systems, Communication Systems, Digital & Analog Devices, etc.

[PSO.2]. An ability to solve complex Electronics and Communication Engineering problems, using latest hardware and software tools, along with analytical skills to arrive cost effective and appropriate solutions.

[PSO.3]. Wisdom of social and environmental awareness along with ethical responsibility to have a successful career and to sustain passion and zeal for real-world applications using optimal resources as an Entrepreneur.

D. Assessment Plan:

Criteria	Description	Maximum Marks
Internal Assessment (Summative)	Sessional Exam I (Close Book)	20
	Sessional Exam II (Close Book)	20
	In class Quizzes and Assignments	20
End Term Exam (Summative)	End Term Exam (Close Book)	40
	Total	100
Attendance (Formative)	A minimum of 75% Attendance is required to be maintained by a student to be qualified for taking up the End Semester examination. The allowance of 25% includes all types of leaves including medical leaves.	
Make up Assignments (Formative)	Students who misses a class will have to report to the teacher about the absence. A makeup assignment on the topic taught on the day of absence will be given. These assignments are limited to a maximum of 5 throughout the entire semester.	
Activity Assignment & Quiz (Summative)	Minimum 3 Quiz will be given.	

E. SYLLABUS

Physical Faults and their modeling: Stuck at Faults, Bridging Faults; Fault collapsing; Fault Simulation: Deductive, Parallel and Concurrent Fault Simulation. Critical Path Tracing.

ATPG for Combinational Circuits: D-Algorithm, Random, Deterministic and Weighted Random Test Pattern Generation; Aliasing and its effect on Fault Coverage.; Controllability and Observability Scan Design, Boundary Scan for Board Level Testing

Memory Testing: Permanent, Intermittent and Pattern Sensitive Faults, Marching Tests;.

PLA Testing: Cross Point Fault Model and Test Generation. Compression Techniques: General Aspects of Compression Techniques; Ones-Count, Transition Count and Parity Check Compression; Syndrome Testing; Signature Analysis.

Built-In-Self-Test (BIST) Concept: TestPattern generation for BIST; Specific BIST Architecture; Introduction to Built-In-Self-Repair (BISR) Approaches.

F. REFERENCE BOOKS

1. M. Abramovici, M. A. Breuer, & A.D. Friedman, Digital Systems Testing and Testable Design, (1e), Piscataway, New Jersey: IEEE Press, 1994.

2. M. L. Bushnell and V. D. Agrawal, Essentials of testing for digital, memory and mixed-signal VLSI circuits, (1e), Boston: Kluwer Academic Publishers, 2000.

G. Lecture Plan:

Lect No.	Topics to be Covered.	Session Outcome	Mode of Delivery	Corresponding CO	Mode of Assessing the Outcome
1.	Overview of the Course	To acquaint and clear teacher's expectations and understand student expectations	Lecture	NA	NA
2	Physical Faults and their modelling: Stuck at Faults	To model stuck-at-fault and detect them in circuit	Lecture	EC3242.1	Class test MTE-1
3	Fault equivalence, collapsing;	To reduce the number of s-a-faults to be tested	Lecture	EC3242.1	Class test MTE-1 ETE
4	Fault dominance, collapsing, bridging fault and its modelling	To find test vectors for fault detection	Lecture	EC3242.1	Class test MTE-1 ETE
5,6	Fault Simulation: Series, and Parallel Fault Simulation.	To simulate the fault tests	Lecture	EC3242.1	Class test MTE-1 ETE
7, 8	Deductive fault simulation	To simulate the fault tests	Lecture, Tutorial	EC3242.1	Class test MTE-1 ETE
9	Concurrent fault simulation	To simulate the fault tests	Lecture	EC3242.1	Class test MTE-1 ETE
10	Critical Path Tracing	To detect faults using critical path tracing	Lecture	EC3242.1	Class test MTE-1
11	ATPG for Combinational Circuits: D-Algorithm	To understand basics of ATPG algorithms, primitive cubes and singular cover	Lecture	EC3242.2	Class test MTE-1 ETE
12	ATPG for Combinational Circuits: D-Algorithm	To analyze test pattern generation using D-Algorithm	Tutorial	EC3242.2	Class test MTE-1 ETE
13	Random, Deterministic and Weighted Random Test Pattern Generation for combinational circuits	To understand random pattern generation method	Lecture	EC3242.2	Class test MTE-1

		Additional: Boolean difference and path sensitization methods of test pattern generation			
14-15	*Test pattern generation for sequential circuits*	To apply test pattern generation algorithm to sequential circuits	Lecture	EC3242.2	Class test MTE-I
16-19	Observability and Controllability (Testability measures)	To assess controllability and observability of each line in combinational circuits *and sequential circuits*	Lecture	EC3242.1	Class test MTE-I ETE
20	Scan Design	To assess the need of Scan chain design	Lecture	EC3242.2	Class test MTE-I ETE
21	Scan Design, Boundary Scan for Board Level Testing;	To evaluate the signal lines for a scan design and use Scan design for board level testing	Lecture	EC3242.2	Class test MTE-I ETE
22	Tutorial: Fault simulation	Numerical practice to understand steps for fault simulation	Lecture	EC3242.2	Class test MTE-I ETE
23	Tutorial: Observability and controllability	Numerical practice to calculate controllability and observability	Lecture	EC3242.1	Class test MTE-I ETE
24	Tutorial: Test pattern generation for combinational circuit	Numerical practice to implement Test pattern generation for combinational circuit	Lecture	EC3242.2	Class test MTE-I ETE
25	Tutorial: Test pattern generation for sequential circuit	Numerical practice to implement Test pattern generation for sequential circuit	Lecture	EC3242.2	Class test
26-27	Memory Testing: Permanent, Intermittent and Pattern Sensitive Faults	Understand different memory faults and state transition diagram to represent faults	Lecture	EC3242.1 EC3242.3	Class test MTE-II ETE
28-29	March Tests	Understand March Test and apply it for testing various faults	Lecture	EC3242.3	Class test MTE-II ETE
30-31	PLA Testing: Cross Point Fault Model and Test Generation.	Represent faults in PLA, generate test for PLA testing	Lecture	EC3242.1 EC3242.3	Class test MTE-II ETE
32-33	Compression Techniques: General Aspects of Compression Techniques; Ones-Count, Transition Count and Parity Check Compression;	Understand the need for response compaction and implement different compression methods	Lecture	EC3242.4	Class test MTE-II ETE
34-36	Syndrome Testing; Signature Analysis	Use LFSR for random sequence generation and signature analysis	Lecture	EC3242.4	Class test MTE-II ETE
37-39	Built-In-Self-Test (BIST) Concept: Test Pattern generation for BIST; Specific BIST Architecture; Introduction to Built-In-Self-Repair (BISR) Approaches.	Understand the need for Built-in self test and its implementation	Lecture	EC3242.5	Class test MTE-II ETE
40-42	Numerical practice	Numerical practice for memory testing, PLA testing, compaction methods, BISR	Tutorial	EC3242.1 EC3242.2 EC3242.3 EC3242.4	Class test MTE-II ETE

A. Course Articulation Matrix: (Mapping of COs with POs)

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

CO	STATEMENT	CORRELATION WITH PROGRAM OUTCOMES												CORRELATION WITH PROGRAM SPECIFIC OUTCOMES		
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
[EC3242.1]	Apply the concepts of testing by modelling different faults for fault free simulation in digital circuits	1		1										1		
[EC3242.2]	Apply various test generation methods for fault detection in digital circuits		2		1										1	
[EC3242.3]	Apply various test methods for fault testing in memories and PLA		2		1									1	1	
[EC3242.4]	Apply different methods for test response compaction for fault detection		2											1	1	
[EC3242.5]	Understand Built-in Self-Test methods for improving testability of digital circuits			1									1		1	

MANIPAL UNIVERSITY JAIPUR

School of Electrical, Electronics & Communication Engineering (SEEC)

Department of Electronics & Communication Engineering
Course Hand-out

VLSI CAD EC4143 | 3 Credits | 3 0 0 3

Class: Program Elective Course (Minor Specialization)

A. Introduction: This course is offered by Dept. of Electronics & Communication Engineering as a program elective Course. The course is mandatory for minor specialization in VLSI. It targets the students interested in development of VLSI design tools. The course focuses on introducing CAD design issues that span the spectrum from circuit modeling with hardware description languages to cell-library binding. It covers relevant mathematical topics followed by study of selective CAD problems and algorithms to solve these problems. This course will form the base for students to read, understand and analyse specialized books and research articles in this field. Students are expected to have elementary knowledge of HDL programming, MOS circuits and digital IC design for better understanding of the course.

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

[EC4143.1] Understand the requirements from a High-level Hardware Description Language (HDL) and CAD Tools to be able to achieve the best designs with the CAD tools for better employability
[EC4143.2] Make use of graph algorithms and Boolean algebra for VLSI Design Automation
[EC4143.3] Choose scheduling algorithms which underpin architectural level synthesis
[EC4143.4] Assess resource sharing and binding algorithms which underpin architectural level synthesis
[EC4143.5] Apply logic optimization for two-level and multiple level combinational and sequential circuits for user-defined constraints
[EC4143.6] Understand Timing Analysis and logical effort for MOS circuits

C. PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

PROGRAM OUTCOMES

[PO.1]. Engineering knowledge: Demonstrate and apply knowledge of Mathematics, Science, and Engineering to classical and recent problems of electronic design & communication system.

[PO.2]. Problem analysis: Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

[PO.3]. Design/development of solutions: Design a component, system, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability.

[PO.4]. Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions

[PO.5]. Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations

[PO.6]. The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice

[PO.7]. **Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development

[PO.8]. **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practices

[PO.9]. **Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings

[PO.10]. **Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions

[PO.11]. **Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments

[PO.12]. **Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

PROGRAM SPECIFIC OUTCOMES

[PSO.1]. An ability to understand the concepts of basic Electronics & Communication Engineering and to apply them to various areas like Signal processing, VLSI, Embedded systems, Communication Systems, Digital & Analog Devices, etc.

[PSO.2]. An ability to solve complex Electronics and Communication Engineering problems, using latest hardware and software tools, along with analytical skills to arrive cost effective and appropriate solutions.

[PSO.3]. Wisdom of social and environmental awareness along with ethical responsibility to have a successful career and to sustain passion and zeal for real-world applications using optimal resources as an Entrepreneur.

D. Assessment Plan:

Criteria	Description	Maximum Marks
Internal Assessment (Summative)	Sessional Exam I (Close Book)	20
	Sessional Exam II (Close Book)	20
	In class Quizzes and Assignments	20
End Term Exam (Summative)	End Term Exam (Close Book)	40
	Total	100
Attendance (Formative)	A minimum of 75% Attendance is required to be maintained by a student to be qualified for taking up the End Semester examination. The allowance of 25% includes all types of leaves including medical leaves.	
Make up Assignments (Formative)	Students who misses a class will have to report to the teacher about the absence. A makeup assignment on the topic taught on the day of absence will be given. These assignments are limited to a maximum of 5 throughout the entire semester.	
Activity Assignment & Quiz (Summative)	Minimum 3 Quiz will be given.	

E. SYLLABUS

F. **Introduction to CAD tools:** Evolution of Design Automation, Types of CAD tools. **Algorithmic Graph Theory:** Graphs, graph optimization, basic algorithms. Hardware Modelling. **Simulation:** Simulation, Gate-level modelling and simulation, Switchlevel modelling and simulation. **Combinational Logic Synthesis:** Binary Decision Diagrams, Two Level Logic Synthesis. **Logic synthesis:** two-level and multilevel Combinational Logic and sequential logic optimization. **Basic concepts of high-level synthesis:** partitioning, scheduling, allocation and binding, Memory modeling Synthesizable and non-synthesizable constructs, Logic Optimization, Optimizing logic using resource sharing. **Estimating delays in a circuit:** issues in Dynamic and Static Timing Analysis. **Introduction to Logical Effort:** Multistage Logic Networks, Logical Effort and Gain Based Synthesis, Logical Effort Optimizing performance.

G. REFERENCE BOOKS

1. G. D. Micheli, Synthesis and optimization of digital systems, (1e), Mc Graw Hill, 2003.
2. S.Imam, M. Pedram, Logic Synthesis for Low Power VLSI Designs, (1e), Kluwer, 1997.
3. M.Smith, Application Specific ICs, (1e), Pearson, 1997.
4. S.Palnitkar, Verilog HDL, A Guide to Digital Design and Synthesis, (2e), Prentice Hall PTR, 2003.
5. S.Brown S., Z.Vranesic, Fundamentals of Digital Logic with Verilog Design, (2e), TMH, 2007.
6. Rabaey, J. M., Chandrakasan, A. P., & Nikolic, B., Digital integrated circuits (2e), Englewood Cliffs, Prentice hall, 2002.

H. Lecture Plan:

Lect No.	Topics to be Covered.	Session Outcome	Mode of Delivery	Corresponding CO	Mode of Assessing the Outcome
1.	Overview of the Course	To acquaint and clear teacher's expectations and understand student expectations	Lecture	NA	NA
2	Introduction to CAD tools: Evolution of Design Automation, Types of CAD tools	To understand need and features of CAD Tools	Lecture	EC4143.1	Class test MTE-1
3-4	**Algorithmic Graph Theory:** Graphs,	To understand graph terminology and Data Structures for Graphs Representation	Lecture	EC4143.2	Class test MTE-1
5-7	**Algorithmic Graph Theory:** graph optimization, basic algorithms	To understand the concept of computational complexity of algorithms and equip students with basic graph algorithms for upcoming topics	Lecture	EC4143.2	Class test MTE-1
8-10	Boolean Algebra, Binary Decision Diagrams	To understand the concept of Boolean algebra and binary decision diagram	Lecture	EC4143.1 EC4143.2	Class test MTE-1
11	Hardware modelling	To understand the need of modelling at different levels of abstraction for CAD	Lecture, Tutorial	EC4143.1	Class test MTE-1

12-13	**Simulation:** Simulation, Gate-level modelling, and simulation, Switch level modelling and simulation	To model the system at gate and switch level	Lecture	EC4143.3	Class test MTE-1
14-17	**Basic concepts of high-level synthesis:** partitioning, scheduling	Apply algorithms for partitioning and scheduling	Lecture	EC4143.3	Class test MTE-1
18-22	**Basic concepts of high-level synthesis:** allocation and binding	Apply concepts of resource allocation and binding	Lecture	EC4143.4	Class test MTE-1
23-30	**Combinational Logic Synthesis, Logic synthesis:** two-level and multilevel Combinational Logic and sequential logic optimization	Perform optimization of combinational and sequential logic	Tutorial	EC4143.4	Class test MTE-1
31-35	Logic Optimization, Optimizing logic using resource sharing	Perform optimization using resource sharing	Lecture	EC4143.5	Class test MTE-1
36-39	**Estimating delays in a circuit:** issues in Dynamic and Static Timing Analysis.	Estimate delays in circuits	Lecture	EC4143.6	Class test MTE-1
40-42	**Introduction to Logical Effort:** Multistage Logic Networks, Logical Effort and Gain Based Synthesis, Logical Effort Optimizing performance.	Calculate logical efforts for VLSI circuits	Lecture	EC4143.6	Class test MTE-1
43	Memory modeling Synthesizable and non-synthesizable constructs	To model memories for CAD	Lecture	EC4143.6	Class test MTE-1

A. Course Articulation Matrix: (Mapping of COs with POs)

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

CO	STATEMENT	CORRELATION WITH PROGRAM OUTCOMES												CORRELATION WITH PROGRAM SPECIFIC OUTCOMES		
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
1	Understand the requirements from a High-level Hardware Description Language (HDL) and CAD Tools to be able to achieve the best designs with the CAD tools					1							2		1	
2	Apply graph algorithms and Boolean algebra for VLSI Design Automation	2												1	1	
3	Apply scheduling algorithms which underpin architectural level synthesis			1											1	
4	Apply resource sharing and binding algorithms which underpin architectural level synthesis			1											1	
5	Apply logic optimization for two-level and multiple level combinational and sequential circuits for user-defined constraints			1											1	
6	Understand Timing Analysis and logical effort for MOS circuits		2	1											1	

MANIPAL UNIVERSITY JAIPUR

School of Electrical, Electronics & Communication Engineering (SEEC)

Department of Electronics & Communication Engineering
Course Hand-out

Information Theory and Coding| EC 4146 | 3 Credits | 3 0 0 3

Session: Aug – Dec. 22 | Faculty: Dr. C.P Gupta | Class: Program Elective

A. Introduction: This course is offered by Dept. of Electronics & Communication Engineering as a Program Elective course, targeting students who wish to pursue research & development in industries or higher studies in field of Information Theory and Coding. This course introduces how various coding takes place in communication and what type of different codes are used in communication system. It also introduces different entropies, channel capacity and purpose of encoding. Students are expected to have background knowledge on Analog and Digital Communication for a better learning.

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

[EC4146.1] Apply the principles of random signal theory to quantify the information and analyze communication system.

[EC4146.2] To study fundamentals of probability, random variable and various statistical analysis Methods.

[EC4146.3] Develop various channel models and apply the skills to analyse different channel for capacity.

[EC4146.4] Apply the Information theory in data compression, transmission and channel encoding, storage and processing, which is also useful in employability.

[EC4146.5] To study & apply various error detection and correction codes.

[EC4146.6] Discuss different codes and their performances use in error control applications.

C. PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

[PO.1]. **Engineering knowledge**: Demonstrate and apply knowledge of Mathematics, Science, and Engineering to classical and recent problems of electronic design & communication system.

[PO.2]. **Problem analysis**: Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

[PO.3]. **Design/development of solutions**: Design a component, system, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability.

[PO.4]. **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions

[PO.5]. **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations

[PO.6]. **The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice

[PO.7]. **Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development

[PO.8]. **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practices

[PO.9]. **Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings

[PO.10]. **Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions

[PO.11]. **Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments

[PO.12]. **Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

PROGRAM SPECIFIC OUTCOMES

[PSO.1]. An ability to understand the concepts of basic Electronics & Communication Engineering and to apply them to various areas like Signal processing, VLSI, Embedded systems, Communication Systems, Digital & Analog Devices, etc.

[PSO.2]. An ability to solve complex Electronics and Communication Engineering problems, using latest hardware and software tools, along with analytical skills to arrive cost effective and appropriate solutions.

[PSO.3]. Wisdom of social and environmental awareness along with ethical responsibility to have a successful career and to sustain passion and zeal for real-world applications using optimal resources as an Entrepreneur.

D. Assessment Plan:

Criteria	Description	Maximum Marks
Internal Assessment (Summative)	Sessional Exam I (Close Book)	15
	Sessional Exam II (Close Book)	15
	In class Quizzes and Assignments , (Accumulated and Averaged)	30
End Term Exam (Summative)	End Term Exam (Close Book)	40
	Total	100
Attendance (Formative)	A minimum of 75% Attendance is required to be maintained by a student to be qualified for taking up the End Semester examination. The allowance of 25% includes all types of leaves including medical leaves.	
Make up Assignments (Formative)	Students who misses a class will have to report to the teacher about the absence. A makeup assignment on the topic taught on the day of absence will be given which has to be submitted within a week from the date of absence. No extensions will be given on this. The attendance for that particular day of absence will be marked blank, so that the student is not accounted for absence. These assignments are limited to a maximum of 5 throughout the entire semester.	
Homework/ Home Assignment/ Activity Assignment (Formative)	There are situations where a student may have to work in home, especially before a flipped classroom. Although these works are not graded with marks. However, a student is expected to participate and perform these assignments with full zeal since the activity/ flipped classroom participation by a student will be assessed and marks will be awarded.	

E. SYLLABUS

Random Signal Theory: Introduction to random variables, discrete and continuous random variables, probability distribution, Cumulative Distribution Function, Joint Distribution, Independent random variable and conditional distribution, Characteristics of random variable: Mean variance and standard deviation, Binomial, Poisson and Normal distributions, Random Processes, Markov Processes. Information Theory: Introduction to information theory and probability, entropy, rate of information, Joint and conditional entropy, Mutual information: noise free channel, channel with independent input and output, Channel capacity: Binary symmetric channel, binary erasure channel, noise free channel, cascaded channels, and binary channel. Coding: Introduction, code efficiency, Shannon theorem, capacity of Gaussian channel, Bandwidth and S/N trade off, Shannon-Fano coding, Huffman coding, LZ coding, Error control coding, Automatic Repeat Request and Forward error correction codes, Block codes and parity check codes, Hamming Weight, Hamming Distance, Minimum distance decoding, Single Parity codes, Hamming Codes, Repetition Codes, Linear block codes, Cyclic code, Convolution code.

F. TEXT BOOKS

- M Kulkarni & K S Shivaprakasha, "Information Theory and Coding", Wiley India Pvt. Ltd, 1st ed.
- R D Singh and S D Sapre, "Communication Systems", 2nd ed., Tata Mcgraw Hill

G. REFERENCE BOOKS

- R. Bose, "Information Theory, Coding and Cryptography", Tata Mcgraw Hill, 2nd ed.
- P. Z. Peebles, Jr., "Probability, Random Variables and Random Signal Principles", McGraw-Hill, Inc., 2nd ed.
- F.M. Reza, "Information Theory", McGraw Hill

H. Lecture Plan:

Lec. No.	Topics	Session Outcome	Mode of Delivery	Corresponding CO	Mode of Assessing the Outcome
1,2,3	Introduction to random variables, discrete and continuous random variables	Students would get acquainted with basic understanding of the probability and random signal theory.	Lecture	EC4146.1 & EC4146.2	In Class Quiz Mid Term-01
4,5,6	Probability distribution, Cumulative Distribution Function, Joint Distribution	Knowledge of Probability distribution, Cumulative Distribution Function, Joint Distribution	Lecture	EC4146.1 & EC4146.2	In Class Quiz Mid Term-01 End Term
7,8,9	Characteristics of random variable: Mean variance and standard deviation	Students would be able to understand random variable and its characteristics.	Lecture	EC4146.1 & EC4146.2	In Class Quiz Mid Term-01 End Term
10,11,12	Binomial, Poisson and Normal distributions, Random Processes, Markov Processes	Understanding of different distributions and random processes	Lecture	EC4146.1 & EC4146.2	In Class Quiz MidTerm-01 End Term
13,14,15	Information Theory: Introduction to information theory and probability	Understating basics of Information theory	Lecture	EC4146.4	MidTerm-02 End Term
16,17,18	entropy, rate of information, Joint and conditional entropy,	Students would get acquainted with basics of entropy	Lecture	EC4146.3& EC4146.4	MidTerm-02 End Term
19.20,21	Mutual information: noise free channel, channel with independent input and output,	Understanding of Mutual information	Lecture	EC4146.3& EC4146.4	In Class Quiz Mid Term-02 End Term
22,23,24	Channel capacity: Binary symmetric channel, binary erasure channel, noise free channel, cascaded channels, and binary channel.	Knowledge of channel capacity	Lecture	EC4146.3& EC4146.4	In Class Quiz Mid Term-02 End Term
25,26,27	Shannon-Fano coding, Huffman coding	Knowledge of coding theorems and applications	Lecture	EC4146.5	In Class Quiz Mid Term-02 End Term
28,29,30	Code efficiency, Code redundancy, Information channels	Understating Code efficiency, Code redundancy, Information channels	Lecture	EC4146.5	End Term
30,31,31	Probability and Entropy relations in Information channels, Mutual information and properties;	Students will be able to apply probability and entropy in information channels.	Lecture	EC4146.5 & EC4146.6	End Term
32,33,34	Coding: Introduction, code efficiency, Shannon theorem, capacity of Gaussian channel, Bandwidth and S/N trade off	Students would get acquainted with error control codes	Lecture	EC4146.5 & EC4146.6	In Class Quiz End Term
35,36,37	Shannon-Fano coding, Huffman coding, LZ coding, Error control coding, Automatic Repeat Request and Forward error correction codes	Knowledge of various coding techniques and codes	Lecture	EC4146.5 & EC4146.6	In Class Quiz End Term
38,39,40	Hamming Weight, Hamming Distance, Minimum distance decoding, Single Parity codes, Hamming Codes, Repetition Codes, Linear block codes, Cyclic code, Convolution code.	Understanding various error detection and error correction codes	Lecture	EC4146.5 & EC4146.6	In Class Quiz End Term
41	Conclusion and Course Summarization	NA	NA	NA	NA

I. Course Articulation Matrix: (Mapping of COs with POs)

CO	STATEMENT	CORRELATION WITH PROGRAM OUTCOMES												CORRELATION WITH PROGRAM SPECIFIC OUTCOMES		
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
EC 4146.1	Apply the principles of random signal theory to quantify the information and analyze communication system	3	2	1	2						1	1	1	3	1	1
EC 4146.2	To study fundamentals of probability, random variable and various statistical analysis Methods.	2	3	2	2			1	1		1		1	1	2	
EC 4146.3	Develop various channel models and apply the skills to analyse different channel for capacity	2	2	1	1		3	1			1	1	2	2	1	1
EC 4146.4	Apply the Information theory in data compression, transmission and channel encoding, storage and processing, which is also useful in employbility.															
EC 4146.5	To study & apply various error detection and correction codes															
EC 4146.6	Discuss different codes and their performances use in error control applications..	2	3	1	2						1	1	1	2	2	1

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

MANIPAL UNIVERSITY JAIPUR

School of Electrical, Electronics & Communication Engineering (SEEC)

Department of Electronics & Communication Engineering
Course Hand-out

Low Power VLSI Design| EC 4152 | 3 Credits | 3 0 0 3

Session: July 22 – Dec 22 | Faculty: Dr. Shilpi Birla| Class: Dep. Elective (VII Sem)

A. Introduction: This course is offered by Dept. of Electronics & Communication Engineering as an department elective, targeting students who wish to pursue research & development in industries or higher studies in field of Electronics Engineering especially VLSI & Low Power VLSI Design. This course will help the students to understand the concept of VLSI circuit of low power operation, to design various circuits for optimize power. The MOS VLSI Design is the pre-requisite for this course.

B. Course Objectives: At the end of the course, students will be able to

[4152.1] Understand the need of low power design & sources of power dissipation.
[4152.2] Understand the MOS devices and its parametric effects and various power dissipation.
[4152.3] Identify various low power circuit level reduction techniques.
[4152.4] Classify various logic level low power reduction techniques.
[4152.5] Analyse the power & performance management of systems.
[4152.6] Implement the knowledge of low power techniques in designing systems.

C. Program Outcomes and Program Specific Outcomes

[PO.1]. Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems

[PO.2]. Problem analysis: Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences

[PO.3]. Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations

[PO.4]. Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions

[PO.5]. Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations

[PO.6]. The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice

[PO.7]. Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development

[PO.8]. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practices

[PO.9]. Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings

[PO.10]. Communication: Communicate effectively on complex engineering activities with the engineering

community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions

[PO.11]. Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments

[PO.12]. Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

[PSO.1]. An ability to understand the concepts of basic Electronics & Communication Engineering and to apply them to various areas like Signal processing, VLSI, Embedded systems, Communication Systems, Digital & Analog Devices, etc.

[PSO.2]. An ability to solve complex Electronics and Communication Engineering problems, using latest hardware and software tools, along with analytical skills to arrive cost effective and appropriate solutions.

[PSO.3]. Wisdom of social and environmental awareness along with ethical responsibility to have a successful career and to sustain passion and zeal for real-world applications using optimal resources as an Entrepreneur.

Program Educational Objectives

- **PEO1**. Graduates will exhibit technical and managerial readiness for electronics, telecommunication and IT industries.
- **PEO2**. Graduates will take up higher studies in niche areas of electronics and communication domain for *the* next level of advancement.
- **PEO3**. Graduates will exhibit productive teamwork in multi-cultural environment.

D. Assessment Plan:

Criteria	Description	Maximum Marks
Internal Assessment (Summative)	Sessional Exam	30
	In class Quizzes and Assignments, Activity feedbacks (Accumulated and Averaged)	30
	Laboratory Sessions	
End Term Exam (Summative)	End Term Exam	40
	Total	100
Attendance (Formative)	A minimum of 75% Attendance is required to be maintained by a student to be qualified for taking up the End Semester examination. The allowance of 25% includes all types of leaves including medical leaves.	
Homework/ Home Assignment/ Activity Assignment (Formative)	There are situations where a student may have to work in home. Although these works are not graded with marks. However, a student is expected to participate and perform these assignments with full zeal since the activity/ flipped classroom participation by a student will be assessed and marks will be awarded.	

E. Syllabus

Introduction: Need for Low Power design, Sources of power dissipation in Digital Integrated circuits. Emerging low power approaches, Hierarchical Low Power Design Methodologies; Device & technology impact on low power: Physics of power dissipation in CMOS devices, Dynamic and static power dissipation, Transistor sizing & gate oxide thickness. Impact of technology Scaling and Device innovation; Probabilistic power analysis: Random logic signals, probability and frequency, probabilistic power analysis techniques, signal entropy; Circuit level power reduction techniques: Power consumption in circuits. Design of Flip Flops and Latches. Low power digital cell library, Low Power Dynamic logic families and Adiabatic Logic Families. Logic level power reduction techniques: Gate reorganization, pre-computation logic, signal gating, logic encoding, state machine encoding, reduction of power in address and data buses; Low power clock distribution: Power dissipation in clock distribution, Single driver versus Distributed buffers, Zero skew versus Tolerable skew; Low power architecture and systems: Power and performance management, switching activity reduction, parallel architecture with voltage reduction, flow graph transformation, low power arithmetic components, low power memory design.

F. Reference Books

R1: G. K. Yeap, "*Practical Low Power Digital VLSI Design*", KAP, 2002.
R2: Rabaey, Pedram, "*Low power design methodologies*" Kluwer Academic, 1997.
R3:K. Roy, Sharat Prasad, "*Low Power CMOS VLSI Circuit Design*" Wiley, 2000.
R4: Kiat, S. Yeo, W. L. Goh, "*CMOS/BiCMOS ULSI Low Voltage Low Power*", Pearson, 2002.

G. Lecture Plan:

Lecture No	**Topics**	**Session Outcome**	**Mode of Delivery**	**Corresponding CO**	**Mode of Assessing the Outcome**
1	Introduction & Overview of the course	Need of the course	Lecture & PPT	NA	NA
2	Need for Low Power design,	Identify the needs of low power circuits in this Electronics world.	Lecture & PPT	4152.1	In Class Quiz Mid Term End Term
3,4,5	Sources of power dissipation in Digital Integrated Circuits-I	Identify different sources of power dissipation in circuits.	Lecture & PPT	4152.1	In Class Quiz Mid Term End Term
6,7	Physics of power dissipation in CMOS devices	Explain the MOS structure and its physics.	Lecture & PPT	4152.1	Home Assignment Mid Term End Term
8,9	Emerging Low Power approaches	Identify new low power approaches.	Lecture & PPT	4152.1	In Class Quiz Mid Term End Term
10	Dynamic Power dissipation	Describe the types of power dissipation in circuits.	Lecture & PPT	4152.2	Class Quiz Mid Term End Term
11	Static Power Dissipation	Explain the static power dissipation.	Lecture & PPT	4152.2	Home Assignment Class Quiz Mid Term End term
12	Transistor sizing & gate oxide thickness.	Recall the sizing effect and thickness effect.	Lecture & PPT	4152.2	Class Quiz Mid Term End Term
13	Impact of technology Scaling and Device innovation	Identify the scaling techniques and it's impact	Lecture & PPT	4152.2	Class Quiz Mid Term End Term
14,15	Power consumption in circuits.	Identify the power consumption in circuits.	Lecture & PPT	4152.2 4152.3	Class Quiz Mid Term End Term
16,17	Circuit level power reduction techniques	Analyse circuit level power reduction techniques.	Lecture & PPT	4152.3	Class Quiz Mid Term End Term
18	Design of Flip Flops and Latches	Describe working of flip flop & latches using low power topologies	Lecture & PPT	4152.3	Class Quiz Mid Term End Term
19,20	Dynamic Logic Families	Analyse the dynamic logic families wrt to Power	Lecture & PPT	4152.3	Class Quiz End Term

21	Gate reorganization structure	Describe the effect of gate reorganization structure	Lecture & PPT	4152.4	Class Quiz End Term
22	Logic Encoding	Illustrate the effect of logic encoding in circuits	Lecture & PPT	4152.4	Class Quiz End Term
23	Encoding Techniques	Explain various coding techniques for low power applications	Lecture & PPT	4152.4	Class Quiz End Term
23	FSM coding	Describe FSM coding which reduces power	Lecture & PPT	4152.4	Class Quiz End Term
24	Numerical Problems	Discussion and analysis of the topics discussed	Lecture & PPT	4152.4	Class Quiz Mid Term II End Term
25	Reduction of power in address and data bus	Describe power reduction in data bus	Lecture & PPT	4152.4	Class Quiz Mid Term II End term
26,27	Switching activity reduction-	Describe how switching activity reduces power	Lecture & PPT	4152.3 4152.5	Class Quiz Mid Term II End Term
28	Power dissipation in clock distribution	Describe clock distribution scheme to reduce power	Lecture & PPT	4152.4	Class Quiz End Term
29	Zero skew versus Tolerable skew	Identify zero skew and tolerable skew	Lecture & PPT	4152.5	Class Quiz End Term
30	Power and performance management	Discuss the power management system and its performance	Lecture & PPT	4152.5	Class Quiz End Term
31	Adiabatic Logic Families	Discuss about Adiabatic logic family	Lecture & PPT	4152.6	Class Quiz End Term
32,33	Design Problems on Adiabatic Logic Families	Discussion and analysis of the topics discussed	Lecture & PPT	4152.6	Class Quiz End Term
34	Parallel architecture with voltage reduction	Discuss how Parallel architecture reduces power.	Lecture & PPT	4152.5	Class Quiz End Term
35	Low power memory design	Discuss low power memory design	Lecture & PPT	4152.6	Class Quiz End Term
36	Design of Low Power systems	Arithmetic systems	Lecture & PPT	4152.6	Class Quiz End Term

H. Course Articulation Matrix: (Mapping of COs with POs)

CO	STATEMENT	CORRELATION WITH PROGRAM OUTCOMES												CORRELATION WITH PROGRAM SPECIFIC OUTCOMES		
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
EC 4152.1	Understand the need of low power design & sources of power dissipation	2												2		
EC 4152.2	Understand the MOS devices and its parametric effects and various power dissipation	2	2											2		
EC 4152.3	Identify various low power circuit level reduction techniques	1	1	2										2	2	
EC 4152.4	Classify various logic level low power reduction techniques.	1	1	2										2	2	
EC 4152.5	Analyse the power & performance management of systems	1	2											2	2	
EC 4152.6	Implement the knowledge of low power techniques in designing systems.	2	2	2	1									2	2	2

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

MANIPAL UNIVERSITY JAIPUR

School of Electrical, Electronics & Communication Engineering Department of Electronics & Communication Engineering

Course Hand-out

Fundamental of Robotics system | EC 4155 | 3 Credits | 3 0 0 3

Session: Jul 22 – Dec 22| Faculty: Dr. Himanshu Chaudhary| Class: Program Elective

A. Introduction: This is an introductory course in robotics, which comes in the class of program electives for the undergraduates who have had little to no other introductory courses on the topic. The course focuses on topics in robotics that relate to modeling, dynamics, and control of robotic manipulators. Mathematical preliminaries include matrix and vector analysis, basic kinematics and kinetics, and classical (frequency-based) control theory. Some background on more advanced topics such as Lagrangian dynamics, and modern linear and non-linear dynamical system analysis definitely help. The contents of the course are thoughtfully designed, so that students would able to incorporate these concepts into their other courses, where control can be achieved via soft computing implementation in robotics. Students will design and work on robotic systems in a group-based term project.

Most, if not all, course-related communication and material sharing, including class note handouts and occasional videos, will be done through Microsoft Team environment.

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

[4155.1]. Understand and employ various factors of the Mathematical Representation of Robots with their programming examples.

[4155.2]. Analyse and evaluate kinematics of serial and parallel robot manipulator models with their programming examples.

[4155.3]. Learn and implement the velocity analysis and statics of robot manipulators with their programming examples.

[4155.4]. Elaborate and implement the dynamics of robot manipulators with their programming examples.

[4155.5]. Demonstrate the ability to develop robotics-based applications in programming environment for encouraging employability skills.

C. PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

[PO.1]. **Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

[PO.2]. **Problem analysis**: Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

[PO.3]. **Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

[PO.4]. **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

[PO.5]. **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

[PO.6]. **The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

[PO.7]. **Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, demonstrate the knowledge of, and need for sustainable development.

[PO.8]. **Ethics**: Apply ethical principles and commit to professional ethics, responsibilities, and norms of the engineering practices.

[PO.9]. **Individual and teamwork:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

[PO.10]. **Communication**: Communicate effectively on complex engineering activities with the engineering community and with society, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

[PO.11]. **Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

[PO.12]. **Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

[PSO.1]. To foster the need of understanding the concepts of mathematics, physics and electronics and communication engineering for better realization of existing and upcoming technology.

[PSO.2]. To promote brainstorming through different learning techniques to prepare students for future endeavours.

[PSO.3]. To cultivate the practice of team-work for building interest towards professional and societal connect.

D. Assessment Plan:

Criteria	Description	Maximum Marks
Internal Assessment (Summative)	Sessional Exam I (Close Book)	15
	Sessional Exam II (Close Book)	15
	In class Quizzes and Activity feedbacks plus case-based projects (Accumulated and Averaged)	30
End Term Exam (Summative)	End Term Exam (Open Book)	40
	Total	100
Attendance (Formative)	A minimum of 75% Attendance is required to be maintained by a student to be qualified for taking up the End Semester examination. The allowance of 25% includes all types of leaves including medical leaves.	
Make up Assignments (Formative)	Students who misses a class will have to report to the teacher about the absence. A makeup assignment on the topic taught on the day of absence will be given which has to be submitted within a week from the date of absence. No extensions will be given on this. The attendance for that particular day of absence will be marked blank, so that the student is not accounted for absence. These assignments are limited to a maximum of 5 throughout the entire semester.	
Homework/ Home Assignment/ Activity Assignment (Formative)	There are situations where a student may have to work in home, especially before a flipped classroom. Although these works are not graded with marks. However, a student is expected to participate and perform these assignments with full zeal since the activity/ flipped classroom participation by a student will be assessed and marks will be awarded.	

E. SYLLABUS

Introduction: Brief History of Robotics, Types of Robots, Technology of Robots, Basic Principles in Robotics. **Mathematical Representation of Robots:** Position and Orientation of a Rigid Body, Transformation Between Coordinate Systems, Representation of Joints, Representation of Links Using Denavit–Hartenberg Parameters, Link Transformation Matrices, examples. **Kinematics of Serial Manipulators:** Degrees of Freedom of a Manipulator, Direct Kinematics of Serial Manipulators, Inverse Kinematics of Serial Manipulators, Manipulator with Non-intersecting Wrist, Inverse Kinematics of a General 6R Robot, Inverse Kinematics for Manipulators With $n < 6$, Inverse Kinematics of Redundant Manipulators, Solution Methods for Non-linear Equations, Examples**. Kinematics of Parallel Manipulators:** Degrees of Freedom, Loop-closure Constraint Equations, Direct Kinematics of Parallel Manipulators, Direct Kinematics of Stewart– Gough Platform, Mobility of Parallel Manipulators, Inverse Kinematics of Parallel Manipulators, Examples. **Velocity Analysis and Statics of Manipulators:** Linear and Angular Velocities of a Rigid Body, Linear and Angular Velocities of Links in Serial Manipulators, Serial Manipulator Jacobian, Parallel manipulator Jacobians, Singularities of Serial and Parallel Manipulators, Statics of Serial Manipulators, Statics of Parallel Manipulators, Singularity in Force Domain, Resolution of Redundancy at Velocity Level, Examples. **Dynamics of Manipulators:** Inertia of a Link, The Lagrangian Formulation, 2R manipulator, Dynamic Equations in Cartesian Space, Inverse Dynamics of Manipulators, Simulation of Equations of Motion, Recursive Formulations of

Dynamics of Manipulators, Newton–Euler Formulation for Inverse Dynamics, Algorithms for Forward Dynamics, Recursive Algorithms for Parallel Manipulators, Examples.

F. TEXT BOOKS

1) A. Ghosal, "Robotics Fundamental Concepts and Analysis", illustrated, OUP India, 2006.
2) R K Mittal, I. J. Nagrath, "Robotics and Control", Tata McGraw-Hill Education, 2003.
3) H. Asada, and J. J. Slotine, "Robot Analysis and Control", New York, NY: Wiley, 1986.

G. REFERENCE BOOKS

1) K Sun Fu, Gonzalez, "Robotics- Control, Sensing, Vision, and Intelligence", McGraw-Hill, 2nd edition, 2010.
2) M. Spong, M. Vidyasagar, S. Hutchinson, "Robot Modeling and Control", Wiley & Sons, 2005.
3) J. J. Craig, "Introduction to Robotics: Mechanics and Control", Addison-Wesley Publishing Company, third Edition, 2003.

H. Lecture Plan:

Lec. No.	Topics	Session Outcome	Mode of Delivery	Corresponding CO	Mode of Assessing the Outcome
1-2	**Introduction:** Brief History of Robotics, Types of Robots, Technology of Robots, Basic Principles in Robotics.	Understand and employ various factors of the Mathematical representation of Robots with their programming examples.	Lecture Microsoft Team followed by activity	4155.1	NA
2-3	**Mathematical Representation of Robots:** Position and Orientation of a Rigid Body, Transformation Between Coordinate Systems, Representation of Joints, Representation of Links Using Denavit–Hartenberg Parameters, Link Transformation Matrices, examples.	Understand and employ various factors of the Mathematical representation of Robots with their programming examples.	Lecture Microsoft Team followed by activity	4155.1	In Class Quiz Mid Term-01 End Term
4-6	**Kinematics of Serial Manipulators:** Degrees of Freedom of a Manipulator, Direct Kinematics of Serial Manipulators, Inverse Kinematics of Serial Manipulators, Manipulator with Non-intersecting Wrist, Inverse Kinematics of a General 6R Robot, Inverse Kinematics for Manipulators With n < 6, Inverse Kinematics of Redundant Manipulators, Solution Methods for Non-linear Equations, Examples.	• Understand and employ various factors of the Mathematical representation of Robots with their programming examples. • Analyse and evaluate kinematics of serial and parallel robot manipulator models with their programming examples.	Lecture Microsoft Team followed by activity	4155.1, 4155.2	In Home Assignment Mid Term-01 End Term Class Project
7-12	**Kinematics of Parallel Manipulators:** Degrees of Freedom, Loop-closure Constraint Equations, Direct Kinematics of Parallel Manipulators, Direct Kinematics of Stewart– Gough Platform, Mobility of Parallel Manipulators, Inverse Kinematics of Parallel Manipulators, Examples.	• Understand and employ various factors of the Mathematical representation of Robots with their programming examples. • Analyse and evaluate kinematics of serial and parallel robot manipulator models with their programming examples.	Lecture Microsoft Team followed by activity	4155.1, 4155.2	In Class Quiz MidTerm-01 End Term Class Project
13-22	**Velocity Analysis and Statics of Manipulators:** Linear and Angular Velocities of a Rigid Body, Linear and Angular Velocities of Links in Serial Manipulators, Serial Manipulator Jacobian, Parallel manipulator Jacobians, Singularities of Serial and Parallel Manipulators, Statics of Serial Manipulators, Statics of Parallel Manipulators, Singularity in Force Domain, Resolution of Redundancy at Velocity Level, Examples.	• Understand and employ various factors of the Mathematical representation of Robots with their programming examples. • Analyse and evaluate kinematics of serial and parallel robot manipulator models with their programming examples. • Learn and implement the velocity analysis and statics of robot manipulators with their programming examples.	Lecture Microsoft Team followed by activity	4155.1, 4155.2, 4155.3	MidTerm-02 End Term Class Project

23-30	**Dynamics of Manipulators:** Inertia of a Link, The Lagrangian Formulation, 2R manipulator, Dynamic Equations in Cartesian Space, Inverse Dynamics of Manipulators, Simulation of Equations of Motion, Recursive Formulations of Dynamics of Manipulators, Newton–Euler Formulation for Inverse Dynamics, Algorithms for Forward Dynamics, Recursive Algorithms for Parallel Manipulators, Examples.	• Understand and employ various factors of the Mathematical representation of Robots with their programming examples. • Analyse and evaluate kinematics of serial and parallel robot manipulator models with their programming examples. • Learn and implement the velocity analysis and statics of robot manipulators with their programming examples. • Elaborate and implement the dynamics of robot manipulators with their programming examples.	Lecture Microsoft Team followed by activity	4155.1, 4155.2, 4155.3, 4155.4	MidTerm-02 End Term Class Project

31-42	Develop robotics-based applications in programming environment.	• Understand and employ various factors of the Mathematical representation of Robots with their programming examples. • Analyse and evaluate kinematics of serial and parallel robot manipulator models with their programming examples. • Learn and implement the velocity analysis and statics of robot manipulators with their programming examples. • Elaborate and implement the dynamics of robot manipulators with their programming examples. • Learn and access trajectory planning and generation of robot manipulator with examples. • Demonstrate the ability to develop robotics-based applications in programming environment for encouraging employability skills.	Lecture Microsoft Team followed by activity	4155.1-4155.6	Class Project

MANIPAL UNIVERSITY JAIPUR

School of Electrical, Electronics & Communication Engineering

Department of Electronics & Communication Engineering
Course Hand-out

Neural Network and Deep Learning | EC 4157 | 3 Credits | 3 0 0 3

Session: Jul 22 – Dec 22 | Faculty: Dr. Himanshu Chaudhary| Class: Program Elective

A. Introduction: This course comes in the class of program electives for the undergraduates. This course will cover fundamental concepts used in soft computing related to the neural networks and deep learning. The contents of the course are thoughtfully designed, so that students would able to incorporate these concepts into implementing the deep learning. The concepts of Artificial Neural Networks (ANNs) will be covered first, followed by convolution neural network (CNN) and deep learning. It offers in-depth knowledge of Deep Learning, convolution neural network, RNN, GAN, and popular deep learning architectures. Applications of CNN techniques to solve a number of real-life problems will be covered to have hands on practices. In summary, this course will provide exposure to theory as well as practical systems and software used in neural networks and deep learning.

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

EC[4157.1]. Compare and employ various factors of the brain and neuron function with mathematical methods.

EC[4157.2]. Compare, analyse and evaluate various neural network models and their training methods with examples.

EC[4157.3]. Develop artificial neural networks-based applications in MATLAB for encouraging employability skills.

EC[4157.4]. Apply and analyse the popular convolution neural networks (CNN) architectures.

EC[4157.5]. Interpret the concepts of RNN, GAN, Auto encoders.

EC[4157.6]. Experiment and evaluate with applications of deep learning based on neural networks with examples for encouraging development skills and entrepreneurship.

C. PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

[PO.1]. **Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

[PO.2]. **Problem analysis**: Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

[PO.3]. **Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

[PO.4]. **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

[PO.5]. **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

[PO.6]. **The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

[PO.7]. **Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, demonstrate the knowledge of, and need for sustainable development.

[PO.8]. **Ethics**: Apply ethical principles and commit to professional ethics, responsibilities, and norms of the engineering practices.

[PO.9]. **Individual and teamwork:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

[PO.10]. **Communication**: Communicate effectively on complex engineering activities with the engineering community and with society, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

[PO.11]. **Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

[PO.12]. **Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

[PSO.1]. To foster the need of understanding the concepts of mathematics, physics and electronics and communication engineering for better realization of existing and upcoming technology.

[PSO.2]. To promote brainstorming through different learning techniques to prepare students for future endeavours.

[PSO.3]. To cultivate the practice of team-work for building interest towards professional and societal connect.

D. Assessment Plan:

Criteria	Description	Maximum Marks
Internal Assessment (Summative)	Sessional Exam I (Close Book)	20
	Sessional Exam II (Close Book)	20
	In class Quizzes/Assignments/MOOC/ Case based projects (Accumulated and Averaged)	20
End Term Exam (Summative)	End Term Exam	40
	Total	100
Attendance (Formative)	A minimum of 75% Attendance is required to be maintained by a student to be qualified for taking up the End Semester examination. The allowance of 25% includes all types of leaves including medical leaves.	
Make up Assignments (Formative)	Students who misses a class will have to report to the teacher about the absence. A makeup assignment on the topic taught on the day of absence will be given which has to be submitted within a week from the date of absence. No extensions will be given on this. The attendance for that particular day of absence will be marked blank, so that the student is not accounted for absence. These assignments are limited to a maximum of 5 throughout the entire semester.	
Homework/ Home Assignment/ Activity Assignment (Formative)	There are situations where a student may have to work in home, especially before a flipped classroom. Although these works are not graded with marks. However, a student is expected to participate and perform these assignments with full zeal since the activity/ flipped classroom participation by a student will be assessed and marks will be awarded.	

E. SYLLABUS

Neural Network: Introduction: history, structure and function of single neuron, neural net architectures, neural learning, use of neural networks, supervised learning networks, Associative memory networks, unsupervised learning networks, Special networks like Simulated Annealing Network, Cascade Correlation network, and Optical neural network. Applications of Neural Network.

Deep Learning: Deep Feed Forward network, regularizations, training deep models, dropouts, Convolutional Neural Network, Recurrent Neural Network, Deep Belief Network. Probabilistic Neural Network: Hopfield Net,

Boltzman machine, RBMs, Sigmoid net, Autoencoders. Deep Learning research: Object recognition, sparse coding, computer vision, natural language processing. Deep Learning Tools: Caffe, Theano, Torch, Matlab.

F. TEXT BOOKS

1) S.N. Deepa, S.N. Sivanandam, "Principles of Soft Computing", Wiley; second edition 2011.
2) S. Jain, "Modelling and Simulation using MATLAB – Simulink", Wiley, 2015.
3) S. Roy, U. Chakraborty, "Soft Computing: Neuro-Fuzzy and Genetic Algorithms", Pearson; first edition, 2013.
4) L. Deng & D. Yu, Deep Learning: Methods and Applications, (1e), Now Publishers, 2014.
5) Goodfellow, Y. Bengio, A. Courville, Deep Learning, (1e), MIT Press, 2016.
6) M. Nielsen, Neural Networks and Deep Learning, (1e), Determination Press, 2015.

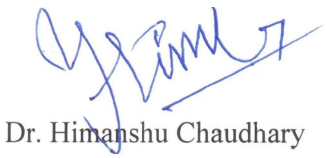
G. REFERENCE BOOKS

1) S. Rajasekaran, G. A. Vijayalakshmi Pai, "Neural Networks, Fuzzy Logic, and Genetic Algorithms: Synthesis and Applications", PHI, 2013.
2) Satish Kumar, "Neural Networks: A Classroom Approach (1e)", Tata McGraw-Hill Education, 2009.
3) Phil Kim, "MATLAB Deep Learning: With Machine Learning, Neural Networks and Artificial Intelligence", Apress, 2017.
4) Taweh Beysolow II, "Introduction to Deep Learning Using R", Apress, 2017.
5) Charu C. Aggarwal, "Neural Networks and Deep Learning", Springer Nature, 2018.

H. Lecture Plan:

Lect. No.	Topics	Session Outcome	Mode of Delivery	Corresponding CO	Mode of Assessing the Outcome
1	Neural Networks, Application scope of Neural Networks, Fuzzy Logic, Hybrid Systems, Soft Computing.	Distinguish various factors of the brain and neuron function with mathematical methods.	Lecture through PPT/ Board followed by activity	4157.1	Board Presentation
2-3	**Introduction** to Artificial Neural Networks, Fundamental Concepts: ANN (Artificial Neural Network), BNN (Biological Neural Network), Symmetry and comparison between ANN and BNN, Basics of ANN: Connection, Learning and Activation Function, Important terminologies of ANN: Weights, Bias, Threshold, Learning Rate, Momentum Factor, Vigilance Parameter.	• Distinguish various factors of the brain and neuron function with mathematical methods. • Compare, analyse and evaluate various neural network models and their training methods with examples. • Develop artificial neural networks-based applications in MATLAB.	Lecture through PPT/ Board followed by activity	4157.1, 4157.2, 4157.3	In Class Quiz Mid Term-01 End Term
4-6	**Fundamental Models of ANN**: McCulloch-Pitts Neuron Model: Architecture and Working, Hebb Net: Architecture, Algorithm, Linear Separability. Examples.	• Compare, analyse and evaluate various neural network models and their training methods with examples. • Develop artificial neural networks-based applications in MATLAB.	Lecture through PPT/ Board followed by activity	4157.2, 4157.3	In Home Assignment Mid Term-01 End Term Class Project

7-12	**Supervised Learning Networks:** Single layer and Multi-Layer Perceptron Networks, Single layer and Multi-Layer Adaptive Linear Neuron, Back-Propagation Network, Examples.	• Compare, analyse and evaluate various neural network models and their training methods with examples. • Develop artificial neural networks-based applications in MATLAB.	Lecture through PPT/ Board followed by activity	4157.2, 4157.3	In Class Quiz MidTerm-01 End Term Class Project
13-22	**Unsupervised Learning:** Fix Weight Competitive Nets: Max Net, Mexican Hat Net, Hamming Net, Kohonen Self Organising Feature Maps, Learning Vector Quantization, Counter Propagation Net, Adaptive Resonant Theory Net1 and 2, Examples.	• Compare, analyse and evaluate various neural network models and their training methods with examples. • Develop artificial neural networks-based applications in MATLAB.	Lecture through PPT/ Board followed by activity	4157.2, 4157.3	MidTerm-02 End Term Class Project
23-30	**Associative Memory Networks:** Auto associative Memory Net, Heteroassociative Memory Net, Bidirectional Associative Memory Net, Hopfield Net: Discrete, Continuous Type, Iterative Auto associative Memory Net. Examples.	• Compare, analyse and evaluate various neural network models and their training methods with examples. • Develop artificial neural networks-based applications in MATLAB.	Lecture through PPT/ Board followed by activity	4157.2, 4157.3	MidTerm-02 End Term Class Project
31-36	**Convolutional Neural Networks**		Lecture through PPT/ Board followed by activity	4157.4	End Term, Class Project
37-43	**Recurrent Neural Network**		Lecture through PPT/ Board followed by activity	4157.3,4157.4,4157.5, 4157.6	In Class Quiz Mid Term-02 End Term Class Project
	Deep learning applications to computer vision and natural language processing(NLP)				



Dr. Himanshu Chaudhary

MANIPAL UNIVERSITY JAIPUR

School of Electrical, Electronics & Communication Engineering (SEEC)

Department of Electronics & Communication Engineering
Course Hand-out

Digital Image Processing| EC 4160 | 3 Credits | 3 0 0 3

Session: Aug 2022 – Nov 2022 | Faculty: Dr Neha Singh, Dr Suddhendu DasMahapatra| Class: Program Elective

A. **Introduction:** This course is offered by Dept. of Electronics & Communication Engineering as Program Elective, targeting students who wish to pursue research& development in industries or higher studies in field of Digital Image Processing and computer vision. The course aims to help the student to learn and understand the fundamentals of digital image processing, various image Transforms, Image Enhancement Techniques, Image restoration Techniques and methods, image compression and Segmentation used in digital image processing.

B. **Course Outcomes:** At the end of the course, students will be able to

[EC4160.1]. Correlate image perception, acquisition and analysis to develop projects and hence develop employability skills **(analysis)**

[EC4160.2]. Execute digital image manipulation and mathematical operations **(Application)**

[EC4160.3]. Validate Image enhancement and restoration techniques for processing **(evaluation)**

[EC4160.4]. Recognize the steps (segmentation and morphological techniques) for image processing for lifelong learning and encouraging entrepreneurship **(Application)**

[EC4160.5]. Evaluate use of image processing filters **(evaluation)**

[EC4160.6] Apply techniques for compression and decompression on digital images for different application requirements **(Application)**

C. PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

PROGRAM OUTCOMES

[PO.1]. **Engineering knowledge**: Demonstrate and apply knowledge of Mathematics, Science, and Engineering to classical and recent problems of electronic design & communication system.

[PO.2]. **Problem analysis**: Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

[PO.3]. **Design/development of solutions**: Design a component, system, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability.

[PO.4]. **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions

[PO.5]. **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations

[PO.6]. **The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice

[PO.7]. **Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development

[PO.8]. **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practices

[PO.9]. **Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings

[PO.10]. **Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions

[PO.11]. **Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments

[PO.12]. **Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

PROGRAM SPECIFIC OUTCOMES

[PSO.1]. An ability to understand the concepts of basic Electronics & Communication Engineering and to apply them to various areas like Signal processing, VLSI, Embedded systems, Communication Systems, Digital & Analog Devices, etc.

[PSO.2]. An ability to solve complex Electronics and Communication Engineering problems, using latest hardware and software tools, along with analytical skills to arrive cost effective and appropriate solutions.

[PSO.3]. Wisdom of social and environmental awareness along with ethical responsibility to have a successful career and to sustain passion and zeal for real-world applications using optimal resources as an Entrepreneur.

PROGRAM EDUCATIONAL OBJECTIVES (PEOS)

PEO1. Graduates will exhibit technical and managerial readiness for electronics, telecommunication, and IT industries

PEO2. Graduates will take up higher studies in niche areas of electronics and communication domain for *the* next level of advancement

PEO3. Graduates will exhibit productive teamwork in multi-cultural environment

D. Assessment Plan:

Criteria	Description	Maximum Marks
Internal Assessment (Summative)	Sessional Exam I	15
	Sessional Exam II	15
	In class Quizzes	30 (Quiz)
End Term Exam (Summative)	End Term Exam	40
	Total	100
Attendance (Formative)	A minimum of 75% Attendance is required to be maintained by a student to be qualified for taking up the End Semester examination. The allowance of 25% includes all types of leaves including medical leaves.	
Project and Quiz (Summative)	There are situations where a student may have to work at home, especially for coding/programming assignments. Some programming assignments on MATLAB will be given to work with the studied techniques. These assignments, in the form of a project will be marked for internal assessment.	

	The hands-on practice will help students to understand the techniques better and provide them base to write functions for different image processing applications. There will be at least 3 quizzes in the semester to form internal (20) marks. The project will carry 10 marks.

E. SYLLABUS

Basics of image processing: Fundamentals of digital image processing, image perception, Image sensing and acquisition, sampling and Quantization, image representation, basic relationship between pixels; **Image enhancement and restoration:** Basic grey level transformation, Histogram equalization, Image subtraction, Spatial smoothing and sharpening filters, Laplacian filters, Frequency domain smoothing and sharpening filters, Homomorphic filtering; **Image restoration**; **Image transforms:** Fourier transform, Fast Fourier Transform, Short Time Fourier Transform, Cosine Transform , discrete wavelet transform; **Image Compression Algorithms and standards:** Lossless and lossy compression: Variable length coding, LZW coding, Bit plane coding, predictive coding, DPCM, Transform coding, Wavelet coding, Basics of Image compression standards- JPEG, JPEG2000; **Morphological processing and segmentation:** Preliminaries, erosion, dilation, Hit-And-Miss transformation, Basic Morphological Algorithms; Detection of discontinuities, Edge linking and boundary detection, Thresholding, Region based segmentation; **Color image processing:** Color Fundamentals, Color Models, Pseudo color Image Processing, processing basics of full color image processing; **Applications:** Character recognition, Biomedical Image processing, Watermarking, multi-resolution analysis.

F. TEXT BOOKS

1. R. C. Gonzalez, R. E. Woods, "*Digital Image Processing"* 2nd Edition - *Pearson Education 2003*.
2. S. Sridhar, Digital Image Processing. Oxford University Press, 2011

G. REFERENCE BOOKS

1. W. K. Pratt, "*Digital Image Processing"* John Willey (2001)
2. M. Sonka, V. Hlavac, R. Boyle, B. colic "*Image Processing Analysis and Machine Vision"* –, Thompson Learniy (1999).
3. A.K. Jain, "*Fundamentals of Digital Image Processing"* PHI, New Delhi (1995).

H. Lecture Plan:

Lecture No.	*Topics to be Covered.*	**Session Outcome**	**Mode of Delivery**	**Corresponding CO**	**Mode of Assessing the Outcome**
1.	Overview of the Course	To acquaint and clear teacher's expectations and understand student expectations	Lecture & PPT	EC4160.1	NA
2	Digital Image fundamentals, Image sensing and Image perception, Image acquisition System	Interpret need of digital images and image processing operations	Lecture & PPT	EC4160.1, EC4160.2	Class Quiz Mid-term-I
3, 4	Image Sampling and Quantization, zooming, shrinking & interpolation	To demonstrate basic processing done during image acquisition	Lecture & PPT	EC4160.1, EC4160.2	Class Quiz, Assignment, Mid-term-I
5	Basic relationships between pixels	To illustrate mathematical relationships between image pixels	Lecture & PPT	EC4160.1, EC4160.2	Class Quiz Mid-term-I, End term
6,7	Image arithmetic QUIZ#1	To perform arithmetic operations on images	Lecture & PPT	EC4160.2, EC4160.5	Class Quiz Mid-term-I, End term
8, 9	Geometric Transformation	To interpret effect of geometric transformations on images	Lecture & PPT	EC4160.1, EC4160.2, EC4160.5	Class Quiz Mid-term-II End-term
10, 11,12	Point Processing, Spatial operations, gray level transformation	To demonstrate the use of spatial processing for image enhancement	Lecture & PPT	EC4160.1, EC4160.2, EC4160.3	Class Quiz Mid-term-I, End term
13	Histogram Processing: equalization, specification and stretching	To comprehend the use of histograms for image enhancement	Lecture & PPT	EC4160.2, EC4160.3	Class Quiz Mid-term-I, Assignment, End term
14,15	Spatial filtering: Smoothing and sharpening spatial filters; Laplacian filters QUIZ # 2	To develop spatial filters for image enhancement	Lecture & PPT	EC4160.2, EC4160.3, EC4160.5	Class Quiz Mid-term-II, End term

16, 17, 18	Frequency domain filtering: 2D DFT, Smoothing and sharpening using frequency domain filters, Homomorphic Filtering	To establish relationship between spatial and frequency domain filtering	Lecture & PPT	EC4160.2, EC4160.3	Class Quiz Mid-term-II End-term
19, 20	Cosine and Hadamard Transform, Transform Operations, other mathematical transforms	To represent image in transform domain	Lecture & PPT	EC4160.2	Class Quiz Mid-term-II
21,22, 23	Image Restoration: Degradation / Restoration Process, noise models and filter types	To analyse images for restoration with respect to noise	Lecture & PPT	EC4160.3, EC4160.5	Class Quiz Mid-term-II End-term
24,25	Color fundamentals, Color Models,	To illustrate the use of color models for images	Lecture & PPT	EC4160.1, EC4160.2	Class Quiz Mid-term-II
26, 27	Pseudo and Full-Color Image processing, Color Transformations, smoothing & sharpening QUIZ #2	To relate gray scale image processing to color image processing	Lecture & PPT	EC4160.3, EC4160.5	Class Quiz Mid-term-II End-term
28, 29, 30	**Morphological processing and segmentation**: Preliminaries, erosion, dilation, Hit-And-Miss transformation, Basic Morphological Algorithms; Detection of discontinuities. Edge linking and boundary detection, Thresholding, Region based segmentation;	To demonstrate the use of spatial masks for morphological processing and segmentation	Lecture & PPT	EC4160.2, EC4160.4, EC4160.5	Class Quiz Mid-term-II End-term
31, 32, 33	Image Compression and standards, Lossless compression: Variable length coding, LZW coding, Bit plane coding, run-length coding	To recall need of compression and basic lossless compression	Lecture & PPT	EC4160.2, EC4160.6	Class Quiz Mid-term-II End-term
34,35	predictive coding, DPCM. Lossy Compression:	To demonstrate the use of lossy compression	Lecture & PPT	EC4160.2, EC4160.6	Class Quiz Mid-term-II End-term
36,37	Transform coding, Wavelet coding. Basics of Image compression standards: JPEG, JPEG2000. QUIZ # 3	To acquaint with ongoing image compression standards	Lecture & PPT	EC4160.6	Class Quiz

38-40	**Applications**: Character recognition, Biomedical Image processing, Watermarking, multi-resolution analysis.	To develop solutions for image processing applications based on the techniques studied	Lecture & PPT	EC4160.1, EC4160.2, EC4160.3, EC4160.4, EC4160.5	Class Quiz Assignment
40	Conclusion and Course Summarization	Course summary and conclusion	Lecture	NA	NA

Dr Neha Singh

I. Course Articulation Matrix: (Mapping of COs with POs)

CO	STATEMENT	CORRELATION WITH PROGRAM OUTCOMES												CORRELATION WITH PROGRAM SPECIFIC OUTCOMES		
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
EC4160.1	Correlate image perception, acquisition and analysis to develop projects and hence develop employability skills **(analysis)**	1		1										1		
EC4160.2	Execute digital image manipulation and mathematical operations **(Application)**	2	1	1	1	1									2	
EC4160.3	Validate Image enhancement and restoration techniques for processing **(evaluation)**	1		1	2									1		
EC4160.4	Recognize the steps (compression, segmentation and morphological techniques) for image processing for lifelong learning and encouraging entrepreneurship **(Application)**	1	2	1										1		
EC4160.5	Evaluate use of image processing filters **(evaluation)**	1		1												1

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

MANIPAL UNIVERSITY JAIPUR

School of Electrical, Electronics & Communication Engineering (SEEC)

Department of Electronics & Communication Engineering
Course Hand-out

SYSTEM VERILOG FOR DESIGN & VERIFICATION | EC 4161 | 3 Credits | 3 0 0 3

Session: JUL 23 – DEC 23 | Faculty: Dr. Shilpi Birla| Class: Dep. Elective (VII Sem)

A. Introduction: This course is offered by Dept. of Electronics & Communication Engineering as a department elective, targeting students who wish to pursue research & development in industries or higher studies in field of Electronics Engineering especially VLSI Design. The objective of the course is to provide a thorough understanding about designing of digital circuits & Test bench-based verification using System Verilog. The Digital Electronics & Verilog HDL is the pre-requisite for this course.

B. Course Objectives: At the end of the course, students will be able to

[4161.1] Explain the concepts of System Verilog, the general problems and methods related to literal values and built-in data types.
[4161.2] Apply the System Verilog various literals, datatypes in various circuit.
[4161.3] Make use of array, structures, and unions in designs in System Verilog codes.
[4161.4] Classify System Verilog Procedural Blocks, Tasks and Functions
[4161.5] Modeling Finite State Machines with System Verilog for Digital applications.
[4161.6] Design complex logic components from specifications to synthesizable System Verilog code.

C. Program Outcomes and Program Specific Outcomes

[PO.1]. Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems

[PO.2]. Problem analysis: Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences

[PO.3]. Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations

[PO.4]. Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions

[PO.5]. Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations

[PO.6]. The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice

[PO.7]. Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development

[PO.8]. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practices

[PO.9]. Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings

[PO.10]. Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions

[PO.11]. Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments

[PO.12]. Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

[PSO.1]. An ability to understand the concepts of basic Electronics & Communication Engineering and to apply them to various areas like Signal processing, VLSI, Embedded systems, Communication Systems, Digital & Analog Devices, etc.

[PSO.2]. An ability to solve complex Electronics and Communication Engineering problems, using latest hardware and software tools, along with analytical skills to arrive cost effective and appropriate solutions.

[PSO.3]. Wisdom of social and environmental awareness along with ethical responsibility to have a successful career and to sustain passion and zeal for real-world applications using optimal resources as an entrepreneur.

Program Educational Objectives

- **PEO1**. Graduates will exhibit technical and managerial readiness for electronics, telecommunication and IT industries.
- **PEO2**. Graduates will take up higher studies in niche areas of electronics and communication domain for *the* next level of advancement.
- **PEO3**. Graduates will exhibit productive teamwork in multi-cultural environment.

D. Assessment Plan:

Criteria	Description	Maximum Marks
Internal Assessment (Summative)	Sessional Exam	30
	In class Quizzes and Assignments, Activity feedbacks (Accumulated and Averaged)	30
	Laboratory Sessions	
End Term Exam (Summative)	End Term Exam	40
	Total	100
Attendance (Formative)	A minimum of 75% Attendance is required to be maintained by a student to be qualified for taking up the End Semester examination. The allowance of 25% includes all types of leaves including medical leaves.	
Homework/ Home Assignment/ Activity Assignment (Formative)	There are situations where a student may have to work in home. Although these works are not graded with marks. However, a student is expected to participate and perform these assignments with full zeal since the activity/ flipped classroom participation by a student will be assessed and marks will be awarded.	

E. Syllabus

Introduction to System Verilog, System Verilog declaration Spaces, System Verilog Literal Values and Built in Data types: assignments, variables, models. System Verilog user defined data types and enumerated types, Arrays, Structures and Unions. Procedural Blocks, Tasks and Functions. System Verilog Procedural Statements. Modeling FSMs with System Verilog.

Reference Books:

1. Christian B. Spear, System Verilog for Verification: A Guide to Learning the Testbench Language Features, Springer 2012
2. Mark Glasser, Harry Foster, Tom Fitzpatrick, Adam Rose, Dave Rich ,Open Verification Methodology Handbook: Creating Testbenches in System Verilog and SystemC, Morgan Kaufmann, 2009
3. Faisal Haque, Jonathan Michelson, Khizar Khan, The Art of Verification with System Verilog Assertions, , Verification Central, 2006.

F. Lecture Plan:

Lecture No	**Topics**	**Session Outcome**	**Mode of Delivery**	**Corresponding CO**	**Mode of Assessing the Outcome**
1	Introduction to System Verilog		Lecture & PPT	NA	NA
2,3	System Verilog Declaration Spaces-Packages	Understand Package declarations	Lecture & PPT	4161.1	In Class Quiz Mid Term I End Term
4,5	System Verilog Declaration Spaces-Declarations	Understand the coding guidelines	Lecture & PPT	4161.1	In Class Quiz Mid Term I End Term
6,7	System Verilog Declaration Spaces-Units & Precision	To use time units and precisions in coding	Lecture & PPT	4161.2	Class Quiz Mid Term I End Term
7,8	System Verilog Literal Values and Built-in Data Types	To know various data types	Lecture & PPT	4161.2	Home Assignment Mid Term I End Term
9,10	System Verilog variables	To know the use of system variables	Lecture & PPT	4161.2	Class Quiz Mid Term I End Term
11,12	Using 2-state types in RTL models	Learns to know the state type variables	Lecture & PPT	4161.2	In Class Quiz Mid Term I End Term
13,14	Signed and unsigned modifiers	Know the various modifiers	Lecture & PPT	4161.2	Class Quiz Mid Term I End Term
15,16	Static and automatic variables	To understand how to use different type of variables	Lecture & PPT	4161.2	Home Assignment Class Quiz Mid Term I End term
17,18	Deterministic variable initialization	To know Initializing sequential logic asynchronous inputs		4161.2	Class Quiz Mid Term I End Term
19,20	Type casting	Use of type cate and synthesis guidelines		4161.2	Class Quiz Mid Term I End Term
21,22	System Verilog User-Defined types	Know different types of user defined types	Lecture & PPT	4161.3	Class Quiz Mid Term I End Term
23,24	Enumerated Types	Use of enumerated data types		4161.3	Class Quiz Mid Term I End Term

25,26	Unions	Understand Implementation of union	Lecture & PPT	4161.3	Class Quiz Mid Term 11 End Term
27,28	Arrays	Use of array & unions	Lecture & PPT	4161.3	Class Quiz Mid Term II End Term
29,30	Structures				
31,32	Procedural Blocks	Understand the concept of procedural block	Lecture & PPT	4161.4	Class Quiz Mid Term II End Term
33,34	Enhancements to tasks and functions	Use of Task & function in system verikig	Lecture & PPT	4161.4	Class Quiz Mid Term II End Term
35,36	SystemVerilog Procedural Statements	Know the use of procedural statements	Lecture & PPT	4161.4	Class Quiz Mid Term II End Term
37,38	Modeling Finite State Machines with SystemVerilog	To learn and implement FSM using system verilog	Lecture & PPT	4161.5	Class Quiz Mid Term II End Term
39,40	Implementation of synthesizable code using system Verilog	Implement the theoretical and practical fundamentals, with modern digital design and verification tools	Discussion	4161.6	End Term

G. Course Articulation Matrix: (Mapping of COs with POs)

CO	STATEMENT	CORRELATION WITH PROGRAM OUTCOMES												CORRELATION WITH PROGRAM SPECIFIC OUTCOMES		
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
EC 4161.1	Explain the concepts of System Verilog, the general problems and methods related to literal values and built-in data types.	1												2		
EC 4161.2	Apply the System Verilog various literals, datatypes in various circuit.	1												2		
EC 4161.3	Apply System Verilog array, structures, and unions in designs.	1	2											2	2	
EC 4161.4	Make use of array, structures, and unions in designs in System Verilog codes.	1	2											2	2	

EC 4161.5	Modeling Finite State Machines with System Verilog for Digital applications.	1	2	2										2	2	
EC 4161.6	Design complex logic components from specifications to synthesizable SystemVerilog code.	2	2	1	1									2	2	2

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation