CURRICULUM AND DETAILED SYLLABI

FOR

B. TECH DEGREE PROGRAMME

IN

ELECTRONICS AND COMMUNICATION ENGINEERING

SEMESTERS VII & VIII

2020 SCHEME
(AUTONOMOUS)

MAR BASELIOS COLLEGE OF ENGINEERING AND TECHNOLOGY
(Approved by AICTE, Autonomous Institution Affiliated to APJ Abdul Kalam Technological University)
MAR IVANIOS VIDYANAGAR, NALANCHIRA, THIRUVANANTHAPURAM – 695015, KERALA.
Phone: 0471 2545866
Fax: 0471 2545869
Web: www.mbcet.ac.in
email: hodec@mbcet.ac.in

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MAR BASELIOS COLLEGE OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

B. TECH DEGREE PROGRAMME

IN

ELECTRONICS AND COMMUNICATION ENGINEERING

CURRICULUM AND DETAILED SYLLABI (S7-S8)

Items	Board of Studies (BoS)	Academic Council (AC)
Date of Approval	**18.11.2020**	**30.12.2020**
	04.02.2021	**17.02.2021**
	25.11.2021	**22.04.2022**
	11.08.2022	**29.08.2022**
	24.02.2023	**20.03.2023**

Sd/-
Head of Department
Chairman, Board of Studies

Sd/-
Principal
Chairman, Academic Council

MAR BASELIOS COLLEGE OF ENGINEERING AND TECHNOLOGY

Vision and Mission of the Institution

Vision:

To be an Institution moulding globally competent professionals as epitomes of Noble Values.

Mission:

To transform the Youth as technically competent, ethically sound and socially committed professionals, by providing a vibrant learning ambience for the welfare of humanity.

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

Vision and Mission of the Department

Vision:

To be a Centre of Excellence in Electronics and Communication Engineering Education and Research for the service of humanity.

Mission:

To provide quality Engineering Education and to carry out Research in the field of Electronics and Communication Engineering addressing the challenges faced by the society.

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)

PEO1: The graduates of the Programme will have a successful career as Professionals in Industry or as Entrepreneurs, encompassing a broad spectrum of areas related to Electronics and Communication Engineering.

PEO2: They will be able to adapt to the changing needs of Industry and Academia through continuous learning and professional upgrading.

PEO3: They will exhibit social responsibility in their pursuit of technical excellence.

PROGRAMME OUTCOMES (POs)

Engineering Graduates will have the ability to:

1. **Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
2. **Problem analysis**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
3. **Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
4. **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
5. **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
6. **The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
7. **Environment and sustainability**: Understand the impact of the professional engineering solution sin societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
8. **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
9. **Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

10. **Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
11. **Project management and finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one‟s own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
12. **Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

PROGRAMME SPECIFIC OUTCOMES (PSOs)

PSO1: Design Electronic Circuits and Systems for Communication, Monitoring and Control Applications.

PSO2: Demonstrate the knowledge, in Electronics, Signal processing, Embedded Systems and Communication Engineering, required for providing technical solutions to real world problems

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

B. Tech Programme in Electronics and Communication Engineering

For the students admitted from 2020-21

Scheduling of Courses

i) Knowledge Segments and Credits

Every course of B. Tech Programme is placed in one of the nine categories as listed in table below. No semester shall have more than six lecture-based courses and two laboratory courses, and/or drawing/seminar/project courses in the curriculum.

Table 1: Credit distribution and the Knowledge Domains

Sl. No.	Category	Category Code	Total credits
1	Humanities and Social Sciences including Management Courses	HSC	8
2	Basic Science Courses	BSC	26
3	Engineering Science Courses	ESC	22
4	Programme Core Courses, Comprehensive Course Work and Viva Voce	PCC	76
5	Programme Elective Courses	PEC	15
6	Open Elective Courses	OEC	3
7	Project Work and Seminar	PWS	10
8	Mandatory Non-credit Courses (P/F) with Grade	MNC	---
9	Mandatory Student Activities (P/F)	MSA	2
	Total Mandatory Credits		**162**
	Value Added Courses (Optional) – Honours/Minor	VAC	20

ii) Semester-wise Credit Distribution

Semester	I	II	III	IV	V	VI	VII	VIII	*Total Credits*
Credits for Courses	*17*	*21*	*22*	*22*	*23*	*23*	*15*	*17*	***160***
Activity Points (Min.)	*40*				*60*				***100***
Credits for Activities	*2*								***2***
Total Credits									***162***
Value Added Courses (Optional) – Honours / Minor									***20***
Total Credits									***182***

SEMESTER I

Slot	Cate-gory Code	Course Number	Courses	L-T-P	Hours	Credit
A	BSC	MA0U10A	Linear Algebra and Calculus	3-1-0	4	4
B ½	BSC	PH0U10A	Engineering Physics A	3-1-0	4	4
		CY0U10A	Engineering Chemistry A	3-1-0	4	4
C ½	ESC	ES0U10A	Engineering Mechanics	2-1-0	3	3
		ES0U10B	Engineering Graphics	2-0-2	4	3
D ½	ESC	ES0U10C	Basics of Civil and Mechanical Engineering	4-0-0	4	4
		ES0U10D	Basics of Electrical and Electronics Engineering	4-0-0	4	4
E	HSC	HS0U10A	Life Skills	2-0-2	4	---
S ½	BSC	PH0U18A	Engineering Physics Lab	0-0-2	2	1
		CY0U18A	Engineering Chemistry Lab	0-0-2	2	1
T ½	ESC	ES0U18A	Civil and Mechanical Workshop	0-0-2	2	1
		ES0U18B	Electrical and Electronics Workshop	0-0-2	2	1
			TOTAL		**23/24**	**17**

SEMESTER II

Slot	Cate-gory Code	Course Number	Courses	L-T-P	Hours	Credit
A	BSC	MA0U10B	Vector Calculus, Differential Equations and Transforms	3-1-0	4	4
B ½	BSC	PH0U10A	Engineering Physics A	3-1-0	4	4
		CY0U10A	Engineering Chemistry	3-1-0	4	4
C ½	ESC	ES0U10A	Engineering Mechanics	2-1-0	3	3
		ES0U10B	Engineering Graphics	2-0-2	4	3
D ½	ESC	ES0U10C	Basics of Civil and Mechanical Engineering	4-0-0	4	4
		ES0U10D	Basics of Electrical and Electronics Engineering	4-0-0	4	4
E	HSC	HS0U10B	Professional Communication	2-0-2	4	---
F	ESC	ES0U10E	Programming in **C**	2-1-2	5	4
S ½	BSC	PH0U18A	Engineering Physics Lab	0-0-2	2	1
		CY0U18A	Engineering Chemistry Lab	0-0-2	2	1
T ½	ESC	ES0U18A	Civil and Mechanical Workshop	0-0-2	2	1
		ES0U18B	Electrical and Electronics Workshop	0-0-2	2	1
			TOTAL		**28/29**	**21**

SEMESTER III						
Slot	**Cate-gory Code**	**Course Number**	**Courses**	**L-T-P**	**Hours**	**Credit**
A	BSC	MA0U20A	Partial Differential Equations and Complex Analysis	3-1-0	4	4
B	PCC	EC1U20A	Solid State Devices	3-1-0	4	4
C	PCC	EC1U20B	Logic Circuit Design	3-1-0	4	4
D	PCC	EC1U20C	Network Theory	3-1-0	4	4
E 1/2	ESC	ES0U20A	Design & Engineering	2-0-0	2	2
	HSC	HS0U20A	Professional Ethics	2-0-0	2	2
F	MNC	NC0U20A	Sustainable Engineering	2-0-0	2	---
S	PCC	EC1U28A	Scientific Computing Lab	0-0-3	3	2
T	PCC	EC1U28B	Logic Design Lab	0-0-3	3	2
R/M	VAC		Remedial/Minor Course	3-1-0/ 4-0-0	4	4
TOTAL					**26/30**	**22/26**

SEMESTER IV						
Slot	**Cate-gory Code**	**Course Number**	**Courses**	**L-T-P**	**Hours**	**Credit**
A	BSC	MA0U20C	Probability, Random Processes and Numerical Methods	3-1-0	4	4
B	PCC	EC1U20D	Analog Circuits	3-1-0	4	4
C	PCC	EC1U20E	Signals and Systems	3-1-0	4	4
D	PCC	EC1U20F	Computer Architecture and Microcontrollers	3-1-0	4	4
E ½	ESC	ES0U20A	Design & Engineering	2-0-0	2	2
	HSC	HS0U20A	Professional Ethics	2-0-0	2	2
F	MNC	NC0U20B	Constitution of India	2-0-0	2	---
S	PCC	EC1U28C	Analog Circuits and Simulation Lab	0-0-3	3	2
T	PCC	EC1U28D	Microcontroller Lab	0-0-3	3	2
R/M/H	VAC		Remedial/Minor/Honours Course	3-1-0/ 4-0-0	4	4
TOTAL					**26/30**	**22/26**

SEMESTER V						
Slot	**Cate-gory Code**	**Course Number**	**Courses**	**L-T-P**	**Hours**	**Credit**
A	PCC	EC1U30A	Linear Integrated Circuits	3-1-0	4	4
B	PCC	EC1U30B	Digital Signal Processing	3-1-0	4	4
C	PCC	EC1U30C	Analog and Digital Communication	3-1-0	4	4
D	PCC	EC1U30D	Control Systems	3-1-0	4	4
E ½	HSC	HS0U30A	Industrial Economics and Foreign Trade	3-0-0	3	3
		HS0U30B	Management for Engineers	3-0-0	3	3
F	MNC	NC0U30A	Disaster Management	2-0-0	2	--
S	PCC	EC1U38A	Analog Integrated Circuits and Simulation Lab	0-0-3	3	2
T	PCC	EC1U38B	Digital Signal Processing Lab	0-0-3	3	2
R/ M/ H	VAC		Remedial/Minor/Honours Course	3-1-0/ 4-0-0	4	4
			TOTAL		**27/31**	**23/27**

SEMESTER VI						
Slot	**Cate-gory Code**	**Course Number**	**Courses**	**L-T-P**	**Hours**	**Credit**
A	PCC	EC1U30E	Electromagnetics	3-1-0	4	4
B	PCC	EC1U30F	VLSI Circuit Design	3-1-0	4	4
C	PCC	EC1U30G	Information Theory and Coding	3-1-0	4	4
D	PEC	EC1UXXX	Programme Elective I	2-1-0 /3-0-0	3	3
E 1/2	HSC	HS0U30A	Industrial Economics & Foreign Trade	3-0-0	3	3
		HS0U30B	Management for Engineers	3-0-0	3	3
F	PCC	EC1U30H	Comprehensive Course work	1-0-0	1	1
S	PCC	EC1U38C	Communication Lab	0-0-3	3	2
T	PWS	EC1U39A	Mini Project	0-0-3	3	2
R/ M/ H	VAC		Remedial/Minor/Honours Course	3-1-0/ 4-0-0	4	4
			TOTAL		**25/29**	**23/27**

PROGRAMME ELECTIVE I

Slot	Category Code	Course Number	Courses	L-T-P	Hours	Credit
D	PEC	EC1U31A	Digital System Design	2-1-0	3	3
		EC1U31B	Power Electronics	3-0-0	3	3
		EC1U31C	Data Analysis	2-1-0	3	3
		EC1U31D	Embedded System	3-0-0	3	3
		EC1U31E	Digital Image Processing	2-1-0	3	3
		EC1U31F	Introduction to MEMS	2-1-0	3	3
		EC1U31G	Quantum Computing	2-1-0	3	3

SEMESTER VII

Slot	Category Code	Course Number	Courses	L-T-P	Hours	Credit
A	PCC	EC1U40A	Microwaves and Antennas	2-1-0	3	3
B	PEC	EC1UXXX	Programme Elective II	2-1-0/ 3-0-0	3	3
C	OEC	EC0UXXX	Open Elective	2-1-0/ 3-0-0	3	3
D	MNC	NC0U40A	Industrial Safety Engineering	2-1-0	3	---
E	PCC	EC1U48A	Electromagnetics Lab	0-0-3	3	2
T	PWS	EC1U49A	Seminar	0-0-3	3	2
U	PWS	EC1U49B	Project Phase I	0-0-6	6	2
R/ M/ H	VAC		Remedial/Minor/Honours Course	0-1-6/ 4-0-0	7/4	4
TOTAL					**24/(31/28)**	**15/19**

PROGRAMME ELECTIVE II

Slot	Category Code	Course Number	Courses	L-T-P	Hours	Credit
B	PEC	EC1U41A	Optical Fiber Communication	3-0-0	3	3
		EC1U41B	Computer Networks	3-0-0	3	3
		EC1U41C	Opto Electronic Devices	2-1-0	3	3
		EC1U41D	Instrumentation	2-1-0	3	3
		EC1U41E	Error Control Codes	2-1-0	3	3
		EC1U41F	Machine Learning	2-1-0	3	3
		EC1U41G	DSP Architectures	2-1-0	3	3

OPEN ELECTIVE

Slot	Category Code	Course Number	Courses	L-T-P	Hours	Credit
C	OEC	EC0U41A	Mechatronics	2-1-0	3	3
		EC0U41B	Biomedical Instrumentation	3-0-0	3	3
		EC0U41C	Electronic Hardware for Engineers	3-0-0	3	3
		EC0U41D	IoT and Applications	2-1-0	3	3
		EC0U41E	Entertainment Electronics	2-1-0	3	3

SEMESTER VIII						
Slot	**Cate-gory Code**	**Course Number**	**Courses**	**L-T-P**	**Hours**	**Credit**
A	PCC	EC1U40B	Wireless Communication	3-0-0	3	3
B	PEC	EC1UXXX	Programme Elective III	3-0-0/ 2-1-0	3	3
C	PEC	EC1UXXX	Programme Elective IV	3-0-0/ 2-1-0	3	3
D	PEC	EC1UXXX	Programme Elective V	3-0-0/ 2-1-0	3	3
T	PCC	EC1U40C	Comprehensive Viva Voce	1-0-0	1	1
U	PWS	EC1U49C	Project Phase II	0-0-12	12	4
R/ M/ H	VAC		Remedial/Minor/Honours Course	0-1-6	7	4
TOTAL					**25/32**	17/21

PROGRAMME ELECTIVE III

Slot	Category Code	Course Number	Courses	L-T-P	Hours	Credit
B	PEC	EC1U42A	Biomedical Engineering	3-0-0	3	3
		EC1U42B	Satellite Communication	3-0-0	3	3
		EC1U42C	Secure Communication	3-0-0	3	3
		EC1U42D	Pattern Recognition	3-0-0	3	3
		EC1U42E	RF Circuit Design	3-0-0	3	3
		EC1U42F	Mixed Signal Circuit Design	2-1-0	3	3
		EC1U42G	Entrepreneurship	3-0-0	3	3

PROGRAMME ELECTIVE IV

Slot	Category Code	Course Number	Courses	L-T-P	Hours	Credit
C	PEC	EC1U43A	Modern Communication Systems	3-0-0	3	3
		EC1U43B	Real Time Operating Systems	2-1-0	3	3
		EC1U43C	Adaptive Signal Processing	2-1-0	3	3
		EC1U43D	Microwave Devices and Circuits	3-0-0	3	3
		EC1U43E	Speech & Audio Processing	3-0-0	3	3
		EC1U43F	Analog CMOS Design	2-1-0	3	3
		EC1U43G	Robotics	3-0-0	3	3

PROGRAMME ELECTIVE V

Slot	Category Code	Course Number	Courses	L-T-P	Hours	Credit
D	PEC	EC1U44A	Mechatronics	3-0-0	3	3
		EC1U44B	Optimization Techniques	2-1-0	3	3
		EC1U44C	Computer Vision	2-1-0	3	3
		EC1U44D	Low Power VLSI	2-1-0	3	3
		EC1U44E	Internet of Things	2-1-0	3	3
		EC1U44F	Renewable Energy Systems	3-0-0	3	3
		EC1U44G	Organic Electronics	3-0-0	3	3

B. Tech (MINOR)

Semester	BASKET I				BASKET II				BASKET III			
	Course Number	Course	L-T-P	Credit	Course Number	Course	L-T-P	Credit	Course Number	Course	L-T-P	Credit
S3	EC0M 20A	Electronic Circuits	3-1-0	4	EC0M 20B	Analog Communication	4-0-0	4	EC0M 20C	Introduction to Signals and Systems	3-1-0	4
S4	EC0M 20D	Microcontrollers	3-1-0	4	EC0M 20E	Digital Communication	3-1-0	4	EC0M 20F	Introduction to Digital Signal Processing	3-1-0	4
S5	EC0M 30A	Embedded System Design	3-1-0	4	EC0M 30B	Communication Systems	4-0-0	4	EC0M 30C	Topics in Digital Image Processing	3-1-0	4
S6	EC0M 30D	VLSI Circuits	3-1-0	4	EC0M 30E	Data Networks	4-0-0	4	EC0M 30F	Topics in Computer Vision	3-1-0	4
S7	EC0M 49A	Mini Project	0-1-6	4	EC0M 49A	Mini Project	0-1-6	4	EC0M 49A	Mini Project	0-1-6	4
S8	EC0M 49B	Mini Project	0-1-6	4	EC0M 49B	Mini Project	0-1-6	4	EC0M 49B	Mini Project	0-1-6	4

B. Tech (HONOURS)

Semester	**GROUP I**				**GROUP II**				**GROUP III**			
	Course Number	**Course**	**L-T-P**	**Credit**	**Course Number**	**Course**	**L-T-P**	**Credit**	**Course Number**	**Course**	**L-T-P**	**Credit**
S4	EC1H 20A	Nanoelectronics	4-0-0	4	EC1H 20B	Stochastic Process for Communication	4-0-0	4	EC1H 20C	Stochastic Signal Processing	4-0-0	4
S5	EC1H 30A	FPGA based System Design	4-0-0	4	EC1H 30B	Detection and Estimation Theory	4-0-0	4	EC1H 30C	Computational Tools for Signal Processing	4-0-0	4
S6	EC1H 30D	Electronic Design and Automation Tools	4-0-0	4	EC1H 30E	MIMO and Multiuser Communication Systems	4-0-0	4	EC1H 30F	Detection and Estimation Theory	4-0-0	4
S7	EC1H 40A	RF MEMS	4-0-0	4	EC1H 40B	Design and Analysis of Antennas	4-0-0	4	EC1H 40C	Multirate Signal Processing and Wavelets	4-0-0	4
S8	EC1H 49A	Mini Project	0-1-6	4	EC1H 49A	Mini Project	0-1-6	4	EC1H 49A	Mini Project	0-1-6	4

SEMESTER VII

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EC1U40A	MICROWAVES AND ANTENNAS	PCC	2	1	0	3	2020

i) PREREQUISITE: EC1U30E- Electromagnetics

ii) COURSE OVERVIEW

This course aims to impart knowledge on the basic parameters of antenna, design and working of various broadband antennas, arrays and its radiation patterns. It also introduces various microwave sources, their principle of operation and study of various microwave hybrid circuits and microwave semiconductor devices.

iii) COURSE OUTCOMES

After the completion of the course, the student will be able to:

Course Outcomes	Description	Level
CO 1	Explain the basic concepts of antenna and its parameters.	Understand
CO 2	Analyse the far field pattern of short dipole and far field dipole antenna.	Apply
CO 3	Design of various broadband antennas, arrays and its radiation pattern.	Apply
CO 4	Analyse the principle of operation of cavity resonators, various microwave sources and microwave amplifier.	Apply
CO 5	Explain the S matrix formulation of various microwave hybrid circuits and operation of microwave semiconductor devices.	Understand

iv) SYLLABUS

Basic antenna parameters: gain, directivity, beam width and effective aperture calculations, effective height, wave polarization, radiation resistance, radiation efficiency, radiation pattern, antenna field zones. Duality and Principles of reciprocity, Field, directivity and radiation resistance of a short dipole and half wave dipole (far field derivation).

Broad band antenna: Principle of Log periodic antenna array and design, helical antenna: types and design. Design of Microstrip Rectangular Patch antennas and feeding methods. Principles of Horn, Parabolic dish antenna (expression for E, H and Gain without derivation), Mobile phone antenna – Inverted F antenna.

Arrays of point sources: field of two isotropic point sources, principle of pattern multiplication, linear arrays of „n‟ isotropic point sources. Array factor, Grating lobes, Design of Broadside, End fire and Dolph Chebyshev arrays. Concept of Phase array.

Microwaves: Introduction, advantages, Cavity Resonators-Derivation of resonance frequency of Rectangular cavity. Single cavity klystron-Reflex Klystron Oscillators: Derivation of Power output, efficiency and admittance. Magnetron oscillators: Cylindrical magnetron, Cyclotron angular frequency, Power output and efficiency. Travelling Wave Tube: Slow wave structures, Helix TWT, Amplification process, Derivation of convection current, axial electric field, wave modes and gain.

Microwave Hybrid circuits: Scattering parameters, Waveguide Tees-Magic tees, Hybrid rings, Formulation of S-matrix. Directional couplers: Two hole directional couplers, S-matrix. Circulators and Isolators, Phase Shifter.

Microwave Semiconductor Devices: Amplifiers using MESFET. Principle of Gunn diodes: Different modes, Principle of operation Gunn Diode Oscillators.

v) a) TEXT BOOKS

1) Balanis, Antenna Theory and Design, 3/e, Wiley Publications.
2) John D. Krauss, Antennas for all Applications, 3/e, TMH.
3) K D Prasad, Antenna and Wave Propagation, Satyaprakash Publications
4) Samuel Y. Liao, Microwave Devices and Circuits, 3/e, Pearson Education, 2003.
5) Robert E. Collin, Foundation of Microwave Engineering, 2/e, Wiley India, 2012.

b) REFERENCES

1) Collin R.E, Antennas & Radio Wave Propagation, McGraw Hill. 1985.
2) Jordan E.C. & K. G. Balmain, Electromagnetic Waves & Radiating Systems, 2/e, PHI.
3) Raju G.S.N., Antenna and Wave Propagation, Pearson, 2013.
4) Sisir K. Das& Annapurna Das, Antenna and Wave Propagation, McGraw Hill,2012
5) Thomas A. Milligan, Modern Antenna Design, IEEE PRESS, 2/e, Wiley Inter science.
6) Das, Microwave Engineering, 3/e, McGraw Hill Education India Education , 2014
7) David M. Pozar, Microwave Engineering, 4/e, Wiley India, 2012.

vi) COURSE PLAN

Module	Contents	No. of hours
I	Basic antenna parameters (all parameters and related simple problems), Relation between parameters (derivation required) Principles of reciprocity (proof required), Duality. Concept of retarded potential, Derivation of Field, directivity and radiation resistance of a short dipole, Derivation of Field, directivity and radiation resistance of a half wave dipole.	**10**
II	Principle of Log periodic antenna array and design, Helical antenna: types and design, Design of Rectangular Patch antennas and feeding techniques, Principles of Horn, Parabolic dish antenna, (expression for E, H, G without derivation). Mobile phone antenna-Inverted F antenna.	**7**
III	Arrays of point sources, field of two isotropic point sources, principle of pattern multiplication Linear arrays of „n‟ isotropic point sources. Grating lobes. Array factor (derivation) Design of Broadside, End fire and Dolph Chebyshev arrays. Concept of Phase array.	**10**
IV	Microwaves: Introduction, advantages, Cavity Resonators-Types,	**10**

	Derivation of resonance frequency of Rectangular cavity (problems required) Single cavity klystron- Reflex Klystron Oscillators: Derivation of Power output, efficiency and admittance.(problems required) Magnetron oscillators: Cylindrical magnetron, Cyclotron angular frequency, Power output and efficiency.(problems required) Travelling Wave Tube: Slow wave structures, Helix TWT, Amplification process, Derivation of convection current, axial electric field, wave modes and gain. (problems required)	
V	Microwave Hybrid circuits: Scattering parameters, Waveguide Tees-Magic tees, Hybrid rings. Formulation of S-matrix. Directional couplers: Two hole directional couplers, S-matrix. Circulators and Isolators. Phase Shifter. Microwave Semiconductor Devices: Principle of Gunn diodes: Different modes, Principle of operation Gunn Diode Oscillators.	**8**
	Total hours	**45**

vii) ASSESSMENT PATTERN

Mark distribution

Total Marks	Continuous Internal Evaluation Marks	End Semester Evaluation Marks	End Semester Examination Duration
150	**50**	**100**	**3 Hours**

Continuous Internal Evaluation Pattern:

Attendance	**10 Marks**
Continuous Assessment Tests (2 numbers)	**25 Marks**
Assignment/Quiz/Course project	**15 Marks**

Simulation Assignments

The following simulation assignments can be done with MATLAB/HFSS/CST Microwave Studio or any Open software.

Simulation of radiation pattern of

a) Microstrip patch antenna

b) Arrays

c) Helical antenna

End Semester Examination Pattern:

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
NC0U40A	INDUSTRIAL SAFETY ENGINERING	MNC	2	1	0	--	2020

i) COURSE OVERVIEW

Objective of the course to impart knowledge of various safety management principles, various safety systems, various machine guarding devices, hazard identification techniques, energy sources, systems & applications and the need in the present context.

ii) COURSE OUTCOMES

After the completion of the course, the student will be able to:

Course Outcomes	Description	Level
CO 1	Explain the theories of accident causation and preventive measures of industrial accidents.	Understand
CO 2	Explain about personal protective equipments, its selection, safety performance, role of housekeeping and work permits in industry.	Understand
CO 3	Explain different safety issues in construction industries.	Understand
CO 4	Summarize various hazards associated with different machines and material handling.	Understand
CO 5	Explain different hazard identification tools in industries with the knowledge of different types of chemical hazards.	Understand

ii) SYLLABUS

Need for safety. Safety and productivity. Definitions: Accident, Injury, Unsafe act, Unsafe Condition, Dangerous Occurrence, Reportable accidents. Theories of accident causation. Safety organization- objectives, types, functions, Role of management

Personal protection in the work environment, Types of PPEs, Personal protective equipment- respiratory and non-respiratory equipment. Performance: Frequency rate, severity rate, incidence rate, activity rate. Housekeeping: Responsibility of management and employees. Typical industrial models and methodology.

Introduction to construction industry and safety issues in construction Safety in various construction operations – Excavation and filling – Under-water works – Under-pinning &Shoring – Ladders & Scaffolds – Tunneling – Blasting – Demolition – Confined space – Temporary Structures. Ergonomics Hazards - Musculoskeletal Disorders and Cumulative Trauma Disorders**.**

Machinery safeguard-Point-of-Operation, Principle of machine guarding -types of guards and devices. Safety in turning, and grinding. Welding and Cutting-Safety Precautions of Gas welding and Arc Welding, Material Handling equipment-operation & maintenance. Hearing Conservation Program in Production industries.

Hazard and risk, Types of hazards –Classification of Fire, Types of Fire extinguishers. Identification of hazards: Inventory analysis, Fire and explosion hazard rating of process plants - Hazard and Operability study (HAZOP)) –Hazardous properties of chemicals, Material Safety Data Sheets

iii) (a) TEXTBOOKS

1. R.K Jain (2000) *Industrial Safety*, Health and Environment management systems, Khanna Publications.
2. Paul S V (2000), *Safety management System and Documentation training Programme* handbook, CBS Publication.
3. Krishnan, N.V. (1997). *Safety management in Industry*. Jaico Publishing House, New Delhi.

(b) REFERENCES

1. AIChE/CCPS. (1992). *Guidelines for Hazard Evaluation Procedures*. (second edition). Centre for Chemical Process Safety, American Institute of Chemical Engineers, New York.
2. Alan Waring. (1996). *Safety management system*. Chapman & Hall, England.

iv) COURSE PLAN

Module	Contents	No. of hours
I	Need for safety. Safety and productivity. Definitions: Accident, Injury, Unsafe act, Unsafe Condition, Dangerous Occurrence, Reportable accidents. Theories of accident causation. Safety, organization- objectives, types, functions, Role of management, supervisors, workers, unions, government and voluntary agencies in safety. Safety policy. Safety Officer-responsibilities, authority. Safety committee-need, types, advantages.	9
II	Personal protection in the work environment, Types of PPEs, Personal protective equipment-respiratory and non-respiratory equipment. Standards related to PPEs. Monitoring Safety Performance: Frequency rate, severity rate, incidence rate, activity rate. Housekeeping: Responsibility of management and employees. Advantages of good housekeeping. 5 s of housekeeping. Work permit system- objectives, hot work and cold work permits. Typical industrial models and methodology. Entry into confined spaces. Technology generation and development, technology generation, process, technology development, importance of technology generation and development.	9

III	Introduction to construction industry and safety issues in construction Safety in various construction operations – Excavation and filling – Under-water works – Under-pinning & Shoring – Ladders & Scaffolds – Tunneling – Blasting – Demolition – Confined space –Temporary Structures. Familiarization with relevant Indian Standards and the National Building Code provisions on construction safety. Relevance of ergonomics in construction safety. Ergonomics Hazards - Musculoskeletal Disorders and Cumulative Trauma Disorders	**9**
IV	Machinery safeguard-Point-of-Operation, Principle of machine guarding -types of guards and devices. Safety in turning, and grinding. Welding and Cutting-Safety Precautions of Gas welding and Arc Welding. Material Handling-Classification-safety consideration- manual and mechanical handling. Handling assessments and techniques- lifting, carrying, pulling, pushing, palletizing and stocking. Material Handling equipment-operation & maintenance. Maintenance of common elements- wire rope, chains slings, hooks, clamps. Hearing Conservation Program in Production industries.	**9**
V	Hazard and risk, Types of hazards –Classification of Fire, Types of Fire extinguishers, fire explosion and toxic gas release, Structure of hazard identification and risk assessment. Identification of hazards: Inventory analysis, Fire and explosion hazard rating of process plants - The Dow Fire and Explosion Hazard Index, Preliminary hazard analysis, Hazard and Operability study (HAZOP)) – methodology, criticality analysis, corrective action and follow-up. Control of Chemical Hazards, Hazardous properties of chemicals, Material Safety Data Sheets	**9**
	Total hours	**45**

vi) ASSESSMENT PATTERN

Mark distribution

Total Marks	**Continuous Internal Evaluation Marks**	**End Semester Evaluation Marks**	**End Semester Examination Duration**
150	**50**	**100**	**3 Hours**

Continuous Internal Evaluation Pattern:

Attendance	**10 Marks**
Continuous Assessment Tests (2 numbers)	**25 Marks**
Assignment/Quiz/Course project	**15 Marks**

Internal Examination Pattern:

Each of the two internal examinations has to be conducted out of 50 marks. First series test shall be preferably conducted after completing the first half of the syllabus and the second series test shall be preferably conducted after completing remaining part of the syllabus. There will be two parts: Part A and Part B. Part A contains 5 questions (preferably, 2 questions each from the completed modules and 1 question from the partly completed module), having 3 marks for each question adding up to 15 marks for part A. Students should answer all questions from Part A.

Part B contains 7 questions (preferably, 3 questions each from the completed modules and 1 question from the partly completed module), each with 7 marks. Out of the 7 questions, a student should answer any 5.

End Semester Examination Pattern:

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EC1U48A	ELECTROMAGNETICS LAB	PCC	0	0	3	2	2020

i) PREREQUISITE: Nil

ii) COURSE OVERVIEW: This course aims to

(i) Provide practical experience in design and analysis of few electronic devices and circuits used for Microwave and Optical communication engineering.

(ii) Familiarize students with simulation of basic Antenna experiments with simulation tools.

iii) COURSE OUTCOMES

After the completion of the course, the student will be able to

Course Outcomes	Description	Level
CO 1	Plot the characteristics of a Gunn diode and Reflex klystron.	Apply
CO 2	Measure the parameters of various microwave components.	Apply
CO 3	Plot the VI characteristics of various optical active devices.	Apply
CO 4	Assemble Optical fiber Digital link to evaluate the numerical aperture and different kind of signal losses in an optical fiber.	Apply
CO 5	Design basic antenna experiments with simulation tools.	Apply
CO 6	Plot the radiation pattern of a given antenna using microwave bench setup.	Apply

iv) SYLLABUS

Microwave Experiments

1. Verify the relation $\lambda_c = 2a$.
2. Find the unknown impedance of the given load using Transmission line equation and verify using Smith chart.
3. Find the coupling coefficient of the given Directional Coupler.
4. Plot the mode characteristics of Reflex Klystron and Gunn diode.
5. Measure the characteristics of Magic Tee, Crystal index, and VSWR of a transmission line

Optical Experiments

1. Find the numerical aperture and V number of the given fiber.
2. Obtain the bending loss and attenuation loss of the given fiber.
3. Plot the V-I characteristics of Laser diode, LED and photodiode.

Antenna Experiments

1. Familiarization of any antenna simulation software.
2. Simulation of antennas and arrays.
3. Study of Vector Network Analyzer.
4. Antenna Pattern Measurement

v) a) TEXTBOOK

1. Samuel Y. Liao, Microwave Devices and Circuits, 3/e, Pearson Education, 2003.
2. Gred Keiser Optical Fiber Communication 5/e Mc Graw Hill, 2013
3. Balanis, Antenna Theory and Design, 3/e, Wiley Publications.

b) REFERENCES

1. John D. Krauss, Antennas for all Applications, 3/e, TMH.
2. Thomas A. Milligan, Modern Antenna Design, IEEE PRESS, 2/e, Wiley Inter science.
3. N.O. Sadiku and S.V. Kulkarni, *Principles of Electromagnetics*, Sixth Edition, Oxford University Press, India, 2015 (Asian adaptation of 'M.N.O. Sadiku, Elements of Electromagnetics, Sixth International Edition, Oxford University Press

vi) COURSE PLAN

Experiment No.	List of exercises/experiments	No. of hours
I	**MICROWAVE EXPERIMENTS (Minimum Four Experiments are mandatory)** 1. Reflex Klystron Mode Characteristics. 2. GUNN diode characteristics. 3. VSWR and Frequency measurement. 4. Verify the relation between Guide wave length, free space wave length and cut off wave length for rectangular wave guide. 5. Unknown load impedance measurement using smith chart and verification using transmission line equation. 6. Measurement of Magic Tee characteristics. 7. Directional Coupler Characteristics.	**12**

	8. Crystal Index Measurement.	
II	**OPTICAL EXPERIMENTS (Minimum Three Experiments are mandatory)** 1. Setting up of Fiber optic Digital link. 2. Measurement of Numerical Aperture of a fiber. 3. Study of losses in Optical fiber. 4. Voltage vs. Current (V-I) characteristics of Laser Diode. 5. Voltage vs. Current (V-I) characteristics of LED. 6. Characteristics of Photodiode	**9**
III	**ANTENNA EXPERIMENTS (Minimum Three Experiments are mandatory)** 1. Familiarization of any antenna simulation software. 2. Simulation of Dipole Antenna. 3. Simulation of Patch Antenna. 4. Simulation of Antenna Array. 5. Study of Vector Network Analyzer. 6. Antenna Pattern Measurement Simulation experiments can be done with MATLAB/HFSS/CST Microwave Studio or any Open software.	**9**
	Total hours	**30**

vii) ASSESSMENT PATTERN

Mark distribution

Total Marks	**Continuous Internal Evaluation Marks**	**End Semester Evaluation Marks**	**End Semester Examination Duration**
150	**75**	**75**	**3 Hours**

Continuous Internal Evaluation Pattern:

Attendance	**15 Marks**
Continuous Assessment	**30 Marks**
Internal Test (Immediately before the II internal test)	**30 Marks**

End Semester Examination Pattern:

Preliminary work	**15 marks**
Implementing the work/Conducting the experiment	**20 marks**
Performance, result and inference (usage of equipment and troubleshooting):	**15 marks**
Viva voce	**20 marks**
Record	**5 Marks**

PROGRAMME ELECTIVE-II

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EC1U41A	OPTICAL FIBER COMMUNICATION	PEC	3	0	0	3	2020

i) PREREQUISITE: Nil

ii) COURSE OBJECTIVES

- To introduce the concepts of light transmission through optical fibers, optical sources and detectors
- To compare the performance of various optical transmission schemes
- To understand the working of optical components, principle of operation of optical amplifiers.
- To understand WDM technique.

iii) COURSE OVERVIEW

This course aims to introduce the concepts of light transmission through optical fibers and introduce the working of optical components.

iv) COURSE OUTCOMES

After the completion of the course, the student will be able to:

Course Outcomes	Description	Level
CO 1	Explain the working and classification of optical fibers in terms of propagation modes	Understand
CO 2	Solve problems of transmission characteristics and losses in optical fiber	Apply
CO 3	Explain the constructional features and the characteristics of optical sources and detectors	Understand
CO 4	Describe the operations of optical amplifiers	Understand
CO 5	Explain the concepts of WDM, FSO and LiFi	Understand

v) SYLLABUS

Optical fiber Communications: The general system, Advantages of optical fiber communication, Optical fiber waveguides: Ray theory transmission, Modes in planar guide, Phase and group velocity **Fibres:** Types and refractive index profiles, Step index fibers, Graded index fibers, Single mode fibers, Cutoff wavelength, Mode field diameter, effective refractive index. Fibre materials, photonic crystal fibre, index guiding PCF, photonic band- gap fibres, fibre cables.

Transmission characteristics of optical fiber: Attenuation, Material absorption losses, Linear scattering losses, Nonlinear scattering losses, Fiber bend loss, Dispersion, Chromatic dispersion, Intermodal dispersion: Multimode step index fiber.

Optical Fiber Connectors: Fiber alignment and joint loss, Fiber splices, Fiber connectors, Fiber couplers.

Optical sources: LEDs and LDs, structures, characteristics**,**modulators using LEDs and LDs. coupling with fibres, noise in Laser diodes, Amplified Spontaneous Emission noise, effects of Laser diode noise in fibre communications

Optical detectors: Types and characteristics, structure and working of PIN and AP, noise in detectors, comparison of performance.Optical receivers, Ideal photo receiver and quantum limit ofdetection.

Optical Amplifiers:basic concept, applications, types, doped fibre amplifiers, EDFA, basic theory, structure and working, Semiconductor laser amplifier, Raman amplifiers, TDFA, amplifier configurations, performance comparison.

The WDM concept, WDM standards, WDM components, couplers, splitters, Add/ Drop multiplexers, gratings, tunable filters. Introduction to free space optics, LiFi technology and VLC. Optical Time Domain Reflectometer (OTDR) – fault detection length and refractive index measurements.

vi) a) TEXT BOOKS

1. Gerd Keiser, Optical Fiber Communications, 5/e, McGraw Hill, 2013.
2. Mishra and Ugale, Fibre optic Communication, Wiley, 2013.
3. Ajoy Ghatak and K. Thyagarajan Introduction to Fiber Optics, Cambridge University Press -1998

b) REFERENCES

1. Chakrabarthi, Optical Fibre Communication, McGraw Hill, 2015.
2. Hebbar, Optical fibre communication, Elsevier, 2014
3. John M Senior- Optical communications, 3/e, Pearson, 2009.
4. Joseph C. Palais, Fibre Optic Communications, 5/e Pearson, 2013.
5. Keiser, Optical Communication Essentials (SIE), 1/e McGraw Hill Education New Delhi, 2008

vii) COURSE PLAN

Module	Contents	No. of hours
I	**Optical fiber Communications:** The general system, Advantages of optical fiber communication, Optical fiber waveguides: Ray theory transmission, Modes in planar guide, Phase and group velocity **Fibres:** Types and refractive index profiles, Step index fibers, Graded index fibers, Single mode fibers, Cutoff wavelength, Mode field diameter, effective refractive index. Fibre materials, photonic crystal fibre, index guiding PCF, photonic band-gap fibres, fibre cables.	**10**
II	**Transmission characteristics of optical fiber:** Attenuation, Material absorption losses, Linear scattering losses, Nonlinear scattering losses, Fiber bend loss, Dispersion, Chromatic dispersion, Intermodal dispersion: Multimode step index fiber. **Optical Fiber Connectors:** Fiber alignment and joint loss, Fiber splices, Fiber connectors, Fiber couplers.	**10**
III	**Optical sources:** LEDs and LDs, structures, characteristics, modulators using LEDs and LDs. coupling with fibres, noise in Laser diodes, Amplified Spontaneous Emission noise, effects of Laser diode noise in fibre communications **Optical detectors:** Types and characteristics, structure and working of PIN and AP, noise in detectors, comparison of performance. Optical receivers, Ideal photo receiver and quantum limit of detection	**10**
IV	**Optical Amplifiers:** basic concept, applications, types, doped fibre amplifiers, EDFA, basic theory, structure and working, Semiconductor laser amplifier, Raman amplifiers, TDFA, amplifier configurations, performance comparison.	**8**
V	The WDM concept, WDM standards, WDM components, couplers, splitters, Add/ Drop multiplexers, gratings, tunable filters. Introduction to free space optics, LiFi technology and VLC. Optical Time Domain Reflectometer (OTDR) – fault detection length and refractive index measurements	**7**
	Total hours	**45**

vi) ASSESSMENT PATTERN

Mark distribution

Total Marks	Continuous Internal Evaluation Marks	End Semester Evaluation Marks	End Semester Examination Duration
150	50	100	3 Hours

Continuous Internal Evaluation Pattern:

Attendance	**10 Marks**
Continuous Assessment Tests (2 numbers)	**25 Marks**
Assignment/Quiz/Course project	**15 Marks**

End Semester Examination Pattern:

There will be two parts; Part A and Part B. Part A contain10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one .Each question can have maximum 2 sub-divisions and carry 14marks.

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EC1U41B	COMPUTER NETWORKS	PEC	3	0	0	3	2020

i) PREREQUISITE: MA0U20C - Probability, Random Process, and Numerical Methods

ii) COURSE OVERVIEW

This course aims to expose students to computer networks taking a top-down approach of viewing from the layer of user applications and zooming into link layer protocols

iii) COURSE OUTCOMES

After the completion of the course, the student will be able to

Course Outcomes	Description	Level
CO 1	Describe the protocols used in web and email applications.	Understand
CO 2	Explain the concept of reliable data transfer, flow control and congestion over a TCP network.	Understand
CO 3	Apply Dijkstra‟s algorithm and distance-vector algorithm in the context of routing over computer networks	Apply
CO 4	Explain the services provided by the link layer and addressing involved in it.	Understand
CO 5	Analyze the delay performance of an ARQ system using standard queuing models.	Apply

iv) SYLLABUS

Components of computer network, Applications of computer network – the Internet, Definition of protocol. Network edges, Network core and Network links- TDM versus statistical multiplexing, Datagram versus Virtual-circuit networks.- Access and physical media. Delay and loss in packet-switched networks. Application layer: Web application: HTTP, Message format, Email application: SMTP, Message format, MIME, POP3 and Web-based email. Transport Layer: UDP, Protocols for reliable data transfer: TCP Connection, segment structure, Congestion Control. Network Layer: Router architecture, -IPv4 and IPv6. Routing Algorithms- Link-State (Dijkstra‟s) Algorithm, Distance vector algorithm. Routing in Internet. Services of link layer, Error detection and correction. Multiple access protocols. Link layer addressing. Ethernet. IEEE 802.11 wireless LAN-Queueing models in computer networks : Littles theorem and examples. Review of Poisson process. M/G/1 Queue. Delay analysis of Go-Back-N ARQ system

v) a) TEXT BOOKS

1. James F. Kurose, Keith W. Ross, *Computer Networking: A Top-Down Approach Featuring the Internet*, 3rd edition, Pearson
2. D. Bertsekas, RG Gallager, *Data Networks*, Prentice Hal

b) REFERENCES

1. N. Abramson, F. Kuo, *Computer Communication Networks*, Prentice Hall
2. A. S. Tanenbaum, D. J. Wetherall, *Computer Networks*, Pearson
3. A. Kumar, D. Manjunath, J. Kuri, *Communication Networking – An Analytical Approach*, Morgan Kauffman Series.
4. Larry L. Peterson, Bruce S. Davie, *Computer Networks – A Systems Approach*, Morgan Kauffman

vi) COURSE PLAN

Module	Contents	No. of hours
I	**Components of computer networks** Components of computer network, Applications of computer network – the Internet, Definition of protocol. Protocol standardization. **Network edges, Network core and Network links** Client and server hosts, connectionless and connection-oriented services provided to hosts, circuit-switched versus packet-switched network cores, FDM, TDM versus statistical multiplexing, Datagram versus Virtual-circuit networks. Access and physical media. **Delay and loss in packet-switched networks** Types of delay, Packet loss. Layered Architecture: Protocol layering, Internet protocol stack, Message encapsulation. **Application Layer** Communication between processes, Web application: HTTP, Message format, Email application: SMTP, Message format, MIME, POP3 and Web-based email. Domain Name System (DNS)	**12**
II	**Transport Layer** UDP, Protocols for reliable data transfer: ARQ protocols, stop-and-wait protocol, Go-backN, Selective Repeat. TCP Connection, segment structure, RTT estimate, Flow control. **Congestion Control** General approaches. TCP congestion control	**8**
III	**Network Layer** Datagram versus virtual-circuit network service, Router architecture, IPv4: datagram format, addressing, address assignment – manual and DHCP, ICMP. IPv6. **Routing Algorithms** Link-State (Dijkstra‟s) Algorithm, Distance vector algorithm. Routing in Internet – RIP, OSPF, BGP.	**10**
IV	**Link Layer** Services of link layer, Error detection and correction – checksum, CRC. Multiple access protocols – Channel partitioning, random access, taking-turns. CSMA, CSMA/CA, CSMA/CD. Link layer addressing: MAC address, ARP, DHCP. Ethernet.	**8**
V	**Wireless Networks** IEEE 802.11 wireless LAN **Queueing models in computer networks** Littles theorem and examples. Review of Poisson process. M/G/1 Queue. Delay analysis of Go-Back-N ARQ system	**7**
	Total hours	**45**

(vii) ASSESSMENT PATTERN

Mark distribution

Total Marks	Continuous Internal Evaluation Marks	End Semester Evaluation Marks	End Semester Examination Duration
150	**50**	**100**	**3 Hours**

Continuous Internal Evaluation Pattern:

Attendance	**10 Marks**
Continuous Assessment Tests (2 numbers)	**25 Marks**
Assignment/Quiz/Course project	**15 Marks**

End Semester Examination Pattern:

There will be two parts; Part A and Part B. Part A contain10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EC1U41C	OPTO-ELECTRONIC DEVICES	PEC	2	1	0	3	2020

i) PREREQUISITE: PH0U10A - Engineering Physics, EC1U20A - Solid State Devices

ii) COURSE OVERVIEW: This course aims to develop an insight over the working principles and performance parameters of various optoelectronics devices used for optical networks and communication.

iii) COURSE OUTCOMES

After the completion of the course the student will be able to:

Course Outcomes	Description	Level
CO 1	Explain the property of absorption, recombination and photoemission in semiconductors.	Understand
CO 2	Distinguish different optical sources used in optoelectronic applications.	Understand
CO 3	Analyse different types of photodetectors based on their performance parameters	Apply
CO 4	Explain various optical modulators and optoelectronic devices.	Understand
CO 5	Explain various optical devices used for optical communication.	Understand

iv) SYLLABUS

Fundamentals of Semiconductor Optoelectronics, Optical Sources, Optical Detectors, Optoelectronic Devices and Modulators, Optical Devices in Optoelectronic Networks.

v) a) TEXT BOOKS

1. Pallab Bhattacharya: Semiconductor Optoelectronic Devices, Pearson, 2009.

b) REFERENCES

1. Mark Csele, Fundamentals of Light Sources and Lasers, Wiley-Interscience, 2004.
2. W.Koechner,M.Bass, Solid State Lasers, Springer, 2003.
3. Yariv, Photonics Optical Electronics in modern communication, 6/e ,Oxford University Press,2006.
4. Harry J R Dutton, Understanding Optical Communications, IBM 1/e 1998.
5. Alastair Buckley, Organic Light-Emitting Diodes, Woodhead, 2013.
6. Stephen J Fonash, Solar Cell Device Physics, Elsevier 2/e, 2010.

vi) COURSE PLAN

Module	Contents	No. of hours
I	Optical processes in semiconductors: electron-hole generation and recombination, Absorption,Auger recombination, Heat generation and dissipation, Heat sources.Various light production mechanisms,Indirect band gap materials, Semiconductors used for optical Applications, Basic principle of LED and LASER, Spontaneous emission and Stimulated Emission, Coherence of sources.	9
II	Construction and Operation of LEDs, Heterojunctions, Surface Emitter and Edge Emitter LEDs, Characteristics of LEDs, LASERs, Threshold Condition for lasing, Line Broadening Mechanisms, Fabry-Perot Lasers, Distributed Feedback(DFB) Lasers, Distributed Bragg Reflector(DBR) Lasers, Vertical Cavity Surface Emitting Lasers (VCSELs), In-Fibre Lasers.	9
III	Principle of Photo Detection,Working of LDR, PN diode, PIN diode, Avalanche Photodiode (APD), Characteristics of APD, Resonant Cavity Photodetector, Photo Transistor, Quantum efficiency, Responsivity, Noise in Photodetectors, Thermal Noise, Dark Current, Shot Noise, Quantum limit of Optical Detection.	9
IV	Optoelectronic ICs, Advantages, Liquid Crystal Display, Structure, TFT display, Structure, Polymer LED, Organic LED, Optical Modulators using PN junction, Electro-Optic Modulators, Acousto-Optic Modulators, Raman-Nath Modulators, Optical switching and Logic devices,Optical Memory. Solar Cells: basic working principle, VI Characteristics, Different types of solar cells, Dye sensitized solar cells (DSSC), Perovskite Solar cells.	9
V	Introduction to optical components, Splitters and Couplers, Directional Couplers, Fiber Bragg Gratings, Multiplexers, Attenuators, Isolators, Circulators, Fixed Filters, Tunable Filters, Add Drop Multiplexers, Waveguide Grating Routers, Optical Cross Connects, Wavelength Convertors, Optical Bistable Devices.	9
	Total hours	**45**

vii) ASSESSMENT PATTERN

Mark distribution

Total Marks	Continuous Internal Evaluation Marks	End Semester Evaluation Marks	End Semester Examination Duration
150	50	100	3 Hours

Continuous Internal Evaluation Pattern:

Attendance	**10 Marks**
Continuous Assessment Tests (2 numbers)	**25 Marks**
Assignment/Quiz/Course project	**15 Marks**

End Semester Examination Pattern:

There will be two parts; Part A and Part B. Part A contain10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EC1U41D	INSTRUMENTATION	PEC	2	1	0	3	2020

i) PREREQUISITE: Nil

ii) COURSE OVERVIEW

This course aims to introduce the basic concepts of electronic measuring instruments for measuring physical variables using transducers and to familiarize the concepts of the control systems PLC, DCS and SCADA.

iii) COURSE OUTCOMES

After the completion of the course, the student will be able to

Course Outcomes	Description	Level
CO 1	Interpret the basic concepts of measuring instruments, its classification, and selection criteria, static and dynamic characteristics.	Understand
CO 2	Explain the principle, construction and working of transducers for measuring physical variables.	Understand
CO 3	Explain the principle, construction and working of various electronic measuring instruments.	Understand
CO 4	Explain the hardware architecture for PLC, DCS and SCADA.	Understand
CO 5	Apply PLC programming for basic applications.	Apply

iv) SYLLABUS

Generalized Configurations and Functional elements of Instrumentation systems. Need for Measurement Systems, Classification of Types of Measuring instruments. Sensors and Transducers: - Need, Classification and selection criteria. Transducer: Principles of operation, construction, applications of Resistive Transducers, Inductive Transducers, and Capacitive Transducers: Active Transducers: Thermocouple, Piezo-electric transducer, Hall Effect transducer, Flow meter. Electronic Measuring Instruments Digital storage oscilloscope, Working principle and applications of waveform analyser, digital frequency meter, harmonic distortion meter, harmonic analyser, spectrum analyser and logic state analyser IEEE - 488 General Purpose Interface Bus (GPIB) Instruments with application.EMI, Grounding and Shielding

PLC, DCS and SCADA PLC Basics: General PLC Programming Procedures, Distributed Control System; hardware components of DCS; DCS software. Introduction to SCADA: overview, Architecture – Monolithic, Distributed and Networked, SCADA Protocols. PLC Programming Basic PLC Programming : Programming ON/OFF Inputs, Creating Ladder diagrams, Register Basics, PLC Timers and Counters, PLC Arithmetic functions, Number comparison functions, Data handling Functions: master control relay function and applications; jump with non-return and return; data table, register and other move functions.

v) a) TEXT BOOKS

1. Ernest Doebelin, Dhanesh N. Manik, *„Doebelin's Measurement Systems"*, McGraw Hill, 7th Edition, 2019
2. Kalsi HS, *"Electronic Instrumentation,"* Tata McGraw Hill, Third Edition
3. John R Hackworth, Frederick D Hackworth, Jr, *"Programmable Logic controllers Programming Methods and Applications",* Pearson Education.

b) REFERENCES

1. Sawhney AK, *"Electrical and Electronics Measurements and Instrumentation,"* Dhanpat Rai and Sons
2. John W Webb, Ronald A. Reis, *"Programmable Logic Controllers- Principles and applications",* PHI , ND, 2006

vi) COURSE PLAN

Module	**Contents**	**No. of hours**
I	**Introduction to measuring instruments** Generalized Configurations and Functional elements of Instrumentation systems, Need for Measurement Systems, Classification of Types of Measuring instruments. Static and Dynamic characteristics of measuring instruments. Sensors and Transducers: - Need, Classification and selection criteria.	**10**
II	Principles of operation, construction, theory, advantages and disadvantages, applications of Resistive Transducers: Potentiometers, strain gauges, (metallic and semi-conductor type), Resistance Thermometer, Thermistors. Inductive Transducers: LVDT (Linear variable differential transformer). Capacitive Transducers: various capacitive transducers based upon familiar equation of capacitance (capacitive microphone) Active Transducers: Thermocouple, Piezo-electric transducer, Hall Effect transducer, Flow meter	**10**
III	Digital storage oscilloscope, Working principle and applications of waveform analyser, digital frequency meter, harmonic distortion meter, harmonic analyser, spectrum analyser and logic state analyser.	**8**
IV	An Overall looks at PLCs, General PLC Programming Procedures, Devices to which PLC Inputs and Outputs are connected. **Distributed Control System:** Meaning and necessity of distributed control; hardware components of DCS; DCS software. **Introduction to SCADA:** SCADA overview, SCADA Architecture – Monolithic, Distributed and Networked, SCADA Protocols- IEC 60870-5-101, DNP-3, Profibus, Modbus	**8**
V	Programming ON/OFF Inputs, Creating Ladder diagrams, Register Basics, PLC Timers and Counters, PLC Arithmetic functions, Number comparison functions, Data handling Functions: Skip function and applications; master control relay function and applications; jump with non-return and return; data table, register and other move functions.	**9**
	Total hours	**45**

(vii) ASSESSMENT PATTERN

Mark distribution

Total Marks	Continuous Internal Evaluation Marks	End Semester Evaluation Marks	End Semester Examination Duration
150	**50**	**100**	**3 Hours**

Continuous Internal Evaluation Pattern:

Attendance	**10 Marks**
Continuous Assessment Tests (2 numbers)	**25 Marks**
Assignment/Quiz/Course project	**15 Marks**

End Semester Examination Pattern:

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EC1U41E	ERROR CONTROL CODES	PEC	2	1	0	3	2020

i) PREREQUISITE: EC1U30G - Information Theory and Coding

ii) COURSE OVERVIEW:

This course aims to give an insight into the various codes used for error control in data transmission.

iii) COURSE OUTCOMES

After the completion of the course, the student will be able to:

Course Outcomes	Description	Level
CO 1	Describe the principles of block codes, types and their bounds.	Understand
CO 2	Illustrate the principles of cyclic codes and Galois Fields, encoding and decoding of binary BCH codes and algorithms for finding the error location polynomial	Understand
CO 3	Demonstrate encoding, decoding and error locationof Reed Solomon codes and Reed Muller codes	Apply
CO4	Illustrate the encoding and decoding of Convolution Codes and Turbo Codes	Apply
CO5	Describe the encoding, decoding and applications of LDPC Codes	Apply
CO6	Discuss the concepts of polar codes and its applications in 5G	Apply

iv) SYLLABUS

Error Control Coding – Relevance of error control codes in Communication System, concepts of Code rate, Hamming Distance, Minimum Distance, Error detecting and correcting capability. Repetition Codes, Hamming Codes, Review of Groups, Fields, Vector Spaces. Linear Block Codes - Generator matrix, Parity Check Matrix. Dual Codes, Error Detection and Correction over hard output channels. Dual of binary Hamming codes. Maximum Likelihood Decoding Simple bounds on block codes - Singleton bound, Hamming Bound, Gilbert-Varshamov bound. Maximum-distance-separable (MDS) codes.

Review of basic concepts of cyclic codes – generator matrix, parity-check matrix. Polynomial view point. Encoding, systematic encoding, syndrome decoding.
Galois Fields -- Irreducible and Primitive Polynomials, Primitive elements, Field extension, Conjugate elements and Minimal Polynomials. Cyclotomic cosets.

BCH Codes - Design, BCH Bound, Decoding BCH codes – Decoding BCH – the general outline, computation of the syndrome, error locator polynomial, Chien Search algorithm, Finding the error locator polynomial. Berlekamp Massey Algorithm. Burst-error correction capability of BCH codes.

Reed Solomon Codes – BCH code viewpoint. Vandermonde matrix view point. MDS property. Generalized Reed-Solomon codes. Application of BCH decoding algorithms to Reed-Solomon decoding. Sudan‟s algorithm for decoding. Use of RS codes in disks and cloud storage. Reed Muller Codes, Encoding and decoding of RM (1, m) codes. Majority-logic decoding of Reed-Muller codes.

Convolution Codes, State Diagram, Systematic Encoders, Decoding of Convolution Codes – Viterbi algorithm, Turbo Codes, Encoding parallel concatenated codes.

Low Density Parity Codes, Construction, Tanner Graphs, Message passing decoding. Example of message passing decoding over binary erasure channels. Message passing of LLR and decoding over AWGN channels.
Polar Codes – Introduction, polarization of BEC channels, Polar transform and frozen bits. LDPC and Polar codes in 5G.

v) TEXT BOOKS & REFERENCES

1. Shu Lin, D. J Costello Jr. Error Control Coding: Fundaments and Applications, Prentice Hall
2. Ron M Roth, Introduction to Coding Theory, Cambridge University Press
3. Todd K. Moon, Error Correction Coding: Mathematical Methods and Algorithms, Wiley.
4. T. Richardson, R. Urbanke, Modern Coding Theory, Cambridge University Press
5. H. Pfister, A Brief Introduction to Polar Codes, Lec. Notes
6. O. Gazi, Polar Codes: A Non-Trivial Approach to Channel Coding, Springer, 2018.
7. A. Thangaraj, LDPC and Polar Codes in 5G Standard, NPTEL Course

vi) COURSE PLAN

Module	Contents	No. of hours
I	**Block Codes and Bounds** Error Control Coding – Relevance of error control codes in Communication System, concepts of Code rate, Hamming Distance, Minimum Distance, Error detecting and correcting capability. Repetition Codes, Hamming Codes, Review of Groups, Fields, Vector Spaces. Linear Block Codes - Generator matrix, Parity Check Matrix. Dual Codes, Error Detection and Correction over hard output channels. Dual of binary Hamming codes. Maximum Likelihood Decoding. Simple bounds on block codes - Singleton bound, Hamming Bound, Gilbert-Varshamov bound. Maximum-distance-separable (MDS) codes.	**9**
II	**Cyclic Codes** Review of basic concepts of cyclic codes – generator matrix, parity- check matrix. Polynomial view point. Encoding, systematic encoding, syndrome decoding. Galois Fields -- Irreducible and Primitive Polynomials, Primitive elements, Field extension, Conjugate elements and Minimal Polynomials. Cyclotomic cosets. BCH Codes - Design, BCH Bound, Decoding BCH codes – Decoding BCH – the general outline, computation of the syndrome, error locator	**9**

	polynomial, Chien Search algorithm, Finding the error locator polynomial. Berlekamp Massey Algorithm. Burst-error correction. Capability of BCH codes.	
III	**Reed-Solomon and Reed-Muller Codes** Reed Solomon Codes – BCH code viewpoint. Vandermonde matrix view point. MDS property. Generalized Reed-Solomon codes. Application of BCH decoding algorithms to Reed-Solomon decoding. Sudan‟s algorithm for decoding. Use of RS codes in disks and cloud storage. Reed Muller Codes, Encoding and decoding of RM (1, m) codes. Majority-logic decoding of Reed-Muller codes.	**9**
IV	**Convolutional and Turbo Codes** Convolution Codes, State Diagram, Systematic Encoders, Decoding of Convolution Codes – Viterbi algorithm. Turbo Codes, Encoding parallel concatenated codes.	**9**
V	**LDPC and Polar Codes** Low Density Parity Codes, Construction, Tanner Graphs, Message passing decoding. Example of message passing decoding over binary erasure channels. Message passing of LLR and decoding over AWGN channels. Polar Codes – Introduction, polarization of BEC channels, Polar transform and frozen bits. LDPC and Polar codes in 5G.	**9**
	Total hours	**45**

vi) ASSESSMENT PATTERN

Mark distribution

Total Marks	**Continuous Internal Evaluation Marks**	**End Semester Evaluation Marks**	**End Semester Examination Duration**
150	**50**	**100**	**3 Hours**

Continuous Internal Evaluation Pattern:

Attendance	**10 Marks**
Continuous Assessment Tests (2 numbers)	**25 Marks**
Assignment/Quiz/Course project	**15 Marks**

End Semester Examination Pattern:

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EC1U41F	MACHINE LEARNING	PEC	2	1	0	3	2020

i) **PREREQUISITE:** MA0U10A-Linear Algebra and Calculus, MA0U20C -Probability, Random Process, and Numerical Methods

ii) COURSE OVERVIEW:

This course aims to impart the fundamentals of machine learning techniques.

iii) COURSE OUTCOMES

After the completion of the course, the student will be able to:

Course Outcomes	Description	Level
CO 1	Explain the basics of machine learning and its different types of applications.	Understand
CO 2	Differentiate regression and classification theory in machine learning.	Understand
CO 3	Apply linear algebra and statistical methods in discriminant based algorithms.	Apply
CO 4	Explain the basics of supervised and unsupervised learning algorithms and non-metric methods.	Understand
CO 5	Summarize ensemble methods, dimensionality reduction, evaluation, model selection.	Apply

iv) SYLLABUS

Basics of machine learning, supervised and unsupervised learning, feature extraction, over- fitting, curse of dimensionality. Review of probability theory. Regression: linear regression, Classification : Bayes‟ decision theory, discriminant functions and decision surfaces, classification applications, Linear discriminant based algorithm: perceptron, gradient descent method, support vector machines. Unsupervised learning: Clustering, Ensemble methods. Dimensionality reduction, Evaluation and model Selection, Confusion matrix.

v) a) TEXT BOOKS

Bernard Widrow and Samuel D. Stearns, ―Adaptive Signal Processing‖, Person Bishop, C. M. “Pattern Recognition and Machine Learning” Springer, New York, 2006.

Theodoridis, S. and Koutroumbas, K. “Pattern Recognition”. Academic Press, San Diego, 2003.

b) REFERENCES

1) Bishop, C. M. “Pattern Recognition and Machine Learning” Springer, New York, 2006.

vi) COURSE PLAN

Module	Contents	No. of hours
I	Basics of machine learning, supervised and unsupervised learning, examples, features, feature vector, training set, target vector, test set feature extraction, over-fitting, curse of dimensionality. Review of probability theory, Gaussian distribution, decision theory.	10
II	Regression: linear regression, error functions in regression 2 multivariate regression, regression applications, bias and variance. Classification : Bayes‟ decision theory, discriminant functions and decision surfaces, Bayesian classification for normal distributions, classification applications.	10
III	Linear discriminant based algorithm: perceptron, Gradient descent method, perceptron algorithm, support vector machines , SVM for separable classes and non-separable classes, multiclass case.	8
IV	Unsupervised learning: Clustering, examples, criterion functions for clustering Proximity measures, algorithms for clustering. Ensemble methods: boosting, bagging. Basics of decision trees, random forest, examples.	7
V	Dimensionality reduction: principal component analysis, Fischer's discriminant analysis. Evaluation and model selection: ROC curves, evaluation measures, validation set, bias-variance trade-off. confusion matrix, recall, precision, accuracy.	10
	Total hours	**45**

vii) ASSESSMENT PATTERN

Mark distribution

Total Marks	Continuous Internal Evaluation Marks	End Semester Evaluation Marks	End Semester Examination Duration
150	50	100	3 Hours

Continuous Internal Evaluation Pattern:

Attendance	**10 Marks**
Continuous Assessment Tests (2 numbers)	**25 Marks**
Assignment/Quiz/Course project	**15 Marks**

End Semester Examination Pattern:

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EC1U41G	DSP ARCHITECTURE	PEC	2	1	0	3	2020

i) **PREREQUISITE:** EC1U30B - Digital Signal processing

ii) **COURSE OVERVIEW**:

The aim of the course is to give an overview of the commonly used DSP algorithms, their applications, and various techniques for the algorithmic and architecture level optimisations through various algorithm to architecture mapping which can lead to efficient hardware implementations. The course also introduces the basic features in Digital Signal Processors, DSP architecture with case studies, the latest architectural trends in DSP and their programming tools.

iii) **COURSE OUTCOMES**

After the completion of the course, the student will be able to:

Course Outcomes	Description	Level
CO 1	Solve the basic resource constraints in a practical DSP system using various techniques/transformations that map the DSP algorithms to efficient architectures.	Understand
CO 2	Illustrate various single core and multicore Digital Signal Processor architectures and identify the optimal processor for solving real life signal processing problems.	Understand
CO 3	Develop algorithms to solve signal processing problems using the latest hardware platforms and software tools.	Apply

iv) **SYLLABUS**

Basics of DSP Algorithm Representation to Architecture Mapping - DSP Algorithm representations, Introduction to Filter structures- Recursive, Fundamentals of DSP algorithm to architecture mapping; Transformations for Improved DSP Architectures - VLSI performance measures, Transformations for improved DSP architectures, Pipelining, Folding and Unfolding Transformations and its applications; Single Core DSP Architectures - Introduction to General Purpose Processors (GPP), The key features of a Digital Signal Processors, Harvard DSP architectures, VLIW Architecture and Single Instruction Multiple Data (SIMD) processor architecture; Homogeneous Multicore DSPs - multicore processors and their applications, Multicore DSP Architectures: The TMS320C66x architecture; Programming the DSPs - Code Composer Studio (CCS) software development tool and the TMS320C6678 EVM kit, OpenMP Application Programming Interface (API) and Open Computing Language (OpenCL), Latest architectural trends in digital signal processing: Introduction to Heterogeneous Multicore DSP Architecture and FPGA SoCs

v) a) TEXT BOOKS

1) Bernard Keshab K. Parhi, "VLSI Signal Processing Systems, Design and Implementation", John Wiley &Sons,1999
2) Naim Dahnoun, “Multicore DSP: from algorithms to real-time implementation on the TMS320C66x SoC”. John Wiley & Sons, 2018.
3) Steven W. Smith, “The Scientist and Engineer‟s Guide to Digital Signal Processing”, Second Edition, California Technical Publishing , 1999.
4) Reference Link for Overview of Latest Processor Architectures–Digital signal processors (DSPs) | Overview | Processors | TI.com, https://training.ti.com/system/files/docs/c66x-corepac-instruction-set-reference-guide.pdf

b) REFERENCES

1) Simon Rulph Chassaing, “Digital Signal Processing and Applications with the C6713 and C6416 DSK”, John Wiley & Sons, 2005.
2) Sen M. Kuo, Woon-Seng S. Gan, Digal Signal Processors: Architectures, Implementations, and Applications, Prentice Hall, 2004.
3) Lars Wanhammar, DSP Integrated Circuits, Academic Press, 1999.
4) B Venkataramani, M Bhaskar, “Digital Signal Processors: Architecture, Programming and Applications”, 2nd Ed., Tata McGraw-Hill Education, 2002.
5) A. Kharin, S. Vityazev and V. Vityazev, "Teaching multi-core DSP implementation on EVM C6678 board," 2017 25th European Signal Processing Conference (EUSIPCO), 2017, pp. 2359-2363, doi: 10.23919/EUSIPCO.2017.8081632

vi) COURSE PLAN

Module	Contents	No. of hours
I	**Basics of DSP Algorithm Representation to Architecture Mapping:** DSP Algorithm representations –Block Diagram, Signal Flow Graph, Data Flow Graph, Dependence Graph; Introduction to Filter structures-Recursive, Non-recursive and Lattice structures; Fundamentals of DSP algorithm to architecture mapping - Loop bound, Iteration Bound, Critical Path, Algorithms for computing Iteration Bound – Longest Path Matrix Algorithm, Minimum Cycle Mean Algorithm.	10
II	**Transformations for Improved DSP Architectures:** VLSI performance measures - area, power, and speed; Transformations for improved DSP architectures: Pipelining - Pipelining of FIR filters, Concept of Fine Grain Pipelining; Parallel Processing – Designing Parallel FIR systems, Pipelining and Parallel Processing for low power. Folding and Unfolding Transformations and its applications.	9
III	**Single Core DSP Architectures:** Introduction to General Purpose Processors (GPP), Microcontroller Units (MCU), Digital Signal Processors (DSP) – comparison and Applications. The key features of a Digital Signal Processors – Dedicated hardware units, circular buffers, Modified bus structures and Memory access schemes. Introduction to Harvard, Super Harvard DSP architectures, Concept of Instruction Level Parallelism, VLIW	9

	Architecture and Single Instruction Multiple Data (SIMD) processor architecture. Case Study: Introduction to a popular DSP from Texas Instruments, The TMS320C67xxSeries Processor - CPU Architecture - CPU Data Paths and Control - Timers -Internal Data/ Program Memory - External Memory Interface.	
IV	**Homogeneous Multicore DSPs:** Introduction to multicore processors and their applications, A brief comparison between DSP SoCs, Field-Programmable Gate Arrays (FPGAs), Graphic Processors and CPUs. Introduction to Multicore DSP Architectures: The TMS320C66x architecture: The CPU, Overview of the peripherals, Useful instructions, Overview of the memory organization.	**8**
V	**Programming the DSPs:** Introduction to Code Composer Studio (CCS) software development tool and the TMS320C6678 EVM kit. Introduction to OpenMP Application Programming Interface (API) and Open Computing Language (OpenCL). Implementation of simple DSP algorithms – Dot Product. Latest architectural trends in digital signal processing: Introduction to Heterogeneous Multicore DSP Architecture and FPGA SoCs.	**9**
	Total hours	**45**

vii) ASSESSMENT PATTERN

Mark distribution

Total Marks	Continuous Internal Evaluation Marks	End Semester Evaluation Marks	End Semester Examination Duration
150	**50**	**100**	**3 Hours**

Continuous Internal Evaluation Pattern:

Attendance	**10 Marks**
Continuous Assessment Tests (2 numbers)	**25 Marks**
Assignment/Quiz/Course project	**15 Marks**

End Semester Examination Pattern:

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

OPEN ELECTIVE

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EC0U41A	MECHATRONICS	OEC	2	1	0	3	2020

i) COURSE OVERVIEW

This course introduces students to the rapidly emerging, multi-disciplinary, and exciting field of Mechatronics

ii) COURSE OUTCOMES

After the completion of the course, the student will be able to:

Course Outcomes	Description	Level
CO 1	Understand the working principles of various sensors and actuators in Mechatronics systems and be able to choose the suitable one for the real world application	Understand
CO 2	Formulate and simulate models of mechatronics systems	Apply
CO 3	Explain the implementation of PLC in mechatronics Applications	Understand
CO 4	Explain the standard fabrication techniques and principle of operation of MEMS devices	Understand
CO 5	Design and analyse the commonly encountered mechatronics systems for real time application	Analyze

iii) SYLLABUS

Introduction to Mechatronics: Structure of Mechatronics system. Comparison between traditional and mechatronics approach. Sensors - Characteristics -Temperature, flow, pressure sensors. Displacement, position and proximity sensing by magnetic, optical, ultrasonic, inductive, capacitive and eddy current methods. Encoders: incremental and absolute. Resolvers and synchros. Piezoelectric sensors. Acoustic Emission sensors. vibration sensors. Force and tactile sensors. Range finders: ultrasonic and light base range finders

Actuators: Hydraulic and Pneumatic actuators - Directional control valves, pressure control valves, process control valves. Rotary actuators. Development of simple hydraulic and pneumatic circuits using standard Symbols. Electrical drives: DC, AC, brushless, servo and stepper motors. Harmonic drive. Magnetostrictive actuators and piezoelectric actuators.

System modelling - Mathematical models and basic building blocks of general mechanical, electrical, fluid and thermal systems. Typical elements of open and closed loop control systems. Adaptive controllers for machine tools. Programmable Logic Controllers (PLC) – Basic structure, input/ output processing. Programming: Timers, Internal Relays, Counters and Shift registers. Development of simple ladder programs for specific purposes.

Micro Electro Mechanical Systems (MEMS): Fabrication: Deposition, Lithography, Micromachining methods for MEMS -Surface and Bulk, Deep Reactive Ion Etching (DRIE) and LIGA processes. Principle, fabrication and working of MEMS based pressure sensor, accelerometer and gyroscope.

Mechatronics in Robotics- choice of Sensors and Actuators. Robotic vision system – Image acquisition: Vidicon, charge coupled device (CCD) and charge injection device (CID) cameras. Image processing techniques: histogram processing: sliding, stretching, equalization and thresholding. Case studies of Mechatronics systems: Automatic camera, bar code reader, simple weighing machine, pick and place robot, automatic car park barrier system, automobile engine management system.

iv) (a) TEXT BOOKS

1) Bolton W., Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering, Person Education Limited, New Delhi, 2007

2) Ramachandran K. P., G. K. Vijayaraghavan, M. S. Balasundaram, Mechatronics: Integrated Mechanical Electronic Systems, Wiley India Pvt. Ltd., New Delhi, 2008.

3) Saeed B. Niku, Introduction to Robotics: Analysis, Systems, Applications, Person Education, Inc., New Delhi, 2006.

4) Devdas Shetty, Richard A. Kolk, “Mechatronics System Design”, Thomson Learning Publishing Company, Vikas publishing house, Second edition, 2001.

(b) REFERENCES

1) David G. Aldatore, Michael B. Histand, Introduction to Mechatronics and Measurement Systems, McGraw-Hill Inc., USA, 2003.

2) Gordon M. Mair, Industrial Robotics, Prentice Hall International, UK, 1998.

3) HMT, Mechatronics, Tata McGraw-Hill Publishing Company Ltd., New Delhi, 2004.

4) Vijay K. Varadan, K. J. Vinoy, S. Gopalakrishnan, Smart Material Systems and MEMS: Design and Development Methodologies, John Wiley & Sons Ltd., England, 2006.

5) Bishop, Robert H. The Mechatronics Handbook-2 Volume Set. CRC press, 2002.

v) COURSE PLAN

Module	Contents	No. of hours
I	Introduction to Mechatronics: Structure of Mechatronics system. Comparison between traditional and mechatronics approach. Sensors - Characteristics -Temperature, flow, pressure sensors. Displacement, position and proximity sensing by magnetic, optical, ultrasonic, inductive, capacitive and eddy current methods. Encoders: incremental and absolute. Resolvers and synchros. Piezoelectric sensors. Acoustic Emission sensors. vibration sensors. Force and tactile sensors. Range finders: ultrasonic and light base range finders	9
II	Actuators: Hydraulic and Pneumatic actuators - Directional control valves, pressure control valves, process control valves. Rotary actuators. Development of simple hydraulic and pneumatic circuits using standard Symbols. Electrical drives: DC, AC, brushless, servo and stepper motors. Harmonic drive. Magnetostrictive actuators and piezoelectric actuators.	9

III	System modelling - Mathematical models and basic building blocks of general mechanical, electrical, fluid and thermal systems. Typical elements of open and closed loop control systems. Adaptive controllers for machine tools. Programmable Logic Controllers (PLC) –Basic structure, input/ output processing. Programming: Timers, Internal Relays, Counters and Shift registers. Development of simple ladder programs for specific purposes.	**9**
IV	Micro Electro Mechanical Systems (MEMS): Fabrication: Deposition, Lithography, Micromachining methods for MEMS - Surface and Bulk, Deep Reactive Ion Etching (DRIE) and LIGA processes. Principle, fabrication and working of MEMS based pressure sensor, accelerometer and gyroscope.	**9**
V	Mechatronics in Robotics- choice of Sensors and Actuators. Robotic vision system – Image acquisition: Vidicon, charge coupled device (CCD) and charge injection device (CID) cameras. Image processing techniques: histogram processing: sliding, stretching, equalization and thresholding. Case studies of Mechatronics systems: Automatic camera, bar code reader, simple weighing machine, pick and place robot, automatic car park barrier system, automobile engine management system.	**9**
	Total hours	**45**

vi) ASSESSMENT PATTERN

Mark distribution

Total Marks	Continuous Internal Evaluation Marks	End Semester Evaluation Marks	End Semester Examination Duration
150	**50**	**100**	**3 Hours**

Continuous Internal Evaluation Pattern:

Attendance	**10 Marks**
Continuous Assessment Tests (2 numbers)	**25 Marks**
Assignment/Quiz/Course project	**15 Marks**

End Semester Examination Pattern:

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EC0U41B	BIOMEDICAL INSTRUMENTATION	OEC	3	0	0	3	2020

i) COURSE OVERVIEW

This course aims to give a brief introduction to human physiology and various instrumentations system used for measurement and analysis of physiological parameters.

ii) COURSE OUTCOMES

After the completion of the course, the student will be able to:

Course Outcomes	Description	Level
CO 1	Explain the human anatomy and physiological signal Measurements.	Understand
CO 2	Illustrate various techniques used for measurement of Blood flow, blood pressure, and respiration rate and body temperature.	Understand
CO 3	Explain the recording of ECG, EEG, EMG and ERG signals.	Understand
CO 4	Summarize the concept of assisting and therapeutic devices.	Understand
CO 5	Describe the advances in medical imaging techniques.	Understand

iii) SYLLABUS

Introduction to human physiological system

Physiological systems of the body (brief discussion on Heart and cardio vascular system, Anatomy of nervous system, Physiology of respiratory systems) problems encountered in biomedical measurements. Sources of bioelectric potentials – resting and action potentials - propagation of action potentials – bio electric potentials example (ECG, EEG, EMG, ERG, EOG, EGG etc.)

Bio potential electrodes and ECG

Bio potential electrodes – theory – microelectrodes – skin surface electrodes – needle electrodes – biochemical transducers –transducers for biomedical applications. Instrumentation for clinical laboratory: Bio Potential amplifiers instrumentation amplifiers, isolation amplifiers, chopper amplifier Electro conduction system of the heart. Electro cardiograph –electrodes and leads – Einthoven triangle, ECG read out devices, ECG machine – block diagram.

Measurement of blood pressure, blood flow and heart sound

Measurement of blood pressure – direct and indirect measurement– oscillometric measurement – ultrasonic method, measurement of blood flow and cardiac output, plethysmography –photo electric and impedance plethysmographs. Measurement of heart sounds –phonocardiography.

Measurement of EEG, EMG and Respiratory Parameters

Electro encephalogram –neuronal communication – EEG measurement, recording and analysis. Muscle response– Electromyogram (EMG) – Nerve Conduction velocity measurements- Electromyogram Measurements. Respiratory parameters – Spiro meter, pneumograph.

Therapeutic Aid

Cardiac pacemakers – internal and external pacemakers, defibrillators. Ventilators, heart lung machine, haemodialysis, lithotripsy, infant incubators

Advances in Radiological Imaging

X-rays- principles of generation, uses of X-rays- diagnostic still picture, fluoroscopy, angiography, endoscopy, and diathermy. Basic principle of computed tomography, magnetic resonance imaging system and nuclear medicine system – radiation therapy. Ultrasonic imaging system – introduction and basic principle.

Electrical safety

Electrical safety– physiological effects of electric current –shock hazards from electrical equipment –method of accident prevention, introduction to tele-medicine

iv) (a) TEXT BOOKS

1) J. G. Webster, Medical Instrumentation, Application and Design, John Wiley and Sons
2) L. Cromwell, F. J. Weibell and L. A. Pfeiffer, Biomedical Instrumentation Measurements, Pearson education, Delhi, 1990.
3) R. S. Khandpur, Handbook of Biomedical Instrumentation, Tata Mc Graw Hill.
4) J. J. Carr and J. M. Brown, Introduction to Biomedical Equipment Technology, Pearson Education.

(b) REFERENCES

1) John Enderele , Susan Blanchard, Joseph Bronzino, Introduction to Biomedical Engg, Academic Press
2) Welkovitz, Biomedical Instruments, Theory and Design, Elselvier
3) Jerry L Prince, Jonathan M Links, Medical Imaging Signals & Systems, Pearson Education

v) COURSE PLAN

Module	Contents	No. of hours
I	**Introduction to human physiological system** Physiological systems of the body (brief discussion on Heart and cardio vascular system, Anatomy of nervous system, Physiology of respiratory systems) problems encountered in biomedical measurements. Sources of bioelectric potentials – resting and action potentials -propagation of action potentials – bio electric potentials example (ECG, EEG, EMG, ERG, EOG, EGG etc.)	9
II	**Bio potential electrodes and ECG** Bio potential electrodes – theory – microelectrodes – skin surface electrodes – needle electrodes – biochemical transducers – transducers for biomedical applications. Instrumentation for clinical laboratory: Bio Potential amplifiers instrumentation amplifiers, isolation amplifiers, chopper amplifier Electro conduction system of	9

	the heart. Electro cardiograph –electrodes and leads – Einthoven triangle, ECG read out devices, ECG machine – block diagram.	
III	**Measurement of blood pressure, blood flow and heart sound** Measurement of blood pressure – direct and indirect measurement– oscillometric measurement – ultrasonic method, measurement of blood flow and cardiac output, plethysmography –photo electric and impedance plethysmographs. Measurement of heart sounds – phonocardiography.	**9**
IV	**Measurement of EEG, EMG and Respiratory Parameters** Electro encephalogram –neuronal communication – EEG measurement, recording and analysis. Muscle response– Electromyogram (EMG) – Nerve Conduction velocity measurements- Electromyogram Measurements. Respiratory parameters – Spiro meter, pneumograph. **Therapeutic Aid** Cardiac pacemakers – internal and external pacemakers, defibrillators. Ventilators, heart lung machine, haemodialysis, lithotripsy, infant incubators	**9**
V	**Advances in Radiological Imaging** X-rays- principles of generation, uses of X-rays- diagnostic still picture, fluoroscopy, angiography, endoscopy, and diathermy. Basic principle of computed tomography, magnetic resonance imaging system and nuclear medicine system – radiation therapy. Ultrasonic imaging system – introduction and basic principle. **Electrical safety** Electrical safety– physiological effects of electric current –shock hazards from electrical equipment –method of accident prevention, introduction to tele-medicine	**9**
	Total hours	**45**

vi) ASSESSMENT PATTERN

Mark distribution

Total Marks	Continuous Internal Evaluation Marks	End Semester Evaluation Marks	End Semester Examination Duration
150	**50**	**100**	**3 Hours**

Continuous Internal Evaluation Pattern:

Attendance	**10 Marks**
Continuous Assessment Tests (2 numbers)	**25 Marks**
Assignment/Quiz/Course project	**15 Marks**

End Semester Examination Pattern:

There will be two parts; Part A and Part B. Part A contain10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EC0U41C	ELECTRONIC HARDWARE FOR ENGINEERS	OEC	3	0	0	3	2020

i) PREREQUISITE: NIL

ii) COURSE OVERVIEW

This course will introduce students the exciting field of electronic hardware designing and prototyping. This will help students to innovate faster with electronics technology.

iii) COURSE OUTCOMES

After the completion of the course, the student will be able to

Course Outcomes	Description	Level
CO 1	Identify various electronic components along with their specifications.	Understand
CO 2	Design PCB using modern software tools.	Apply
CO 3	Explain various testing procedures of electronic products.	Understand
CO 4	Experiment and debug various software and hardware issues of a PC.	Apply

iv) SYLLABUS

Types of Components, Component Package Types, Introduction & Brief History, Introduction to Electronic Design Automation (EDA), Introduction to PCB Design using OrCAD tool, Introduction to PCB Design using PROTEUS tool, Types of Product Testing, Quality Standards, Testing Procedures, Safety Testing of Household Appliances, Testing of Electric Iron/Electric Kettle, Assembly and Maintenance of PC, Installation, Assembly and dismantling.

v) a) TEXT BOOKS

1) C. Robertson. PCB Designer´s Reference. Prentice Hall, 2003.
2) D. Brooks, Signal Integrity Issues and Printed Circuit Board Design, Prentice Hall, 2003.
3) Advances in Electronic Testing, edited by D Gizopoulos, 2006

b) REFERENCES

1) C. Coombs, Printed Circuits Handbook, McGraw-Hill Professional, 6 edition, 2007.
2) Electronic Testing Handbook, McGraw-Hill, Dec 1993
3) PC Repair and Maintenance, A Practical Guide, Joel Rosenthal, Kevin Irwin, 2003
4) A Simple Guide to Computer Maintenance and Troubleshooting, AdaneNegaTarekegn, Alemu KumilachewTegegne, 2015

vi) COURSE PLAN

Module	Contents	No. of hours
I	Types of Components: - Active Components: Diode, Transistor, MOSFET, LED, SCR, Integrated Circuits (ICs) Passive Components: Resistor, Capacitor, Inductor, Transformer, Speaker/Buzzer. Component Package Types: - Axial lead, Radial Lead, Single Inline Package(SIP), Dual Inline Package (DIP), Transistor Outline (TO), Pin Grid Array (PGA), Metal Electrode Face (MELF), Leadless Chip Carrier (LCC), Small Outline Integrated Circuit (SOIC), Quad Flat Pack(QPF) and Thin QFP(TQFP), Ball Grid Array (BGA), Plastic Leaded Chip Carrier (PLCC). Introduction & Brief History: - What is PCB, Difference between PWB and PCB, Types of PCBs: Single Sided (Single Layer), Multi-Layer (Double Layer), PCB Materials.	9
II	Introduction to Electronic Design Automation (EDA): - Brief History of EDA, Latest Trends in Market, How it helps and why it requires, Different EDA tools, Introduction to SPICE and PSPICE Environment, Introduction and Working of PROTEUS.Introduction to PCB Design using OrCAD tool: - PCB Designing Flow Chart: Schematic Entry, Net listing, PCB Layout Designing, Prototype Designing, Design Rule Check(DRC), Design For Manufacturing(DFM) PCB Making: Printing, Etching, Drilling, Assembly of components Introduction to PCB Design using PROTEUS tool: - Assembly of simple circuits	10
III	Types of Product Testing: - Acceptance Testing, Type Testing , Safety Testing, Safety, safety standards, safety certificates (CE, UL and VDE), Effect of environmental testing(refer to IEC 60068-1 for guidance). Quality Standards: - General awareness of quality standards, quality management systems & documentation, Awareness on ISO 17025, ISO 9001, Calibration and Uncertainty of measurements, Awareness on disposal of Electronic waste	7
IV	Testing Procedures: - Switch Mode Power Supply - (Applicable Standard: IS 14886) Safety Testing(Earth Leakage current Test, Dielectric Test, Short Circuit Protection), Performance Testing (Line Regulation, Load Regulation for a variation of Load Min to Max load and vice versa) Inverter, UPS - Inverter (Applicable Standard: IS 13314) Visual Inspection, High Voltage Test, Insulation Resistance Test, No Load Test, Output Test. UPS (Applicable Standard: IEC 62040-3) Steady State Input Voltage Tolerance, Output-Normal Mode – No Load, Full Load, Overload, Short Circuit. Safety Testing of Household Appliances: - (Applicable Standard IS 302-1) Definitions and Terminology, Protection against Shock, Power Input and Current, Leakage Current and Electric Strength at Operating Temperature Testing of Electric Iron/Electric Kettle: - (Applicable Standard: IS 302-2) Ground bond resistance, Touch Current, Temperature (Thermostatic Cut off) Power Consumption.	8

V	Assembly and Maintenance of PC: - Introduction to Computer - Difference between Hardware & Software, Booting concept, Different input and output devices/ cables, connectors, different types of motherboard, controller cards, Ethernet cards, Different types of RAM used in PC‟s. Installation: - BIOS setting, Formatting of Hard Disk, Installation of Windows, Off-line drive installation / online drive installation / Windows file repairing / BIOS password break / Administrative password break / Data recovery. Application Software Installation, Dual Booting Installation. Assembly and dismantling:- Assembly and dismantling of PCs front panel connection, servicing of computer, Type of Backup, Taking Backup files and fine tuning the system, running diagnostics tool, running of virus protection program.	**11**
	Total hours	**45**

vii) ASSESSMENT PATTERN

Mark distribution

Total Marks	Continuous Internal Evaluation Marks	End Semester Evaluation Marks	End Semester Examination Duration
150	**50**	**100**	**3 Hours**

Continuous Internal Evaluation Pattern:

Attendance	**10 Marks**
Continuous Assessment Tests (2 numbers)	**25 Marks**
Assignment/Quiz/Course project	**15 Marks**

End Semester Examination Pattern:

There will be two parts; Part A and Part B. Part A contain10questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EC0U41D	IOT AND APPLICATIONS	OEC	2	1	0	3	2020

i) PREREQUISITE: Students should have a basic knowledge in Embedded systems.

ii) COURSE OVERVIEW

This course aims to develop skills in IoT system development and to apply the same in real life applications

iii) COURSE OUTCOMES

After the completion of the course the student will be able to:

Course Outcomes	Description	Level
CO 1	Understand the IoT fundamentals and architecture modeling	Understand
CO 2	Understand the smart things in IoT and functional blocks	Understand
CO 3	To understand the communication networks and protocols used in IoT.	Understand
CO 4	To understand the cloud resources, data analysis and applications.	Apply
CO 5	To apply the IoT processes in embedded applications.	Apply

iv) SYLLABUS

Introduction to IoT- Definitions and Characteristics, Architectural View, Logical Design of IoT-Functional blocks, Communication models, IoT Levels & Deployment Templates.

IoT and M2M- M2M, Difference between IoT and M2M, SDN and NFV for IoT, Smart Objects: Sensors, Actuators, and Smart Objects, Wireless Sensor Networks, Communication Protocols for Wireless Sensor Networks- Connecting Smart Objects

Unified Data Standards –Protocols –IEEE 802.15.4 -The Physical Layer, The Media-Access Control Layer, Uses of 802.15.4, Modbus, ZigBee-Zigbee Architecture- LoRaWAN -Standardization and Alliances, Physical Layer, MAC Layer, Topology, LTE-M, NB-IoT-Network layer. IP-based protocols -6LoWPAN and RPL

Data Collection, storage and computing Using a Cloud Platform-Introduction, Cloud Computing Paradigm for Data Collection, Storage and Computing, Cloud Deployment Models, Cloud based platforms. IoT Physical Devices & Endpoints-IoT Device –Raspberry-Pi -Board-Linux on Raspberry-Pi-Raspberry-Pi Interfaces. Raspberry Pi interfacing and Programming.

IoT privacy, security and vulnerabilities solutions, vulnerabilities, security requirements, threat analysis, security tomography, layered attacker model, Identity management. Smart and Connected Cities-An IoT Strategy for Smarter Cities, Smart City Security Architecture - Smart City Use-Case Examples

v) (a) TEXT BOOKS

1. Vijay Madisetti and ArshdeepBahga, “Internet of Things (A Hands-on- Approach)”, 1st Edition, VPT, 2014 (Module1,2,4)
2. David Hanes, Gonzalo Salgueiro, Patrick Grossetete, Rob Barton and Jerome Henry, IoT Fundamentals: Networking Technologies, Protocols and Use Cases for Internet of Things, Cisco Press, 2017. (Module2,3,5)
3. Rajkamal, “Internet of Things: Architecture and Design Principles”, McGraw Hill (India) Private Limited.
4. Raspberry Pi Cookbook, Software and Hardware Problems and solutions, Simon Monk, O'Reilly (SPD), 2016, ISBN.

(b) REFERENCES

1. Olivier Hersent, David Boswarthick, Omar Elloumi, “The Internet of Things –Key applications and Protocols”, Wiley, 2012 (Module 3)
2. Al-Fuqaha et al. Internet of things: A survey on enabling technologies, protocols, and applications. IEEE Communications Surveys & Tutorials (2015), pp. 2347- 2376.
3. The Internet of Things (The MIT Press Essential Knowledge series) Paperback – March 20, 2015 by Samuel Greengard
4. The Internet of Things: Converging Technologies for Smart Environments and Integrated Ecosystems, Ovidu Vermesan and Peter Friess, River Publishers.
5. Internet of Things - From Research and Innovation to Market Deployment-RIVER PUBLISHERS, PETER FRIESS, OVIDIU VERMESAN (Editors)
6. Internet of Things Security and Data Protection, Sébastien Ziegler, Springer International Publishing 2019.

vi) COURSE PLAN

Module	Contents	No. of hours
I	Introduction to IoT technology: Definitions and Characteristics of IoT, IoT Architectural View, Physical Design of IOT, Logical Design of IoT- IoT Functional blocks, IoT communication models, IoT Enabling Technologies, IoT Levels & Deployment Templates.	**9**
II	IoT and M2M- M2M, Difference between IoT and M2M, SDN and NFV for IoT, Smart Objects: The “Things” in IoT: Sensors, Actuators, and Smart Objects, Sensor Networks- Wireless Sensor Networks (WSNs), Communication Protocols for Wireless Sensor Networks- Connecting Smart Objects- Communication Criteria.	**9**
III	Unified Data Standards –Protocols –IEEE 802.15.4 -The Physical Layer, The Media-Access Control Layer, Uses of 802.15.4 ,The Future of 802.15.4: 802.15.4e and 802.15.4g–Modbus– ZigBee-Zigbee Architecture- LoRaWAN -Standardization and Alliances, Physical Layer, MAC Layer, Topology, LTE-M, NB-IoT-Network layer –The next generation: IP-based protocols - 6LoWPAN and RPL, Overview of the 6LoWPAN Adaptation Layer.	**9**
IV	Data Collection, storage and computing Using a Cloud Platform-Introduction, Cloud Computing Paradigm for Data Collection, Storage and Computing-Cloud Computing Paradigm, Cloud Deployment Models-Everything as a Service and Cloud Service Models-SaaS,	**9**

	PaaS, IaaS, DaaS. Cloud based platforms-XIVELY, NIMBITS. IoT Physical Devices & Endpoints-IoT Device-Building blocks – Raspberry-Pi -Board-Linux on Raspberry-Pi-Raspberry-Pi Interfaces (serial, SPI, I2C). Raspberry Pi interfacing and programming examples using python (LED, switch, sensor, serial, SPI, I2C devices). Controlling GPIO outputs and displaying sensor readings using web interface/cloud. (Python programming is required only for assignments and projects and not for examinations. Other end nodes and platforms can also be used).	
V	IoT privacy, security and vulnerabilities solutions, vulnerabilities, security requirements, threat analysis, security tomography, layered attacker model, Identity management, access control, secure message communication. Smart and Connected Cities-An IoT Strategy for Smarter Cities-Vertical IoT Needs for Smarter Cities, Global vs. Siloed Strategies-Smart City IoT Architecture-Street Layer, City Layer, Data Center Layer, Services Layer- Smart City Security Architecture. Smart City Use-Case Examples – Street lighting, smart parking, smart traffic and air pollution monitoring	**9**
	Total hours	**45**

vii) ASSESSMENT PATTERN

Mark distribution

Total Marks	Continuous Internal Evaluation Marks	End Semester Evaluation Marks	End Semester Examination Duration
150	**50**	**100**	**3 Hours**

Continuous Internal Evaluation Pattern:

Attendance	**10 Marks**
Continuous Assessment Tests (2 numbers)	**25 Marks**
Assignment/Quiz/Course project	**15 Marks**

End Semester Examination Pattern:

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EC0U41E	ENTERTAINMENT ELECTRONICS	OEC	2	1	0	3	2020

i) COURSE OVERVIEW

This course introduces students to various industry standards, algorithms and technologies used to carry out digital audio and video broadcasting in the infotainment industry.

ii) COURSE OUTCOMES

After the completion of the course, the student will be able to:

Course Outcomes	Description	Level
CO 1	Describe packetized streaming of digital media	Understand
CO 2	Discuss the critical aspects of DVB and DAB standards used for media broadcasting	Understand
CO 3	Realize video coding/compression algorithms to produce high-definition video in MPEG-4 standard	Apply
CO 4	Discuss the use of modern display technologies for video reproduction	Understand

iii) SYLLABUS

Brief Review of Analog Television: Scanning, Horizontal and Vertical Synchronization, Color information, Transmission methods. NTSC and PAL standards. Digital media streaming: Packetized elementary stream of audio- video data, MPEG data stream, MPEG-2 transport stream packet, Accessing a program, scrambled programs, program synchronization. PSI, Additional (Network information and service description) information in data streams for set-top boxes.

Digital Video Broadcasting (DVB): Satellite TV broadcasting – DVB-S Parameters, DVB-S Modulator, DVB-S set-top box, DVB-S2. Cable TV broadcasting – DVB-C Standard, DVB-C Modulator, DVB- C set-top box. Terrestrial TV broadcasting – DVB-T Standard, DVB-T Modulator, DVB-T Carriers and System Parameters, DVB-T receiver. Broadcasting for Handheld devices – DVB-H Standard. DVB tele-text, DVB subtitling system.

Digital Audio Broadcasting (DAB): Comparison of DAB with DVB. Physical layer of DAB. DAB Modulator, DAB Data Structure, DAB single frequency networks, Data broadcasting using DAB. Digital Radio Mondiale (DRM): Transmitter and receiver, Data rates.

High Definition Video and Audio: Pixel resolution, Comparison with Standard Definition TV, Review of Discrete Cosine Transforms (DCT), Video Compression - Quantization levels, Horizontal/Vertical blanking interval, Vertical Color resolution, DPCM of moving pictures, DCT, Run-length coding. MPEG-4 Video coding. Psycho-acoustic model, Principle of audio coding, Sub-band coding in MPEG layer 1 and 2, MPEG Layer 3 and Dolby Digital, Multichannel sound.

Display Technology: Block diagram of video reproduction system in a TV, Cathode Ray tubes, Basic principle of Plasma displays, LC displays, Light-emitting diode displays, Field emission displays, Organic light emitting device displays. Television of future: Holographic TV, Virtual Reality, Augmented Reality.

iv) a) TEXT BOOKS

1) W. Fischer, Digital Video and Audio Broadcasting Technology: A Practical Engineering Guide (Signals and Communication Technology), Springer, 2020
2) Lars-Ingemar Lundström, Understanding Digital Television: An Introduction to DVB Systems with Satellite, Cable, Broadband and Terrestrial TV, Focal Press, Elsevier, 2006.
3) K F Ibrahim, Newnes Guide to Televeision and Video Technology, Newnes, 2007.
4) Jiun-Haw Lee, David N. Liu, Shin-Tson Wu, Introduction to Flat Panel Displays, Wiley, 2008.

b) REFERENCES

1) C. Poynton, "Digital Video and HD Algorithms and Interfaces,"Morgan Kaufmann, 2012.
2) Wolfgang Hoeg, Thomas Lauterbach, Digital audio broadcasting: principles and applications of DAB, DAB+ and DMB, Wiley, 2009.
3) John Watkinson, Introduction to Digital Audio, Focal Press, 1994.
4) John Watkinson, Art of Digital Video, Focal Press, 2008.
5) John Watkinson, Introduction to Digital Video, Focal Press, 2001.

v) COURSE PLAN

Module	Contents	No. of hours
I	Analog Television, Scanning, Horizontal and Vertical Synchronization, Colour information, NTSC and PAL standards. Analog TV Transmission Packetized elementary stream. MPEG data stream, MPEG-2 transport stream packet. Accessing a program, scrambled programs, program synchronization. Program Specific Information. Additional (Network information and service description) information in data streams	9
II	Introduction to DVB, DVB-S Parameters, DVB-S Modulator, DVB-S set-top box, DVB-S2. DVB-C Standard, DVB-C Modulator, DVB-C set-top box. DVB-T Standard, DVB-T Modulator, DVB-T Carriers and System Parameters, DVB-T receiver. Broadcasting for Handheld devices – DVB-H Standard. DVB teletext, DVB subtitling system.	9

III	Introduction to DAB, Comparison of DAB with DVB. Physical layer of DAB. DAB Modulator, DAB Data Structure, DAB single frequency networks, Data broadcasting using DAB. Digital Radio Mondiale (DRM): Transmitter and receiver, Data rates.	**8**
IV	HDTV versus SDTV, Pixel resolution, Review of Discrete Cosine Transforms (DCT) Video Compression - Quantization levels, Horizontal/Vertical blanking interval, Vertical Colour resolution, DPCM of moving pictures, DCT, Run-length and Huffman coding. MPEG-4. Psychoacoustic model, Principle of audio coding. Subband coding in MPEG layer 1 and 2. MPEG Layer 3 and Dolby Digital, Multichannel sound	**10**
V	Block diagram of video reproduction system in a TV Cathode Ray tubes, Basic principle of Plasma displays, LC displays, Light-emitting diode displays, Field emission displays, Organic light emitting device displays. Holographic TV, Virtual Reality, Augmented Reality.	**9**
	Total hours	**45**

vi) ASSESSMENT PATTERN

Mark distribution

Total Marks	Continuous Internal Evaluation Marks	End Semester Evaluation Marks	End Semester Examination Duration
150	**50**	**100**	**3 Hours**

Continuous Internal Evaluation Pattern:

Attendance	**10 Marks**
Continuous Assessment Tests (2 numbers)	**25 Marks**
Assignment/Quiz/Course project/Simulation Assignment	**15 Marks**

Simulation Assignments (optional)

1. Realise live streaming of audio and video data using Python/MATLAB-Simulink or other platforms.
2. Realise a basic video compression scheme from basic principles studied from this course using Python/MATLAB. Obtain the performance parameters before and after comparison.
3. Simulate a DAB transmitter and receiver system using MATLAB/Simulink and study its performance under Gaussian noise.

End Semester Examination Pattern:

There will be two parts; Part A and Part B. Part A contain10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EC1U49A	SEMINAR	PWS	0	0	3	2	2020

i) PREREQUISITE: Nil

ii) COURSE OVERVIEW

The course „Seminar" is intended to enable a B.Tech graduate to read, understand, present and prepare report about an academic document. The learner shall search in the literature including peer reviewed journals, conference, books, project reports etc., and identify an appropriate paper/thesis/report in her/his area of interest, in consultation with her/his seminar guide. This course can help the learner to experience how a presentation can be made about a selected academic document and also empower her/him to prepare a technical report

iii) COURSE OUTCOMES

After the completion of the course the student will be able to:

Course Outcomes	Description	Level
CO 1	Identify academic documents from the literature which are related to her/his areas of interest	Apply
CO 2	Read and apprehend an academic document from the literature which is related to her/ his areas of interest	Analyze
CO 3	Prepare a presentation about an academic document (Cognitive knowledge level	Create
CO 4	Give a presentation about an academic document	Apply
CO 5	Prepare a technical report	Create

IV) GENERAL GUIDELINES

- The Department shall form an Internal Evaluation Committee (IEC) for the seminar with academic coordinator for that program as the Chairperson/Chairman and seminar coordinator & seminar guide as members.
- During the seminar presentation of a student, all members of IEC shall be present.
- Formation of IEC and guide allotment shall be completed within a week after the University examination (or last working day) of the previous semester.
- Guide shall provide required input to their students regarding the selection of topic/ paper.
- Choosing a seminar topic: The topic for a UG seminar should be current and broad based rather than a very specific research work. It's advisable to choose a topic for the Seminar to be closely linked to the final year project area. Every member of the project team could choose or be assigned Seminar topics that covers various aspects linked to the Project area.
- A topic/paper relevant to the discipline shall be selected by the student during the semester break
- Topic/Paper shall be finalized in the first week of the semester and shall be submitted to the IEC.
- The IEC shall approve the selected topic/paper by the second week of the semester.
- Accurate references from genuine peer reviewed published material to be given in the report and to be verified

V) EVALUATION PATTERN

Total marks: 100, only CIE, minimum required to pass 50

Seminar Guide: 20 marks (Background Knowledge – 10 (The guide shall give deserving marks for a candidate based on the candidate's background knowledge about the topic selected), Relevance of the paper/topic selected – 10).

Seminar Coordinator: 20 marks (Seminar Diary – 10 (Each student shall maintain a seminar diary and the guide shall monitor the progress of the seminar work on a weekly basis and shall approve the entries in the seminar diary during the weekly meeting with the student), Attendance – 10).

Presentation: 40 marks to be awarded by the IEC (Clarity of presentation – 10, Interactions – 10 (to be based on the candidate's ability to answer questions during the interactive session of her/his presentation), Overall participation – 10 (to be given based on her/his involvement during interactive sessions of presentations by other students), Quality of the slides – 10).

Report: 20 marks to be awarded by the IEC (check for technical content, overall quality, templates followed, adequacy of references etc.).

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EC1U49B	PROJECT PHASE I	PWS	0	0	6	2	2020

i) PREAMBLE: The course „Project Work‟ is mainly intended to evoke the innovation and invention skills in a student. The course will provide an opportunity to synthesize and apply the knowledge and analytical skills learned, to be developed as a prototype or simulation. The project extends to 2 semesters and will be evaluated in the 7th and 8th semester separately, based on the achieved objectives. One third of the project credits shall be completed in 7th semester and two third in 8th semester. It is recommended that the projects may be finalized in the thrust areas of the respective engineering stream or as interdisciplinary projects. Importance should be given to address societal problems and developing indigenous technologies

ii) COURSE OVERVIEW:

The aim of this course is to apply engineering knowledge in solving practical problems, to foster innovation in design of products, processes or systems, and to develop creative thinking in finding viable solutions to engineering problems.

iii) COURSE OUTCOMES

After the completion of the course, the student will be able to:

Course Outcomes	Description	Level
CO 1	Model and solve real world problems by applying knowledge across domains	Apply
CO 2	Develop products, processes or technologies for sustainable and socially relevant applications	Apply
CO 3	Function effectively as an individual and as a leader in diverse teams and to comprehend and execute designated tasks	Apply
CO 4	Plan and execute tasks utilizing available resources within timelines, following ethical and professional norms	Apply
CO 5	Identify technology/research gaps and propose innovative/creative solutions	Analyse
CO 6	Organize and communicate technical and scientific findings effectively in written and oral forms	Apply

Phase 1 Target

- Literature study/survey of published literature on the assigned topic
- Formulation of objectives
- Formulation of hypothesis/ design/ methodology
- Formulation of work plan and task allocation.
- Block level design documentation
- Seeking project funds from various agencies

- Preliminary Analysis/Modeling/Simulation/Experiment/Design/Feasibility study
- Preparation of Phase 1 report

Evaluation Guidelines & Rubrics

Total: 100 marks (Minimum required to pass: 50 marks).

- Project progress evaluation by guide: 30 Marks.
- Interim evaluation by the Evaluation Committee: 20 Marks.
- Final Evaluation by the Evaluation Committee: 30 Marks.
- Project Phase - I Report (By Evaluation Committee): 20Marks.

(The evaluation committee comprises HoD or a senior faculty member, Project coordinator and project supervisor).

MINORS

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EC0M49A	MINI PROJECT	VAC	0	1	6	4	2020

i) COURSE OVERVIEW

The course aims

To estimate the ability of the students in transforming the theoretical knowledge studied in to a working model of an electronic system

For enabling the students to gain experience in organisation and implementation of small projects.

Design and development of Small electronic project based on hardware or a combination of hardware and software for electronics systems.

ii) COURSE OUTCOMES

After the completion of the course, the student will be able to:

Course Outcomes	Description	Level
CO 1	Practice acquired knowledge within the selected area of technology for project development.	Apply
CO 2	Identify, discuss and justify the technical aspects and design aspects of the project with a systematic approach.	Apply
CO 3	Reproduce, improve and refine technical aspects for engineering projects.	Apply
CO 4	Work as a team in development of technical projects.	Apply
CO 5	Communicate and report effectively project related activities and findings.	Apply

iii) COURSE PLAN

In this course, each group consisting of three/four members is expected to design and develop a moderately complex electronic system with practical applications, this should be a working model. The basic concept of product design may be taken into consideration.

Students should identify a topic of interest in consultation with Faculty/Advisor. Review the literature and gather information pertaining to the chosen topic. State the objectives and develop a methodology to achieve the objectives. Carryout the design/fabrication or develop codes/programs to achieve the objectives. Demonstrate the novelty of the project through the results and outputs. The progress of the mini project is evaluated based on a minimum of two reviews.

The review committee may be constituted by the Head of the Department. A project report is required at the end of the semester. The product has to be demonstrated for its full design specifications. Innovative design concepts, reliability considerations, aesthetics/ergonomic aspects taken care of in the project shall be given due weight.

vi) ASSESSMENT PATTERN

Mark distribution

Total Marks	Continuous Internal Evaluation Marks	End Semester Evaluation Marks	End Semester Examination Duration
150	**75**	**75**	**1 Hours**

Evaluation

The internal evaluation will be made based on the product, the report and a viva- voce examination, conducted by a 3-member committee appointed by Head of the Department comprising HoD or a senior faculty member, Academic coordinator for that program, project guide/coordinator.

The Committee will be evaluating the level of completion and demonstration of functionality/specifications, presentation, oral examination, work knowledge and involvement.

Split-up of CIE

Component	Marks
Attendance	10
Marks awarded based on guide‟s evaluation	15
Project Report	10
Evaluation by Committee	40

Split-up of ESE

Component	Marks
Level of completion	10
Demonstration of functionality	25
Project Report	10
Viva-voce	20
Presentation	10

HONOURS

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EC1H40A	RF MEMS	VAC	4	0	0	4	2020

i) PREREQUISITE: Nil

ii) COURSE OVERVIEW

This course introduces students to the rapidly emerging, area of MEMS with special emphasis on its applications in RF and wireless engineering

iii) COURSE OUTCOMES

After the completion of the course, the student will be able to:

Course Outcomes	Description	Level
CO 1	Describe the various fabrication techniques and actuation mechanisms used in RF MEMS design	Understand
CO 2	Explain the principle of operation of MEMS switches	Understand
CO 3	Explain the construction and operation of micromachined passive elements	Understand
CO 4	Describe the construction and operation of micromachined passive filters, phase shifters and antenna	Understand
CO 5	Discuss the various levels and constraints in MEMS packaging	Understand

iv) SYLLABUS

RF MEMS for wireless applications, MEMS technology and fabrication, mechanical modeling of MEMS devices, MEMS materials and fabrication techniques surface micromachining, Bulk micromachining, LIGA, Actuation Mechanisms in MEMS, Piezoelectric, Electrostatic, Thermal,Magnetic. Capacitive shunt and series switches: Physical description, circuit model and electromagnetic modeling; Techniques of MEMS switch fabrication and packaging; Design of MEMS switches Micromachined passive elements - micromachined inductors: Effect of inductor layout, reduction of stray capacitance of planar inductors, folded inductors, variable inductors and polymer-based inductors; MEMS Capacitors: Gap-tuning and area tuning capacitors, dielectric tunable capacitors. Principle of operation of micromachined filters, surface acoustic wave filters, micromachined filters for millimeter wave frequencies; Various types of MEMS phase shifters; Ferroelectric phase shifters. Micromachined antennas: Micromachining techniques to improve antenna performance, reconfigurable antennas. Integration and Packaging: Role of MEMS packages, types of MEMS packages, module packaging, packaging materials and reliability issues.

v) a) TEXT BOOKS

1) Vijay Varadan, K. J. Vinoy, K. A. Jose, “RF MEMS and Their Applications”, Wiley, 2003.
2) Hector J. De Los Santos,.“RF MEMS Circuit Design for Wireless Applications”, Artech House, 2002

b) REFERENCES

1) Gabriel M. Rebeiz, “RF MEMS: Theory, Design, and Technology”, Wiley, 2003
2) Eun Sok kim “Fundamentals of Micro electro mechanical Systems (MEMS)” McGraw Hill

vi) COURSE PLAN

Module	Contents	No. of hours
I	RF MEMS for wireless applications, MEMS technology and fabrication, mechanical modelling of MEMS devices, MEMS materials and fabrication techniques surface micromachining, Bulk micromachining, LIGA, Actuation Mechanisms in MEMS, Piezoelectric, Electrostatic, Thermal, Magnetic.	**12**
II	Introduction to MEMS switches; Capacitive shunt and series switches: Physical description, circuit model and electromagnetic modelling; Techniques of MEMS switch fabrication and packaging; Design of MEMS switches	**12**
III	Micromachined passive elements - micromachined inductors: Effect of inductor layout, reduction of stray capacitance of planar inductors, folded inductors, variable inductors and polymer-based inductors; MEMS Capacitors: Gap-tuning and area tuning capacitors, dielectric tunable capacitors.	**12**
IV	Principle of operation of - micromachined filters, surface acoustic wave filters, micromachined filters for millimetre wave frequencies; Various types of MEMS phase shifters; Ferroelectric phase shifters	**12**
V	Micromachined antennas: Micromachining techniques to improve antenna performance, reconfigurable antennas. Integration and Packaging: Role of MEMS packages, types of MEMS packages, module packaging, packaging materials and reliability issues.	**12**
	Total hours	**60**

vii) ASSESSMENT PATTERN

Mark distribution

Total Marks	Continuous Internal Evaluation Marks	End Semester Evaluation Marks	End Semester Examination Duration
150	**50**	**100**	**3 Hours**

Continuous Internal Evaluation Pattern:

Attendance	**10 Marks**
Continuous Assessment Tests (2 numbers)	**25 Marks**
Assignment/Quiz/Course project	**15 Marks**

End Semester Examination Pattern:

There will be two parts; Part A and Part B. Part A contain10questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EC1H40B	DESIGN AND ANALYSIS OF ANTENNAS	VAC	4	0	0	4	2020

i) **PREREQUISITE:** EC1U30E-ELECTROMAGNETICS, EC1U40A-MICROWAVE AND ANTENNAS

ii) COURSE OVERVIEW

This course aims to impart knowledge on the basic parameters, matching techniques, design and working of various broad band antennas, practical antennas, antenna arrays and its radiation patterns. It also introduces standard software to design antennas with a set of given specifications.

iii) COURSE OUTCOMES

After the completion of the course, the student will be able to

Course Outcomes	Description	Level
CO 1	Understand the concept of radiation mechanism, antenna parameters and antenna matching techniques.	Understand
CO 2	Illustrate the far filed pattern of different types of antennas.	Understand
CO 3	Analyze different types of broad band antennas and its radiation patterns	Apply
CO 4	Design of various practical antennas, antenna arrays and field patterns	Apply
CO 5	Familiarize Antenna Design Software and design microstrip patch antenna.	Apply

iv) SYLLABUS

Review of Antenna Parameters, Relation between radiation fields and magnetic vector potential, Antenna matching, Review of different antennas, Analysis of Circular Loop and Biconical Antenna, Helical Antennas, Current induced in a dipole antenna, Near fields of linear antennas, self and mutual impedance, arrays of parallel dipoles, Yagi-Uda antennas, Radiation from open-ended wave-guides, Designing an antenna with a set of given specifications using standard software, Parabolic reflector antennas, gain and beam width of reflector antennas, aperturefield and current distribution methods, radiation patterns of reflector antenna, Frequency independent antennas, Antenna arrays, Adaptive Beam forming. 2D arrays – Rectangular and Circular array.

v) a) TEXT BOOKS

1) Sopholes J. Orfanidis – Electromagnetic waves and antennas. Available at: http://eceweb1.rutgers.edu/~orfanidi/ewa/
2) Consrantive A Balanis -Antenna Theory - Analysis and Design – 2/e John Wiley & Sons.
3) John D. Krans, Ronald J. Marhefka : Antennas for all Applications , 3/e, TMH
4) Thomas A Milligan – Modern Antenna Design, 2/e John Wiley & Sons.

b) REFERENCES

1) Collin R.E, Antennas & Radio Wave Propagation, McGraw Hill. 1985.
2) Jordan E.C. & K. G. Balmain, Electromagnetic Waves & Radiating Systems, 2/e, PHI.
3) Raju G.S.N., Antenna and Wave Propagation, Pearson, 2013.
4) Sisir K.Das & Annapurna Das, Antenna and Wave Propagation, McGraw Hill,2012

vi) COURSE PLAN

Module	Contents	No. of hours
I	Review of Antenna Parameters: -Polarization, Input impedance, Gain. Relation between radiation fields and magnetic vector potential – Helmholtz equation and Lorentz conditions. Antenna matching –T match, Baluns, Gamma and Omega match. Review of dipole antennas (short dipole and arbitrary length), Monopole antennas, V and rhombic antennas. Folded dipole and it's properties.	12
II	Analysis of Circular Loop and Biconical Antenna. Helical Antennas (normal mode and axial mode) – relation for far fields, radiation resistance and gain. Current induced in a dipole antenna – Pocklington and Hallen's integral equations. Solution of Hallen's integral equation for current induced in a dipole antenna for delta gap model.	12
III	Near fields of linear antennas, self and mutual impedance, arrays of parallel dipoles, Yagi-Uda antennas.Aperture antenna – Field equivalence principle. Radiation from open-ended wave-guides, horn antennas, horn radiation fields, horn directivity, optimum horn design, Rectangular micro-strip antennas –field analysis and design.Designing an antenna with a set of given specifications using standard software (MATLAB/HFSS/CST Microwave Studio or any Open software)	13
IV	Parabolic reflector antennas, gain and beam width of reflector antennas, aperture-field and current distribution methods, radiation patterns of reflector antennas, dualreflector antennas, lens antennas -hyperbolic lens and zoned lens. Frequency independent antennas – Rumsey Principle – Spiral Antennas. Design of log periodic dipole arrays.	11
V	Antenna arrays – General expression for array factor. Grating lobes. One dimensional arrays- Broad side, end fire and Chebyshev arrays. Concept of beam steering. Design of array using Schelkunnof's zero placement method and Fourier series method. Woodward-Lawson frequency-sampling design, Narrow beam design and Butler matrix beam former. Adaptive Beam forming. 2D arrays – Rectangular and Circular array.	12
	Total hours	**60**

vii) ASSESSMENT PATTERN

Mark distribution

Total Marks	Continuous Internal Evaluation Marks	End Semester Evaluation Marks	End Semester Examination Duration
150	**50**	**100**	**3 Hours**

Continuous Internal Evaluation Pattern:

Attendance	**10 Marks**
Continuous Assessment Tests (2 numbers)	**25 Marks**
Assignment/Quiz/Course project	**15 Marks**

End Semester Examination Pattern:

There will be two parts; Part A and Part B. Part A contain10questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Simulation Assignments

The following simulation assignments can be done with MATLAB/HFSS/CST Microwave Studio or any Open software.

- Design a rectangular microstrip antenna (using MATLAB) for 1.8 GHz with RT-Duroid 5880 FR4 substrate having permittivity 4.4, loss tangent=0.001 and h=1.6mm and also plot 3D, 2D radiation patterns and VSWR.

- The dimensions of a rectangular microstrip antenna are: L=3.733cm and W=3.973 cm. The substrate height h=1.6mm and dielectric constant = 4.4. If operating frequency is 1.8 GHz. Write a MATLAB program to calculate

(a) The input impedance

(b) The position of the inset feed point for matching to 50 ohm feeder line.

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EC1H40C	MULTIRATE SIGNAL PROCESSING AND WAVELETS	VAC	4	0	0	4	2020

i) PREREQUISITE: EC1U30B - Digital Signal processing

ii) COURSE OVERVIEW:

The aim of this course is to introduce the idea of wavelets, and the related notions of time frequency analysis, of time-scale analysis, and to describe the way in which technical developments related to wavelets have led to numerous applications. The concepts of multirate filter banks are also introduced. The relation between wavelets and multirate systems is brought out to illustrate how wavelets may be realized in practice.

iii) COURSE OUTCOMES

After the completion of the course, the student will be able to:

Course Outcomes	Description	Level
CO 1	Explain the concepts, properties and interconnection of Multirate systems, Wavelets and Filterbanks and apply them in the analysis of signal processing systems.	Understand
CO 2	Design wavelets and multirate systems using the time domain and the frequency domain approaches.	Apply
CO 3	Apply the wavelet transform, wavelet packet transform and its variants as a tool in 1-D and 2-D signal analysis and processing.	Apply

iv) SYLLABUS

Basics of Multirate processing and Filter banks: Introduction to multiresolution and multirate signal processing with some example applications, Multirate System Fundamentals, Noble Identities. Introduction to digital filter banks, Perfect Reconstruction.

Introduction to Wavelet Transform:

The Uncertainty Principle, Short Time Fourier Transform, The Gabor Transform and its generalization, Wavelet Transform – CWT and DWT, Families of wavelets: Orthogonal and biorthogonal wavelets, Vanishing moments and regularity.

The Multiresolution Analysis (MRA), Wavelets and Filter Banks:

The Multiresolution Analysis and Orthogonality, The Haar Filter Bank, The Daubechies‟ family of MRA, Daubechies‟ Filter banks,

Biorthogonal Wavelets:

Introduction to biorthogonal Wavelet Systems, Signal representation and Construction of Biorthogonal wavelets, Design of Wavelet systems, Design of Daubechies Wavelets using frequency domain approach, JPEG 2000 5/3 filter bank and Spline MRA.

Wavelet packets and 2-D DWT:

The wavelet packet transform, Introduction to 2-D DWT, Embedded Zero-tree Wavelet (EZW) Coding. Applications of wavelets.

v) a) TEXT BOOKS

1) Bernard P. P. Vaidyanathan, Multirate Systems and Filter Banks, Pearson Education, 2006.
2) K. P. Soman, K. I. Ramachandran, "Insight Into Wavelets - From Theory to Practice", Prentice Hall of India, 3rd Edition, Eastern Economy Edition, Prentice Hall of India Private Limited, 2010. Video lectures and Transcripts: Adv. Digital Signal Processing: Multirate and Wavelet NPTEL Lecture series - https://nptel.ac.in/courses/117/101/117101001/

b) REFERENCES

1) Simon Rulph Gilbert Strang and Truong Q. Nguyen, Wavelets and Filter banks, 2nd Edition, Wellesley- CambridgePress,1998
2) Raghuveer M. Rao, Ajit S. Bopardikar, “Wavelet Transforms: Introduction to Theory and Applications, Prentice Hall, 1998.
3) N.J. Fliege, Multirate Digital Signal Processing, John Wiley, 1999.

vi) COURSE PLAN

Module	Contents	No. of hours
I	**Basics of Multirate processing and Filter banks:** Introduction to multiresolution and multirate signal processing with some example applications, Multirate System Fundamentals: Basic multirate operations – Decimation and Interpolation, Transform domain analysis of Decimators and Interpolators, Decimation and Interpolation filters, Fractional sampling rate alteration Interconnection of decimators and interpolators, The Noble Identities. Introduction to digital filter banks, The DFT filter bank, Two Channel Quadrature Mirror Filterbank (QMF), Two channel Conjugate Quadrature Filter Bank (CQF). Perfect Reconstruction.	13
II	**Introduction to Wavelet Transform:** The Uncertainty Principle - Time-bandwidth product uncertainty, The time frequency plane and its tilings, Short Time Fourier Transform, The Gabor Transform and its generalization, Wavelet Transform in general and origin of Wavelets. The Continuous Wavelet Transform (CWT), Condition of admissibility and its implications. Introduction to Discrete Wavelet Transform (DWT), DWT from CWT, Logarithmic Scale Discretization and Dyadic Discretization, Families of wavelets: Orthogonal and biorthogonal wavelets, Vanishing moments and regularity.	12

III	**The Multiresolution Analysis (MRA), Wavelets and Filter Banks:** The Multiresolution Analysis: The Dyadic Haar Multiresolution Analysis - The Haar Scaling Functions and Function spaces, Nested spaces, The Haar Wavelet function, Orthogonality of the Haar Scaling and Wavelet functions. Relating Scaling and Wavelet functions of Haar and Filters, The Haar Filter Bank, Z-domain analysis of Haar filter bank. The Daubechies" family of MRA, Daubechies" Filter banks, Relating QCF filter banks and Daubechies" wavelets.	**12**
IV	**Biorthogonal Wavelets:** Introduction to biorthogonal vector space, Biorthogonal Wavelet Systems, Signal representation using Biorthogonal Wavelet System, Construction of Biorthogonal wavelets Design of Wavelet systems using frequency domain approach – Frequency domain characterisation of filter coefficients, Design of Daubechies Wavelets using frequency domain approach, JPEG 2000 5/3 filter bank and Spline MRA.	**12**
V	**Wavelet packets and 2-D DWT:** The wavelet packet transform, Best wavelet packet tree, Noble identities and the Haar wave Packet Transform. Introduction to 2-D DWT, Wavelet transform of an image, The Embedded Zero-tree Wavelet (EZW) Coding. Applications of wavelets in audio & image compression and denoising.	**11**
	Total hours	**60**

ASSESSMENT PATTERN

Mark distribution

Total Marks	Continuous Internal Evaluation Marks	End Semester Evaluation Marks	End Semester Examination Duration
150	**50**	**100**	**3 Hours**

Continuous Internal Evaluation Pattern:

Attendance	**10 Marks**
Continuous Assessment Tests (2 numbers)	**25 Marks**
Assignment/Quiz/Course project	**15 Marks**

End Semester Examination Pattern:

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

SEMESTER VIII

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EC1U40B	WIRELESS COMMUNICATION	PCC	3	0	0	3	2020

i) COURSE OVERVIEW

This course aims to introduce students to basic theory and principles of wireless communication systems in general, and cellular systems in particular. It also introduces basics of radio wave propagation.

ii) COURSE OUTCOMES

After the completion of the course, the student will be able to:

Course Outcomes	Description	Level
CO 1	Summarize the basics of cellular system and cellular design fundamentals.	Understand
CO 2	Describe the wireless channel models and discuss capacity of wireless channels.	Understand
CO 3	Analyze the performance of the modulation techniques for flat-fading channels and multicarrier modulation.	Apply
CO 4	Illustrate how receiver performance can be enhanced by various diversity techniques.	Apply
CO 5	Identify advantages of various equalization techniques and multiple-access techniques in wireless communication.	Understand
CO 6	Calculate system parameters such antenna height, range, maximum usable frequency in different modes of radio wave propagation.	Apply

iii) SYLLABUS

Introduction to Wireless Communication Systems: Generations: 2G, 3G, 4G, 5G. Wireless LAN, Bluetooth and Personal Area networks, Broadband Wireless Access WiMAX Technology. Wireless Spectrum allocation, Standards.

Cellular System Design Fundamentals: Frequency Reuse, channel assignment strategies, Handoff strategies, Interference and system capacity, trunking and grade off service, improving coverage and capacity – cell splitting, sectoring, microcells.

Path loss and shadowing: Free space path loss, Two-Ray model, Shadowing

Statistical Multipath Channel Models: Time-varying channel impulse response, Narrowband fading, Wideband fading models, Delay spread and Coherence bandwidth, Doppler spread and Coherence time, Flat fading versus frequency selective fading, Slow fading versus fast fading, Discrete-time model.

Capacity of Wireless Channels: Review of Capacity in AWGN, Capacity of flat fading channel – Ergodic capacity, Capacity with Outage, Capacity with CSI-R. (Derivations of capacity formulae are not required; Only expressions, computations and significance required.)

Digital Signaling for Flat fading Channels: Analysis of Average Error Probability and Outage probability of BPSK in flat-fading channels.

Multi-carrier Modulation: Data transmission using multicarrier modulation for frequency-selective fading channels. Overlapping subchannels, Mitigation of Subcarrier Fading, Discrete Implementation of multicarrier – OFDM. Cyclic prefix, Peak-to-average power

Diversity: Receiver diversity – selection combining, maximal ratio combining. Transmitter diversity – Alamouti scheme for 2x2 MIMO.

Equalization: Equalization – Linear and non-linear equalization, Zero forcing, MMSE equalizers. LMS algorithm. Adaptive Equalization.

Multiuser Systems: Uplink and Downlink, Multiple Access, Frequency-Division Multiple Access (FDMA), Time-Division Multiple Access (TDMA), Code-Division Multiple Access (CDMA), Orthogonal Frequency-Division Multiple Access (OFDMA).

Radio Wave Propagation: Ground wave propagation, Plane earth reflection, Space wave and surface wave, Spherical earth propagation, Tropospheric waves, Ionospheric propagation, Effects of earth‟s magnetic field, Critical frequency, Maximum usable Frequency, Virtual height.

iv) a) TEXT BOOKS

1. Andrea Goldsmith, Wireless Communications, Cambridge University Press, 2005
2. Theodore S. Rappaport, Wireless communication: Principles and Practice, 2/e, Pearson Education, 1990.
3. Aditya Jagannatham, Principles of Modern Wireless Communication Systems, Mc Graw Hill, 2017.
4. Robert Collin, Antennas and Radiowave Propagation, McGraw Hill, 2016.

b) REFERENCES

1. David Tse and Pramod Viswanath, Fundamentals of Wireless Communication, Cambridge University Press, 2005
2. Jochen Schiller, Mobile Communications, Pearson, 2008.
3. Andreas F Molish, Wireless Communications, 2nd Edition , Wiley India Publications, 2013.
4. W. C. Y. Lee, Mobile Cellular Telecommunication, McGraw Hill,2017.
5. Gordon L. Stuber, Principles of Mobile Communication , Springer,2017
6. Rahim Thafazoli, Technologies for The Wireless Future , Volume 2 , Wiley and Sons,2004.
7. Edward C Jordan and Keith G Balmain, Electromagnetic Wave and Radiating System, Pearson.

v) COURSE PLAN

Module	Contents	No. of hours
I	**Introduction to wireless communication systems:** Generations: 2G, 3G, 4G, 5G., Wireless LAN, Bluetooth and Personal Area networks, Broadband Wireless Access -- WiMAX Technology. Wireless Spectrum allocation, Standards. Cellular concept, Frequency Reuse, channel assignment strategies, Handoff strategies, Interference and system capacity, trunking and grade off service. improving coverage and capacity – cell splitting, sectoring, microcells.	9
II	Wireless Channels- Free space path loss, Two-Ray model, Shadowing, Time-varying channel impulse response, Narrowband fading, Wideband fading models – Delay spread and Coherence bandwidth, Doppler spread and Coherence time, Flat fading versus frequency selective fading, Slow fading versus fast fading, Discrete-time model. Review of Capacity in AWGN, Capacity of flat fading channel – Ergodic capacity, Capacity with Outage, Capacity with CSI-R.	9
III	Modulation Techniques-Average Probability of error and outage probability, Performance evaluation of BPSK in flat fading channels, Multi carrier modulation in frequency-selective channel, OFDM – DFT/IDFT, Cyclic Prefix,PAPR.	9
IV	Diversity,Equalization and Multiple Access- Receiver Diversity – Selection combining, Maximal ratio combining, Transmit Diversity – Alamouti for 2x2 MIMO, Equalization – linear and nonlinear, ZF and MMSE, LMS, Adaptive, Multiple access – FDMA, TDMA, CDMA, OFDMA	9
V	Radio Wave Propagation- Ground wave propagation, Plane earth reflection, Space wave and surface Wave, Spherical earth propagation, Tropospheric waves, Ionospheric Propagation, Effects of earth‟s magnetic field, Critical frequency, Maximum usable Frequency, Virtual height.	9
	Total hours	**45**

vi) ASSESSMENT PATTERN

Mark distribution

Total Marks	Continuous Internal Evaluation Marks	End Semester Evaluation Marks	End Semester Examination Duration
150	**50**	**100**	**3 Hours**

Continuous Internal Evaluation Pattern:

Attendance	**10 Marks**
Continuous Assessment Tests (2 numbers)	**25 Marks**
Assignment/Quiz/Course project	**15 Marks**

End Semester Examination Pattern:

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

PROGRAMME ELECTIVE-III

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EC1U42A	BIOMEDICAL ENGINEERING	PEC	3	0	0	3	2020

i) COURSE OVERVIEW

This course will introduce aspects of biomedical engineering as applied to biological systems described using engineering principles and the use of modern diagnostic and therapeutic equipment.

ii) COURSE OUTCOMES

After the completion of the course, the student will be able to:

Course Outcomes	Description	Level
CO 1	To explain the functioning of physiological systems and generation of bioelectric potentials and its implications in diagnostics	Understand
CO 2	To describe the principles used for diagnosis of abnormalities in the cardiovascular system	Understand
CO 3	To explain the techniques used for diagnosis and therapy in the neuromuscular and respiratory system	Understand
CO 4	To explain the principle and working of different types of bio medical equipment/device	Understand
CO 5	Classify various diagnostic medical imaging techniques.	Understand

iii) SYLLABUS

Introduction to bio-medical engineering, overview of anatomy and physiological systems of the body. Sources of bio-electric potential: Resting and action potential, propagation of action potentials. Bioelectric potentials examples (ECG, EEG, EMG, ERG, EOG, EGG concept only.) Electrode theory: Nernst relation, Electrode skin interface, Bio potential electrodes: Microelectrodes, skin surface electrodes, needle electrodes Instrumentation for clinical laboratory: Bio potential amplifiers-instrumentation amplifiers, carrier amplifiers, isolation amplifiers, chopper amplifiers.

Heart and cardiovascular system (brief discussion), electro conduction system of the heart. Electrocardiography, ECG machine block diagram, ECG lead configurations, ECG recording system, Einthoven triangle, analysis of ECG signals. Measurement of blood pressure: Direct, indirect and relative methods of blood pressure measurement, auscultatory method, oscillometric and ultrasonic non-invasive pressure measurements. Measurement of blood flow: Electromagnetic blood flowmeters and ultrasonic blood flow meters

The human nervous system. Neuron, action potential of brain, brain waves, types of electrodes, placement of electrodes, evoked potential, EEG recording, analysis of EEG. Electrical activity of muscles- EMG. Signal Acquisition and analysis. Applications of EMG - myoelectric control system. Electrical stimulation of the muscle and nerve, Functional Electrical Stimulation-Principle and applications. Physiology of respiratory system (overview), Respiratory parameters, spirometer, body plethysmographs, gas exchange and distribution.

Instruments for clinical laboratory: Oxymeters, pH meter, blood cell counter, flame photometer, spectrophotometer. Therapeutic Equipments: Principle, block schematic diagram, working and applications of : pacemakers, cardiac defibrillators, heart–lung machine, dialyzers, surgical diathermy equipment, ventilators Biomedical Telemetry system: Components of biotelemetry system, application of telemetry in medicine, single channel telemetry system for ECG and temperature measurement

Medical Imaging systems (Basic Principle only): X-ray imaging - Properties and production of Xrays, X-ray machine, applications of X-rays in medicine. Computed Tomograpy: Principle, image reconstruction, scanning system and applications Ultrasonic imaging systems: Basic pulse echo system, propagation of ultrasonic through tissues and reflections, display types, A-Scan, B-Scan, M-Scan, applications, real-time ultrasonic imaging systems and probes. Magnetic Resonance Imaging – Basic NMR components, Biological effects and advantages of NMR imaging Patient Safety: Electric shock hazards, leakage current, safety codes for electro medical equipments

(a) TEXT BOOKS

1) R. S. Khandpur, Handbook of Biomedical Instrumentation, Tata Mc Graw Hill.

2) Leslie Cromwell, Fred J. Weibell, Erich A. Pfeiffer, Biomedical Instrumentation and Measurements, PHI, 2nd Edition, 2004

(b) REFERENCES

1) John G Webster, "Medical Instrumentation application and design", John Wiley 3rd e/d

2) J. J. Carr, "Introduction to Biomedical Equipment Technology", Pearson Education 4th e/d.

3) Richard Aston, "Principle of Biomedical Instrumentation and Measurement". Merrill Education/Prentice Hall.

4) Barbara Christe, Introduction to Biomedical Instrumentation, Cambridge University Press, 2008

iv) COURSE PLAN

Module	Contents	No. of hours
I	Introduction to bio-medical engineering, overview of anatomy and physiological systems of the body. Sources of bio-electric potential: Resting and action potential, propagation of action potentials. Bioelectric potentials examples (ECG, EEG, EMG, ERG, EOG, EGG concept only.) Electrode theory: Nernst relation, Electrode skin interface, Bio potential electrodes: Microelectrodes, skin surface electrodes, needle electrodes Instrumentation for clinical laboratory: Bio potential amplifiers-instrumentation amplifiers, carrier amplifiers, isolation amplifiers,	9

	chopper amplifiers.	
II	Heart and cardiovascular system (brief discussion), electro conduction system of the heart. Electrocardiography, ECG machine block diagram, ECG lead configurations, ECG recording system, Einthoven triangle, analysis of ECG signals. Measurement of blood pressure: Direct, indirect and relative methods of blood pressure measurement, auscultatory method, oscillometric and ultrasonic non-invasive pressure measurements. Measurement of blood flow: Electromagnetic blood flowmeters and ultrasonic blood flow meters	**9**
III	The human nervous system. Neuron, action potential of brain, brain waves, types of electrodes, placement of electrodes, evoked potential, EEG recording, analysis of EEG. Electrical activity of muscles- EMG. Signal Acquisition and analysis. Applications of EMG - myoelectric control system. Electrical stimulation of the muscle and nerve, Functional Electrical Stimulation-Principle and applications. Physiology of respiratory system (overview), Respiratory parameters, spirometer, body plethysmographs, gas exchange and distribution.	**9**
IV	Instruments for clinical laboratory: Oxymeters, pH meter, blood cell counter, flame photometer, spectrophotometer. Therapeutic Equipments: Principle, block schematic diagram, working and applications of : pacemakers, cardiac defibrillators, heart–lung machine, dialyzers, surgical diathermy equipment, ventilators Biomedical Telemetry system: Components of biotelemetry system, application of telemetry in medicine, single channel telemetry system for ECG and temperature measurement	**9**
V	Medical Imaging systems (Basic Principle only): X-ray imaging - Properties and production of Xrays, X-ray machine, applications of X-rays in medicine. Computed Tomograpy: Principle, image reconstruction, scanning system and applications Ultrasonic imaging systems: Basic pulse echo system, propagation of ultrasonic through tissues and reflections, display types, A-Scan, B-Scan, M-Scan, applications, real-time ultrasonic imaging systems and probes. Magnetic Resonance Imaging – Basic NMR components, Biological effects and advantages of NMR imaging Patient Safety: Electric shock hazards, leakage current, safety codes for electro medical equipments	**9**
	Total hours	**45**

vi) ASSESSMENT PATTERN

Mark distribution

Total Marks	Continuous Internal Evaluation Marks	End Semester Evaluation Marks	End Semester Examination Duration
150	50	100	3 Hours

Continuous Internal Evaluation Pattern:

Attendance	**10 Marks**
Continuous Assessment Tests (2 numbers)	**25 Marks**
Assignment/Quiz/Course project	**15 Marks**

End Semester Examination Pattern:

There will be two parts; Part A and Part B. Part A contain10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EC1U42B	SATELLITE COMMUNICATION	PEC	3	0	0	3	2020

PRE-REQUISITE: EC1U30C -Analog &Digital communication

COURSE OVERVIEW: This course aims to impart the basic knowledge of satellite communication and its applications.

i) COURSE OUTCOMES

After the completion of the course, the student will be able to:

Course Outcomes	Description	Level
CO 1	Explain the basic concepts of satellite communication and satellite orbits.	Understand
CO 2	Describe satellite communication subsystems& launching mechanisms of satellites.	Understand
CO 3	Calculate satellite link budgets.	Apply
CO 4	Explain the various methods of satellite access.	Understand
CO 5	Discuss various applications of satellite communications.	Understand

ii) SYLLABUS

Satellite Orbits:

Introduction to Satellite Communication, Historical background, Basic concepts of Satellite Communications, Kepler‟s laws of planetary motion, types of satellite orbits, orbit determination. Definitions of terms for Earth-Orbiting Satellites, Orbital Elements, Apogee and Perigee Heights, satellite stabilization, orbital effects on satellites performance. Antenna Look Angles, The Polar Mount Antenna, Limits of Visibility, launch systems for geostationary satellites.

Satellite System:

The Space Segment Introduction, The Power Supply, Attitude Orbit Control, Satellite stabilization, Station Keeping, Thermal Control, TT&C Subsystem, Transponders, Antenna Subsystem
The Earth Segment
Types of earth station, architecture & design considerations. Transmit-Receive Earth Station, Wideband receiver, the input demultiplexer, the power amplifier, Satellite tracking.

The Satellite Link design:

Introduction, Transmission Theory, System Noise Temperature and G/T Ratio, Design of Downlinks
Ku-Band GEO Satellite Systems, Uplink Design , Design for Specified CNR: Combining CNR and C/I Values in Satellite Links ,System Design for Specific Performance. Regional &global satellite systems INSAT, INTELSAT& INMARSAT.

Modulation & Multiple Access

Introduction, Digital Modulation techniques preferred in satellites, Multiple Access, Frequency Division Multiple Access(FDMA) , Time Division Multiple Access (TDMA), Transmitter Power in TDMA Networks, Demand Assignment Multiple Access (DAMA), Random Access (RA) , Packet Radio Systems and Protocols, Code Division Multiple Access (CDMA)

Satellite Application:

Introduction, Frequency bands, , Comparison between Satellite & terrestrial networks, Satellite Telephony, Satellite Television, DTH, Satellite Radio broadcasting, Remote Sensing Satellite; Classification, orbits, payloads, Weather Forecasting Satellites: Orbits, payloads.

Navigation Satellite: Basic principles of satellite navigation, GPS Position Location Principle functional segments of GPS, Indian Contribution to positioning systems. NGSO satellite systems.

iii) (a) TEXT BOOKS

1. Dennis Roddy, Satellite Communications, 4th Edition, McGraw- Hill International edition, 2006
2. Timothy Pratt,Jeremy E,Allnutt, Satellite Communications, Wiley, 3rd Edition, October 2019

b) References:

1. Gerard Maral,Michel Bousquet,Zhili Sun, Satellite Communications Systems: Systems, Techniques and Technology,Wiley,6thedition,April 2020
2. Anil K. Maini, Varsha Agrawal, Satellite Communications, Wiley India Pvt. Ltd., 2015
3. TRI.T. HA, Digital Satellite Communications, McGraw-Hill,second edition

iv) COURSE PLAN

Module	Contents	No. of hours
I	Introduction to Satellite Communication, Historical background, Basic concepts of Satellite Communications, Kepler‟‟slaws of planetary motion, types of satellite orbits, orbit determination. Definitions of terms for Earth-Orbiting Satellites, Orbital Elements, Apogee and Perigee Heights, satellite stabilization, orbital effects onsatellites performance. Antenna Look Angles, The Polar Mount Antenna, Limits of Visibility, launch systems for geostationary satellites.	**9**
II	The Space Segment Introduction, The Power Supply, Attitude& Orbit Control, Satellite stabilization, Station Keeping, Thermal Control, TT&C Subsystem, Transponders, Antenna Subsystem The Earth Segment Types of earth station, architecture & design considerations .Transmit-Receive Earth Station ,Wideband receiver, the input demultiplexer, the power amplifier, Satellite tracking.	**10**
III	Introduction, Transmission Theory, System Noise Temperature and G/T Ratio, Design of Downlinks Ku-Band GEO Satellite Systems, Uplink Design , Design for Specified CNR: Combining CNR and C/I Values in Satellite Links ,System Design for Specific Performance. Regional &global satellite systems	**8**

	INSAT, INTELSAT& INMARSAT.	
IV	Introduction, Digital Modulation techniques preferred in satellites, Multiple Access ,Frequency Division Multiple Access (FDMA) , Time Division Multiple Access (TDMA), Transmitter Power in TDMA Networks, Demand Assignment Multiple Access (DAMA), Random Access (RA) , Packet Radio Systems and Protocols, Code Division Multiple Access (CDMA)	**9**
V	Introduction, Frequency bands, , Comparison between Satellite & terrestrial networks, Satellite Telephony, Satellite Television, DTH, Satellite Radio broadcasting, Remote Sensing Satellite; Classification, orbits, payloads, Weather Forecasting Satellites: Orbits, payloads. Navigation Satellite: Basic principles of satellite navigation, GPS Position Location Principle functional segments of GPS, Indian Contribution to positioning systems. NGSO satellite systems.	**9**
	Total hours	**45**

v) ASSESSMENT PATTERN

Mark distribution

Total Marks	Continuous Internal Evaluation Marks	End Semester Evaluation Marks	End Semester Examination Duration
150	**50**	**100**	**3 Hours**

Continuous Internal Evaluation Pattern:

Attendance	**10 Marks**
Continuous Assessment Tests (2 numbers)	**25 Marks**
Assignment/Quiz/Course project	**15 Marks**

END SEMESTER EXAMINATION PATTERN

There will be two parts; Part a and Part B. Part A contain 10 questions with 2 questions from each module,having 3 marks for each question. students should answer all questions. Part B contains 2questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EC1U42C	SECURE COMMUNICATION	PEC	3	0	0	3	2020

i) PREREQUISITE: Nil

ii) COURSE OVERVIEW

This course aims to provide an insight into the theory and technology behind secure communication.

iii) COURSE OUTCOMES

After the completion of the course the student will be able to:

Course Outcomes	Description	Level
CO 1	Explain network security services and mechanisms and the types of attacks they are designed for.	Understand
CO 2	Model the symmetric encryption process and different encryption techniques	Apply
CO 3	Apply the concepts of group, ring, field, modular arithmetic, Euclidean algorithm, Finite fields and polynomial arithmetic	Apply
CO 4	Illustrate the principles of modern symmetric ciphers like the Data Encryption Standard and Advanced Encryption Standard	Understand
CO 5	Outline the concepts of public key cryptography, RSA algorithm, key distribution and management for public key systems	Understand
CO 5	Explain the requirements for authentication and the types of functions used to produce an authenticator	Understand

iv) SYLLABUS

Introduction and Classic Encryption Techniques. Groups,Rings and Fields, Modular arithmetic, Euclidian algorithm, Finite Fields of the form GF(p), Polynomial arithmetic

Block Cipher Principles – Stream Ciphers and Block Ciphers, Feistel Cipher, The Data encryption standard,The AES Standard.,

Principles of public key cryptosystems-Fermat‟s theorem, Euler‟s Totient Function, Euler‟s theorem,RSA algorithm, Key management.

Authentication requirements, Authentication functions- Message Encryption, Public Key Encryption, Message Authentication Code, Hash function

v) (a) Text Books

1. William Stallings, Cryptography and Network security: principles and practice", 4th Edition, Prentice Hall of India, New Delhi, 2006

(b) Reference Books:

1. Behrouz A. Forouzan, Cryptography and Network security Tata McGraw-Hill, 2008
2. David S. Dummit& Richard M Foote, Abstract Algebra, 2nd Edition, Wiley India Pvt.Ltd.,2008.
3. Douglas A. Stinson, Cryptography, Theory and Practice, 2/e, Chapman & Hall, CRC Press Company, Washington, 2005.
4. Lawrence C. Washington, Elliptic Curves: Theory and Cryptography, Chapman &Hall, CRCPress Company, Washington, 2008.N.
5. Koeblitz: A course in Number theory and Cryptography, 2008
6. Thomas Koshy: Elementary Number Theory with Applications, 2/e, Academic Press,2007
7. Tyagi and Yadav, Cryptography and network security, Dhanpatrai, 2012

vi) COURSE PLAN

Module	Contents	No. of hours
I	**Introduction and Classic Encryption Techniques** OSI security architecture, Security attacks – Passive attacks, Active attacks, Security services- Authentication, Access Control, Data Confidentiality, Data integrity, Nonrepudiation, Availability service. Model for network security. Symmetric cipher model, Cryptography, Cryptoanalysis, Substitution techniques- Hill Cipher, One time pad,Transposition Techniques.	**9**
II	**Finite Fields**:Groups,Rings and Fields, Modular arithmetic, Euclidian algorithm, Finite Fields of the form GF(p), Polynomial arithmetic	**10**
III	**Block Ciphers. Data Encryption Standard, AES Cipher** Block Cipher Principles – Stream Ciphers and Block Ciphers, Feistel Cipher, Feistel Decryption algorithm, The Data encryption standard, DES Decryption - Avalanche effect,The AES Cipher, substitute bytes transformation, Shift row transformation, Mix Column transformation	**11**
IV	**Public Key Cryptography, RSA and Key Management** Principles of public key cryptosystems-Public key cryptosystems, Application for Public key cryptosystem requirements, Fermat‟s theorem, Euler‟s Totient Function, Euler‟s theorem, RSA algorithm, Key management, Distribution of public keys, Publicly available directory, Public key authority, public key certificates, Distribution of secret keys using public key cryptography	**9**
V	**Message Authentication and Hash Function**	

	Authentication requirements, Authentication functions- Message Encryption, Public Key Encryption, Message Authentication Code, Hash function	**6**
	Total hours	**45**

vii) ASSESSMENT PATTERN

Mark distribution

Total Marks	**Continuous Internal Evaluation Marks**	**End Semester Evaluation Marks**	**End Semester Examination Duration**
150	**50**	**100**	**3 Hours**

Continuous Internal Evaluation Pattern:

Attendance	**10 Marks**
Continuous Assessment Tests (2 numbers)	**25 Marks**
Assignment/Quiz/Course project *Atleast one assignment should be simulation of one type transistor amplifier on any circuit simulation software.*	**15 Marks**

End Semester Examination Pattern:

There will be two parts; Part A and Part B. Part A contain10questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EC1U42D	PATTERN RECOGNITION	PEC	3	0	0	3	2020

i) PREREQUISITE: MA0U10A -Linear Algebra and Calculus, MA0U20C -Probability, Random Process and Numerical Methods, Basics of Machine Learning.

ii) COURSE OVERVIEW

This course aims to impart the fundamentals of statistical pattern recognition and neural network techniques

iii) COURSE OUTCOMES

After the completion of the course, the student will be able to:

Course Outcomes	Description	Level
CO 1	Understand the basics of statistical pattern recognition	Understand
CO 2	Apply statistical methods in linear classification	Apply
CO 3	Apply linear algebra and statistical methods in parameter and non-parameter Estimation	Apply
CO 4	Apply statistical methods in non-linear classification and neural networks	Apply
CO 5	Understand the basics of deep learning networks, convolutional neural networks	Understand

iv) SYLLABUS

Basics of pattern recognition system, various applications, classification of pattern recognition systems, design of Pattern recognition system. Statistical pattern recognition: review of probability theory, Gaussian distribution, Bayes decision theory, optimal solutions for minimum error and minimum risk criteria.

Linear Classifiers, linearly separable classes, normal density, discriminant functions, decision surfaces, linear discriminants, binary class, multiple classes, cost functions, perceptron algorithm, SVM, Fisher‟s linear discriminant.

Parameter estimation methods: Maximum-Likelihood estimation, Bayesian parameter estimation, mixture models, mixtures of Gaussians, Expectation-maximization method.
Non-Parameter methods: Non-parametric techniques for density estimation - Parzen-window method, K-nearest neighbour density estimation, nearest neighbor rule.

Nonlinear classifiers, the XOR problem, two-layer multilayer perceptrons, multilayer perceptrons, neural networks, feed-forward networks, hidden units, activation function, weight vector, bias, cost functions, forward and backward propagation, learning by gradient descent, backpropagation algorithm.

Introduction to deep learning networks, deep feedforward networks, ReLU, bias-variance tradeoff, regularization, dropout, vanishing/exploding gradients, weight initialization for deep networks, basics of convolutional neural networks, layers of convolutional neural networks.

v) a) TEXT BOOKS

1) Bishop, C. M. “Pattern Recognition and Machine Learning” Springer, New York, 2006.
2) Duda, R.O., Hart, P.E., and Stork, D.G. “Pattern Classification”. Wiley, New York, 2001.

b) REFERENCES

1) Hastie, T., Tibshirani, R. and Friedman, J. “The Elements of Statistical Learning”. Springer. 2001.
2) Theodoridis, S. and Koutroumbas, K. “Pattern Recognition”. Academic Press, San Diego, 2003.
3) Ian Goodfellow, Yoshua Bengio, Aaron Courville. “Deep Learning” MIT Press, 2016.
4) Morton Nadier and Eric Smith P., “Pattern Recognition Engineering”, John Wiley & Sons, New York, 1993.

vi) COURSE PLAN

Module	Contents	No. of hours
I	Basics of pattern recognition system, various applications, types of pattern recognition systems, design of Pattern recognition system. Statistical pattern recognition: review of probability theory, Bayes decision theory, optimal solutions for minimum error and minimum risk criteria.	9
II	Linear Classifiers, linearly separable classes, normal density, discriminant functions, decision surfaces, linear discriminants, binary class, multiple classes, cost functions, perceptron algorithm, SVM, Fisher‟s linear discriminant.	9
III	Parameter estimation methods: Maximum-Likelihood estimation, Bayesian parameter estimation, mixture models, mixtures of Gaussians, Expectation-maximization method. Non-parametric techniques for density estimation - Parzen-window method, K-nearest neighbour density estimation, nearest neighbor rule.	9
IV	Nonlinear classifiers, the XOR problem, two-layer multilayer perceptrons, multilayer perceptrons, neural networks, feed-forward networks, hidden units, activation function, weight vector, bias, cost functions, forward and backward propagation, learning by gradient descent, backpropagation algorithm.	9

V	Introduction to deep learning networks, deep feedforward networks, ReLU, bias-variance tradeoff, regularization, dropout, vanishing/exploding gradients, weight initialization for deep networks, basics of convolutional neural networks, layers of convolutional neural networks	**9**
	Total hours	**45**

vii) ASSESSMENT PATTERN

Mark distribution

Total Marks	Continuous Internal Evaluation Marks	End Semester Evaluation Marks	End Semester Examination Duration
150	**50**	**100**	**3 Hours**

Continuous Internal Evaluation Pattern:

Attendance	**10 Marks**
Continuous Assessment Tests (2 numbers)	**25 Marks**
Assignment/Quiz/Course project	**15 Marks**

Simulation Assignments (using Python or Matlab)

- Linear classifiers
- Maximum likelihood estimation,
- Bayesian estimation
- Expectation-maximization method.
- Multilayer perceptrons
- Backpropagation
- Deep learning examples
- Basic CNN

End Semester Examination Pattern:

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EC1U42E	RF CIRCUIT DESIGN	PEC	3	0	0	3	2020

i) **PREREQUISITE:** EC1U30E -Electromagnetics, EC1U20D -Analog Circuits and EC1U20C -Network Theory

ii) COURSE OVERVIEW

This course deals with the analysis, design and simulation of Radio Frequency (RF) Circuits and Components for wireless communication systems. The course provides fundamentals of transmission lines, high frequency circuit behavior, impedance matching networks, filters, active RF components, amplifiers, and mixers. The course will enable the students to use CAD tools for simulating and designing RF circuits.

iii) COURSE OUTCOMES

After the completion of the course, the student will be able to:

Course Outcomes	Description	Level
CO 1	Explain the basic idea about RF networks and working of RF filter Circuits	Understand
CO 2	Describe the behaviour of RF components and application of Network analyzer in parameter measurement	Understand
CO 3	Apply the principle of RF networks in the designing of RF amplifiers, RF Oscillators and Mixers	Apply

iv) SYLLABUS

Introduction to RF System: Importance of radio frequency design, RF behavior of resistors, inductors and capacitors. **Transmission Lines**-Equivalent Circuit representation-General Transmission Line Equation-Terminated transmission lines- Input impedance, Standing waves, VSWR, Return loss, Insertion loss, Characteristic impedance, Phase velocity, Planar Transmission Lines- Microstrip lines and Striplines- Constructional Features.

RF Network Analysis: Single and Multi-port Networks– Definitions-Impedance matrix, scattering matrix, Transmission (ABCD) matrix. **Impedance Matching Networks-**Design of Matching Circuits using Lumped Elements, Single Stub tuning, Quarter-Wave Transformers, Multi-Section Transformer -Binomial Transformer**. RF Filter Design**- Filter Design using insertion loss technique.

RF Components: Active RF components- Bipolar junction Transistor – Construction-Functionality-Power Frequency Limitations of High Frequency transistors, GaAs devices - Familiarization of RF Field Effect Transistors and High Electron Mobility Transistors-Constructional details**, RF circuit measurements and characterization**- Using Vector Network analyzer- S parameter, Reflection Coefficient and Insertion loss Measurement**. Modeling and Simulation of RF circuits using** – Open source or Commercial EM Simulation Software.

Radio Frequency Amplifiers: Amplifier design using S-parameters - Characteristics of Amplifier Power Relations, Stability Considerations – Stability Circles, Tests for Unconditional

Stability, **High frequency amplifier design –** Single stage amplifier Design – Design for maximum gain, Low noise amplifier design.

Radio Frequency Oscillators and Mixers: Basic oscillator model- Feedback oscillator design- Negative Resistance Oscillator- Dielectric Resonator Oscillator - YIG Tuned Oscillator. **Mixer -** Basic characteristics- Single-Ended Mixer Design, Single-balanced and double- balanced mixers.

v) a) TEXT BOOKS

1) Ludwig, Reinhold. RF Circuit Design: Theory & Applications, 2/e. Pearson Education India, 2000.
2) Pozar, David M. Microwave and RF design of wireless systems. John Wiley & Sons, 2000

b) REFERENCES

1) Radmanesh, Matthew M. Advanced RF & microwave circuit design: the ultimate guide to superior design. Author House, 2008.
2) Carr, Joseph J. Secrets of RF circuit design. McGraw-Hill Education, 2001.
3) Misra, Devendra K. Radio-frequency and microwave communication circuits: analysis and design. John Wiley & Sons, 2012.
4) Mathew M. Radmanesh, “Radio Frequency & Microwave Electronics”, 2nd Edition, Pearson Education Asia, 2002.
5) Rohde, Ulrich L., and David P. Newkirk. RF/microwave circuit design for wireless applications. John Wiley & Sons, 2000.
6) Davis, W. Alan, and Krishna Kumar Agarwal. Radio frequency circuit design. John Wiley, 2001.
7) Christopher, Bowick, Ajluni Cheryl, and Blyler John. RF Circuit Design. Newnes, 2007.
8) Abrie, Pieter LD. Design of RF and microwave amplifiers and oscillators. Artech House, 1999.

vi) COURSE PLAN

Module	**Contents**	**No. of hours**
I	Introduction to RF circuits- Importance of radio frequency design, RF behaviour of resistors , Inductors and capacitors, Transmission Lines- Equivalent Circuit representation- General Transmission Line Equation, Terminated transmission lines- Input Impedance Standing waves, VSWR, Return loss, Insertion loss, Characteristic impedance, Planar Transmission Lines- Microstrip lines and Striplines- Constructional Features	**9**
II	Single and Multi-port Networks- Impedance matrix, Scattering matrix, Transmission (ABCD) matrix, Impedance matching Network- Design of Matching Circuits using Lumped Elements, Single Stub Matching Quarter-Wave Transformers, Multi-Section Transformer- Binomial Transformer, RF Filter Design- Filter Design using insertion loss technique	**9**

Module	Contents	No. of hours
III	Active RF components - Bipolar junction Transistor – Construction - Functionality-Power Frequency Limitations of High Frequency transistor GaAs devices - Familiarization of RF Field Effect Transistors and High Electron Mobility Transistors – Constructional details, RF circuit measurements and characterization - Using Vector Network analyzer - S parameter, Reflection Coefficient and Insertion loss Measurement, Modelling and Simulation of RF circuits using- Opensource/Commercial EM simulation software	**10**
IV	Amplifier design using S-parameters- Characteristics of Amplifier Power Relations Stability Considerations – Stability Circles, Tests for Unconditional Stability, High frequency amplifier design– Single stage amplifier Design –Design for maximum gain, Low noise amplifier design	**9**
V	Basic oscillator model-Feedback oscillator design-Negative Resistance Oscillator, Dielectric Resonator Oscillator- YIG Tuned Oscillator, Mixer- Basic characteristics - Single-Ended Mixer Design Single-balanced and double- balanced mixers	**8**
	Total hours	**45**

vii) ASSESSMENT PATTERN

Mark distribution

Total Marks	Continuous Internal Evaluation Marks	End Semester Evaluation Marks	End Semester Examination Duration
150	50	100	3 Hours

Continuous Internal Evaluation Pattern:

Attendance	**10 Marks**
Continuous Assessment Tests (2 numbers)	**25 Marks**
Assignment/Quiz/Course project	**15 Marks**

End Semester Examination Pattern:

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Code	**Course Name**	**Category**	**L**	**T**	**P**	**Credit**	**Year of Introduction**
EC1U42F	MIXED SIGNAL CIRCUIT DESIGN	PEC	2	1	0	3	2020

i) PRE-REQUISITE: EC1U20D ANALOG CIRCUITS, EC1U20B LOGIC CIRCUIT DESIGN

ii) COURSE OVERVIEW:

Goal of this course is to give the knowledge about various analog and digital CMOS circuits and to impart the skill in analysis and design of analog and digital CMOS circuits.

iii) COURSE OUTCOMES

After the completion of the course, the student will be able to:

Course Outcomes	**Description**	**Level**
CO 1	Analyse various analog and digital CMOS subcircuits	Understand
CO 2	Analyse various CMOS amplifiers.	Understand
CO 3	Analyse Data Converters.	Understand

iv) SYLLABUS

CMOS Amplifiers Active load: MOS resistor, MOS current source, diode connected MOS. CMOS **Amplifiers:** Common source amplifier with resistive and active loads, Common source amplifier with source degeneration, Common gate and Common drain amplifier (only voltage gain and input and output impedances of the circuits).

CMOS Differential Amplifiers MOS Current Mirror: Simple, Cascode and Wilson current mirror circuits. **CMOS Differential Amplifier**: Differential Amplifier with resistive, current source, with current mirror and cascode loads(only voltage gain and input and output impedance of the circuits).

CMOS Operational Amplifier Opamp Performance parameters, Single stage and two stage op-amps with different types of load. Gain Boosting in Opamp.

References and Switched Capacitor Circuits References: Supply Independent Biasing, Temperature independent references– band gap reference. Switched Capacitor Circuits: Switched capacitor resistor, Switched CapacitorIntegrator,1st order filter.

Data Converters DAC: Non-idealities in DAC, Types: Resistive, Charge redistribution, Voltage Scaling, Cyclic and Pipelined

ADC: Non-idealities in ADC, Sample and Hold circuit, quantization errors, Types of ADC : Flash, two step, pipelined, successive approximation, Folding.

v) (a) TEXT BOOKS

1) Behzad Razavi, “Design of Analog CMOS Integrated Circuits”, McGraw-Hill, 2/e, 2002
2) Meyer Gray , Hurst, Lewis, “Analysis and Design of Analog Integrated Circuits”, 5th Edition ,Wiley 2009.

(b) OTHER REFERENCES

1) Phillip E. Allen, Douglas R. Holbery, CMOS Analog Circuit Design, Oxford, 2004.
2) Razavi B., Fundamentals of Microelectronics, Wiley student Edition2014.
3) Baker, Li, Boyce, CMOS: Circuits Design, Layout and Simulation, PHI, 2000.

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vi) COURSE PLAN

Module	Contents	No. of hours
I	**CMOS Amplifiers** **Active load:** MOS resistor, MOS current source, diode connected MOS. CMOS **Amplifiers:** Common source amplifier with resistive and active loads, Common source amplifier with source degeneration, Common gate and Common drain amplifier (only voltage gain and input and output impedances of the circuits).	9
II	**CMOS Differential Amplifiers** **MOS Current Mirror**: Simple, Cascode and Wilson current mirror circuits. **CMOS Differential Amplifier**: Differential Amplifier with resistive, current source, with current mirror and cascode loads(only voltage gain and input and output impedance of the circuits)	9
III	**CMOS Operational Amplifier** Opamp Performance parameters, Single stage and two stage op-amps with different types of load. Gain Boosting in Opamp	9
IV	**References and Switched Capacitor Circuits References**: Supply Independent Biasing, Temperature independent references– band gap reference. Switched Capacitor Circuits: Switched capacitor resistor, Switched CapacitorIntegrator,1st order filter.	9
V	**Data Converters** **DAC**: Non-idealities in DAC, Types: Resistive, Charge redistribution, Voltage Scaling, Cyclic and Pipelined. **ADC**: Non-idealities in ADC, Sample and Hold circuit, quantization errors, Types of ADC : Flash, two step, pipelined, successive approximation, Folding.	9
	Total hours	**45**

vii) ASSESSMENT PATTERN

Mark distribution

Total Marks	Continuous Internal Evaluation Marks	End Semester Evaluation Marks	End Semester Examination Duration
150	**50**	**100**	**3 Hours**

Continuous Internal Evaluation Pattern:

Attendance	**10 Marks**
Continuous Assessment Tests (2 numbers)	**25 Marks**
Assignment/Quiz/Course project	**15 Marks**

End Semester Examination Pattern:

There will be two parts; Part A and Part B. Part A contain10questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EC1U42G	ENTREPRENEURSHIP	PEC	3	0	0	3	2020

i) PREREQUISITE: Students should have a basic knowledge in management

ii) COURSE OVERVIEW

To understand the knowledge of entrepreneurship and apply in the organization.

iii) COURSE OUTCOMES

After the completion of the course the student will be able to:

Course Outcomes	Description	Level
CO 1	Discuss the fundamental concepts of entrepreneurship	Understand
CO 2	Explain entrepreneurial motivation and motivation theories	Understand
CO 3	Discuss types of enterprises and ownership structure	Understand
CO 4	Explain the various institutional support and policies offered for entrepreneurship development	Understand
CO 5	Apply project evaluation methods	Apply

iv) SYLLABUS

Entrepreneurship: definition, requirements to be an entrepreneur, entrepreneur and intrapreneur, women entrepreneurship, rural and urban entrepreneurship. Entrepreneurial Motivation: Maslow‟s need hierarchy theory, McClelland‟s acquired need theory.

Types of Enterprises: Small, medium and large-scale enterprises, role of small enterprises in economic development; Types of ownership Structures: Proprietorship, partnership, limited liability s and co-operatives: their formation, capital structure and source of finance.

Institutional Support and Policies: institutional support towards the development of entrepreneurship in India, technical consultancy organizations, Government programs, policies

Project identification and selection, project report, contents and formulation, elements of project formulation, project design and network analysis. Project evaluation methods internal rate of return method and net present value method.

Management of Enterprises: introduction to human resource management: planning, job analysis, Enterprise financing, raising and managing capital, shares, debentures, bonds, cost of capital; break- even analysis, balance sheet analysis.

v) (a) TEXT BOOKS

1. Khanka S S Entrepreneurial Development, S Chand & Company Ltd. New Delhi,2011
2. Ram Chandran, Entrepreneurial Development, Tata McGraw Hill, New Delhi, 2008
3. Saini, J. S. Entrepreneurial Development Programmes and Practices, Deep & Deep Publications,2012

(b) REFERENCES

1. Badhai, B Entrepreneurship for Engineers, B. K. Publications Private Limited, 2019
2. Desai, Vasant, Project Management and Entrepreneurship Himalayan Publishing Mumbai, 2017
3. Gupta, Srinivasan, „Entrepreneurial Development", S Chand & Sons, New Delhi,2020

vi) COURSE PLAN

Module	Contents	No. of hours
I	**Entrepreneurship:** definition, requirements to be an entrepreneur, entrepreneur and intrapreneur, entrepreneur and manager, growth of entrepreneurship in India, women entrepreneurship, rural and urban entrepreneurship. **Entrepreneurial Motivation:** motivating factors, motivation theories-Maslow"s need hierarchy theory, McClelland"s acquired need theory, government"s policy actions towards entrepreneurial motivation, entrepreneurship development programmes.	**9**
II	**Types of Enterprises:** Small-scale, medium-scale and large-scale enterprises, role of small enterprises in economic development; **Types of ownership Structures:** Proprietorship, partnership, limited liability companies and co-operatives: their formation, capital structure and source of finance.	**9**
III	**Institutional Support and Policies:** institutional support towards the development of entrepreneurship in India, technical consultancy organizations, Government programs, policies, incentive and institutional networking for enterprise setting, women entrepreneurship development in India, promotional schemes.	**9**
IV	**Project identification and selection:** Identification and Selection process of projects, project report, contents and formulation, elements of project formulation, project design and network analysis **Project evaluation:** Concept of project evaluation, methods of project evaluation: internal rate of return method and net present value method.	**9**
V	**Management of Enterprises:** Objectives and functions of management, scientific management, general and strategic management; introduction to human resource management: planning, job analysis, training, recruitment and selection, marketing and organizational dimension of enterprises; enterprise financing, raising and managing capital, shares, debentures, bonds, cost of capital; break-even analysis, balance sheet analysis.	**9**
	Total hours	**45**

vii) ASSESSMENT PATTERN

Mark distribution

Total Marks	Continuous Internal Evaluation Marks	End Semester Evaluation Marks	End Semester Examination Duration
150	**50**	**100**	**3 Hours**

Continuous Internal Evaluation Pattern:

Attendance	**10 Marks**
Continuous Assessment Tests (2 numbers)	**25 Marks**
Assignment/Quiz/Course project	**15 Marks**

End Semester Examination Pattern:

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

PROGRAMME ELECTIVE-IV

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EC1U43A	MODERN COMMUNICATION SYSTEMS	PEC	3	0	0	3	2020

i) PRE-REQUISITE: MA0U20C -Probability, Random Process and Numerical Methods, EC1U30C - Analog and Digital Communication, EC1U30G -Information Theory and Coding

ii) COURSE OVERVIEW: This course aims to impart knowledge on the basics of modern communication systems and the breakthrough wireless technologies.

iii) COURSE OUTCOMES

After the completion of the course, the student will be able to:

Course Outcomes	Description	Level
CO 1	Explain OFDM, OFDMA and SC-FDMA techniques used in cellular communication	Apply
CO 2	Discuss the different wireless communication standards for short range communication	Understand
CO 3	Explain the IoT architecture and various connectivity technologies used in IoT Systems	Understand
CO 4	Explain various communication standards for connected autonomous vehicles .	Understand
CO 5	Explain the significance and architecture of software defined radio and cognitive radio.	Understand

iv) SYLLABUS

Cellular Communication System

Need for Multi carrier system, Basics of Orthogonal Frequency Division Multiplexing (OFDM), Multiple access for OFDM systems, Orthogonal Frequency Division Multiple Access (OFDMA), Single carrier Frequency Division Multiple Access (SC-FDMA). Cellular concept, path loss and shadowing, Doppler shift, Multipath effect, Significance of diversity in wireless communication systems.

Short Range Communication System

Introduction to current wireless technologies, background and current scenario, future wireless network requirements, IEEE 802.11 (Wi-Fi) standards and applications (IEEE 802.11a/b/g/n/ac/ax), HiperLAN technology, WPAN (IEEE 802.15.1, IEEE 802.15.3 & IEEE 802.15.4) and WMAN (IEEE 802.16a - WiMAX), Space time wireless standards, IEEE 802.16 (Wi-Max standard), 3GPP-LTE standard, Millimeter wave characteristics, Channel performance at 60 GHz, Development of millimeter wave standards, Indoor and outdoor applications for millimeter wave communications. 6G Networks – Use Cases and Technologies.

IoT System

Introduction of IoT, characteristics, physical and logical design of IoT, IoT Enabling Technologies – Wireless Sensor networks, Cloud computing. Introduction to IoT, Evolution of IoT, IoT Networking Components.IoT Connectivity Technologies – Zigbee, Wireless HART, RFID, NFC, LoRa, WiFi, Bluetooth. IoT Communication Technologies – Infrastructure Protocols – IPv6, 6LoWPAN, Data Protocols – MQTT, MQTT-SN, CoAP. IoT Case Studies and Future Trends – Agricultural IoT, Vehicular IoT, Healthcare IoT.

Intelligent Transport System

Introduction to Intelligent Vehicular Communication – Evolution, Vehicular Networks and ITS, Vehicular Communication Standards/ Technologies – DSRC, IEEE 802.11p WAVE, IEEE 1609, IEEE 802.15.7 - Visible Light Communication (VLC), 4G/5G-Device to Device (D2D), 6G Cellular Networks and Connected Autonomous Vehicles, Operational Scenario – Collision Avoidance.

Software Defined Radio System

Software radio concepts, Operating frequency bands, Transmitter and Receiver specifications of SDR, Architecture of SDR, Introduction of cognitive radio, significance of cognitive radio and spectrum subleasing, spectrum sharing in cognitive radio, implementation of cognitive radio.

v) (a) TEXT BOOKS

1. Aditya K. Jagannatham, “Principles of Modern Wireless Communication Systems”, Tata McGraw Hill, 2016.
2. T.L. Singal, “Wireless Communications”, Tata McGraw Hill Education Private Limited, Second Edition, 2011.
3. K. C. Huang, Z. Wang, “Millimeter Wave Communication systems”, John Wiley &Sons.
4. Sudip Misra, Anandarup Mukherjee & Arijit Roy. “Introduction to IoT”. Cambridge University Press. 2021.
5. George J. Dimitrakopoulos. “Current Technologies in Vehicular Communication”, Springer International Publishing, 2017.
6. He, J., Yang, K. and Chen, H.H, “6G Cellular Networks and Connected Autonomous Vehicles”, IEEE Network, vol. 35, no. 4, pp. 255 -261, 2020.
7. Walter Tuttlebee, “SDR Enabling Technologies”, John Wiley.

8. Huseyin Arslan, “Cognitive Radio, SDR and Adaptive Wireless System”, Springer, 2007.

b) REFERENCES

1. Dipankar Raychaudhuri, Mario Gerla, “Emerging Wireless Technologies and the Future Mobile Internet”, Cambridge University Press, 2011.

2. ArshdeepBahga, A., & Vijay Madisetti V. “Internet of Things: A hands-on approach”. Vpt., 2014.

3. Paul, A., Chilamkurti, N., Daniel, A. and Rho, S. “Intelligent vehicular networks and communications: fundamentals, architectures and solutions”. Elsevier, 2016.

4. Peter B. Kenington, „RF and baseband techniques for software defined radio”, Artech House Mobile Communication, 2005.

vi) COURSE PLAN

Module	**Contents**	**No. of hours**
I	Need for Multi carrier system, Basics of Orthogonal Frequency Division Multiplexing (OFDM), Multiple access for OFDM systems, Orthogonal Frequency Division Multiple Access (OFDMA), Single carrier Frequency Division Multiple Access (SC-FDMA). Cellular concept, path loss and shadowing, Doppler shift, Multipath effect, Significance of diversity in wireless communication systems.	**9**
II	Introduction to current wireless technologies, background and current scenario, future wireless network requirements, IEEE 802.11 (Wi-Fi) standards and applications (IEEE 802.11a/b/g/n/ac/ax), HiperLAN technology, WPAN (IEEE 802.15.1, IEEE 802.15.3 & IEEE 802.15.4) and WMAN (IEEE 802.16a - WiMAX), Space time wireless standards, IEEE 802.16 (Wi-Max standard), 3GPP-LTE standard, Millimeter wave characteristics, Channel performance at 60 GHz, Development of millimeter wave standards, Indoor and outdoor applications for millimeter wave communications. 6G Networks – Use Cases and Technologies.	**10**
III	Introduction of IoT, characteristics, physical and logical design of IoT, IoT Enabling Technologies – Wireless Sensor networks, Cloud computing. Introduction to IoT, Evolution of IoT, IoT Networking Components. IoT Connectivity Technologies – Zigbee, Wireless HART, RFID, NFC, LoRa, WiFi, Bluetooth. IoT Communication Technologies – Infrastructure Protocols – IPv6, 6LoWPAN, Data Protocols – MQTT, MQTT-SN, CoAP. IoT Case Studies and Future Trends – Agricultural IoT, Vehicular IoT, Healthcare IoT.	**8**
IV	Introduction to Intelligent Vehicular Communication – Evolution, Vehicular Networks and ITS, Vehicular Communication Standards/ Technologies – DSRC, IEEE 802.11p WAVE, IEEE 1609, IEEE 802.15.7 - Visible Light Communication (VLC), 4G/5G-Device to Device (D2D), 6G Cellular Networks and Connected Autonomous Vehicles, Operational Scenario – Collision Avoidance.	**8**
V	Software radio concepts, Operating frequency bands, Transmitter and Receiver specifications of SDR, Architecture of SDR, Introduction of cognitive radio, significance of cognitive radio and spectrum subleasing, spectrum sharing in cognitive radio, implementation of cognitive radio.	**10**
	Total hours	**45**

vii) ASSESSMENT PATTERN

Mark distribution

Total Marks	Continuous Internal Evaluation Marks	End Semester Evaluation Marks	End Semester Examination Duration
150	**50**	**100**	**3 Hours**

Continuous Internal Evaluation Pattern:

Attendance	**10 Marks**
Continuous Assessment Tests (2 numbers)	**25 Marks**
Assignment/Quiz/Course project	**15 Marks**

End Semester Examination Pattern:

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EC1U43B	REAL TIME OPERATING SYSTEMS	PEC	2	1	0	3	2020

i) PREREQUISITE: Students should have a basic knowledge in Computer Architecture and Microcontrollers

ii) COURSE OVERVIEW

To understand RTOS, its basic structure, building blocks, various operations and to summarize the different scheduling algorithms used in RTOS.

iii) COURSE OUTCOMES

After the completion of the course the student will be able to:

Course Outcomes	Description	Level
CO 1	Summarize the functions and structure of general-purpose operating systems.	Understand
CO 2	Use different scheduling algorithms on processes and threads.	Apply
CO 3	Interpret a real time operating system along with its synchronization, communication and interrupt handling tools.	Understand
CO 4	Illustrate task constraints and analyze the different scheduling algorithms on tasks.	Analyse
CO 5	Illustrate the applications of real time operating systems.	Apply

iv) SYLLABUS

Operating system: Types, Objectives and functions, Kernel, Process - States, Process Control Block, Operations on processes

Process Scheduling: FCFS, SJF, Priority, Round-Robin, Multilevel Queue and Multilevel Feedback Queue Scheduling. Thread: Structure.User and kernel level threads, multi-threading models, multiprocessor scheduling

Real Time Operating Systems: Structure and characteristics of Real Time Systems, Task: Task states, Task synchronization -Semaphores- types, Inter task communication mechanisms: message queues, pipes, event registers, signals, Exceptions and interrupt handling.

Task constraints, Task scheduling: Aperiodic task scheduling: EDD. EDF, LDF, EDF with precedence constraints. Periodic task scheduling:Rate monotonic and Deadline monotonic, Real time Kernel-Structure, State transition diagram, Kernel primitives.

Features of FreeRTOS and Linux Commercial real time operating systems: PSOS, VRTX, RT LinuxFeatures and application only. Case study of (Kernel design, threads and task scheduling) RTOS: MicroC/OS-II. RTOS control system used in real life applications - in adaptive cruise control.

v) (a) TEXT BOOKS

1. Abraham Silberschatz- „Operating System Principles‟: Wiley India,7th edition, 2011
2. William Stallings –„Operating systems- Internals and design principles‟, Prentice Hall, 7th edition, 2011
3. Qing Li – „Real-Time Concepts for Embedded Systems „„ CMP Books, 2013
4. Giorgio C. Buttazzo, -„HARD REAL-TIME COMPUTING SYSTEMS Predictable Scheduling Algorithms and Applications‟, Kluwer Academic Publishers.

(b) REFERENCES

1. Tanenbaum -„Modern Operating Systems‟ ,Pearson Edition, 3/e, 2007.
2. Jean J Labrosse , „Micro C/OS-II, The Real Time Kernel‟ , CMP Books, 2011
3. Rajib Mall, „Real-Time Systems: Theory and Practice „ , 2008.
4. David E. Simon „An Embedded Software Primer‟, Pearson 2012
5. Raj Kamal, „Embedded Systems – Architecture, Programming and Design‟,Tata McGraw Hill

vi) COURSE PLAN

Module	Contents	No. of hours
I	Operating system: Types, Objectives and functions, Kernel, Process - States, Process Control Block, Operations on processes.	**9**
II	Process Scheduling: FCFS, SJF, Priority, Round-Robin, Multilevel Queue and Multilevel Feedback Queue Scheduling. Thread: Structure. User and kernel level threads, multi-threading models, multiprocessor scheduling	**9**
III	Real Time Operating Systems: Structure and characteristics of Real Time Systems, Task: Task states, Task synchronization - Semaphores-types, Inter task communication mechanisms: message queues, pipes, event registers, signals, Exceptions and interrupt handling.	**9**
IV	Task constraints, Task scheduling: Aperiodic task scheduling: EDD. EDF, LDF, EDF with precedence constraints. Periodic task scheduling:Rate monotonic and Deadline monotonic, Real time Kernel- Structure, State transition diagram, Kernel primitives.	**9**
V	Features of FreeRTOS and Linux Commercial real time operating systems: PSOS, VRTX, RT Linux Features and application only. Case study of (Kernel design, threads and task scheduling) RTOS: MicroC/OS-II. RTOS control system used in real life applications - in adaptive cruise control.	**9**
	Total hours	**45**

vii) ASSESSMENT PATTERN

Mark distribution

Total Marks	Continuous Internal Evaluation Marks	End Semester Evaluation Marks	End Semester Examination Duration
150	**50**	**100**	**3 Hours**

Continuous Internal Evaluation Pattern:

Attendance	**10 Marks**
Continuous Assessment Tests (2 numbers)	**25 Marks**
Assignment/Quiz/Course project	**15 Marks**

End Semester Examination Pattern:

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EC1U43C	ADAPTIVE SIGNAL PROCESSING	PEC	2	1	0	3	2020

i) PREREQUISITE: EC1U30B - Digital Signal processing

ii) COURSE OVERVIEW:

This course aims to introduce to the concept and need of adaptive filters and popular adaptive signal processing algorithms.

iii) COURSE OUTCOMES

After the completion of the course, the student will be able to:

Course Outcomes	Description	Level
CO 1	Explain the basic concepts of statistical signal processing.	Understand
CO 2	Design filters for optimising the cost function indicating error in estimation of parameters and appreciate the need for adaptation in design.	Apply
CO 3	Evaluate the performance of various methods for designing adaptive filters through estimation of different parameters of stationary random process clearly considering practical application specifications.	Apply
CO 4	Analyse convergence and stability issues associated with adaptive filter design and come up with optimum solutions for real life applications taking care of requirements in terms of complexity and accuracy	Apply
CO 5	Design and implement filtering solutions for applications such as channel equalisation, interference cancelling and prediction considering present day challenges	Apply

iv) SYLLABUS

Basics of adaptive systems, applications, different performance functions, searching performance surface-stability and rate of convergence, LMS/Newton algorithm, adaptive recursive filters, Kalman filters, Applications-adaptive modelling and system identification: Multipath communication channel, geophysical exploration, Kalman filter as the unifying basis for RLS filters, Inverse adaptive modelling

v) a) TEXT BOOKS

1) Bernard Widrow and Samuel D. Stearns, ―Adaptive Signal Processing‖, Person Education, 1985
2) Mons H Hays -Statistical Digital Signal Processing and Modeling -Wiley Publications, 2006

b) REFERENCES

1) Simon Haykin, ―Adaptive Filter Theory‖, Pearson Education, 2003.
2) John R. Treichler, C. Richard Johnson, Michael G. Larimore, ―Theory and Design of Adaptive Filters, Prentice-Hall of India, 2002.

3) John G. Proakis, Dimitris G. Manolokis, “Digital Signal Processing”, Prentice Hall of India, New Delhi, 2005
4) S. Thomas Alexander, “Adaptive Signal Processing - Theory and Application”, Springer Verlag.
5) D. G. Manolokis, V. K. Ingle and S. M. Kogar, “Statistical and Adaptive Signal Processing”, Mc Graw Hill International Edition, 2000.

vi) COURSE PLAN

Module	**Contents**	**No. of hours**
I	Adaptive systems- Definitions and characteristics - applications – properties examples - adaptive linear combiner input signal and weight vectors - performance function-gradient and minimum mean square error - introduction to filtering- smoothing and prediction - linear optimum filtering-orthogonality - Wiener – Hopf equation performance surface	**10**
II	Searching performance surface-stability and rate of convergence: Learning curve gradient search - Newton's method - method of steepest descent - comparison - Gradient estimation - performance penalty - variance - excess MSE and time constants – mis adjustments	**9**
III	LMS algorithm, convergence of weight vector: LMS/Newton algorithm - properties - sequential regression algorithm - adaptive recursive filters - random-search algorithms - lattice structure - adaptive filters with orthogonal signals.	**9**
IV	Kalman filters-recursive minimum mean square estimation for scalar random variable. Applications-adaptive modeling and system identification: Multipath communication channel, geophysical exploration, Kalman filter as the unifying basis for RLS filters.	**9**
V	Inverse adaptive modeling: Equalization, and deconvolution adaptive equalization of telephone channels-adapting poles and zeros for IIR digital filter synthesis	**8**
	Total hours	**45**

vii) ASSESSMENT PATTERN

Mark distribution

Total Marks	Continuous Internal Evaluation Marks	End Semester Evaluation Marks	End Semester Examination Duration
150	**50**	**100**	**3 Hours**

Continuous Internal Evaluation Pattern:

Attendance	**10 Marks**
Continuous Assessment Tests (2 numbers)	**25 Marks**
Assignment/Quiz/Course project	**15 Marks**

End Semester Examination Pattern:

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EC1U43D	MICROWAVE DEVICES AND CIRCUITS	PEC	3	0	0	3	2020

i) PREREQUISITE: Nil

ii) COURSE OBJECTIVES

- To study microwave semiconductor devices & applications.
- To study microwave sources and amplifiers.
- To analyse microwave networks.
- To introduce microwave integrated circuits

iii) COURSE OVERVIEW

This goal of this course is to understand with active and passive microwave semiconductor devices, components, microwave sources and amplifiers used in microwave communication systems, analysis of microwave networks and microwave integrated circuits.

iv) COURSE OUTCOMES

After the completion of the course, the student will be able to

Course Outcomes	Description	Level
CO 1	Understand the limitation of conventional solid state devices at Microwave, Gunn – effect diodes, Microwave generation and amplification, IMPATT and TRAPATT diodes	Understand
CO 2	Design of Bipolar transistors, MESFET, Microwave amplifiers and oscillator	Apply
CO 3	Analysis of Microwave Network Analysis and the corresponding signal flow graphs	Apply
CO 4	Design of Microwave filters, Filter design by image parameter method, Filter transformation and implementation	Apply
CO 5	Understand different MICs, Distributed and lumped elements of integrated circuits, Diode control devices.	Understand

v) SYLLABUS

Introduction, Characteristic, features of microwaves, Gunn diodes, Bipolar transistors, FET, MESFET Microwave amplifiers and oscillators, Microwave Network Analysis, Impedance matching and tuning. Microwave filters, Filter design by image parameter method, Filter transformation and implementation, Introduction to MICSs, Distributed and lumped elements of integrated circuits, Diode control devices.

vi) a) TEXT BOOKS:

1. David M. Pozar, Microwave Engineering, 4/e, Wiley India, 2012.
2. Robert E. Collin, Foundation of Microwave Engineering, 2/e, Wiley India, 2012.
3. Samuel Y. Liao, Microwave Devices and Circuits, 3/e, Pearson Education, 2003.

b) REFERENCES:

1. Bharathi Bhat and Shiban K. Koul: Stripline-like Transmission Lines for MIC, New Age International (P) Ltd, 1989.
2. I. Kneppo, J. Fabian, et al., Microwave Integrated Circuits, BSP, India, 2006.
3. Leo Maloratsky, Passive RF and Microwave Integrated Circuits, Elsevier, 2006.

vii) COURSE PLAN

Module	Contents	No. of hours
I	Introduction, Characteristic, features of microwaves, Limitation of conventional solid state devices at Microwave Gunn – effect diodes – Gunn effect, Ridley – Watkins-Hilsum theory, Modes of operation, Limited space – Charge accumulation (LSA) mode of Gunn diode. Microwave generation and amplification. Structure, Operation, Power output and efficiency of IMPATT and TRAPATT diodes	9
II	Bipolar transistors – biasing, FET – biasing, MESFET – Structure, Operation. Microwave amplifiers and oscillators – Amplifiers – Gain and stability, Single stage transistor amplifier design Oscillator design – One port negative resistance oscillators.	9
III	Microwave Network Analysis – Equivalent voltages and currents, Impedance and Admittance matrices, Scattering matrix, The transmission matrix Signal flow graphs. Impedance matching and tuning – Matching with lumped elements, Single stub tuning, Double stub tuning. Quarter wave transformer, Theory of small reflections	9
IV	Microwave filters, Periodic structures, Analysis of periodic structures Filter design by image parameter method – Constant k, m-derived and composite. Filter design by insertion loss method. Filter transformation and implementation	9
V	Introduction to MICSs:-Technology of hybrid MICs, monolithic MICs. Comparison of both MICs. Planar transmission lines such as stripline, microstrip line, and slotline Distributed and lumped elements of integrated circuits - capacitors, inductors, resistors, terminations, attenuators, resonators and discontinuities Diode control devices – switches, attenuators, limiters. Diode phase shifter. Circulators and isolators.	9
	Total hours	**45**

viii) ASSESSMENT PATTERN

Mark distribution

Total Marks	Continuous Internal Evaluation Marks	End Semester Evaluation Marks	End Semester Examination Duration
150	**50**	**100**	**3 Hours**

Continuous Internal Evaluation Pattern:

Attendance	**10 Marks**
Continuous Assessment Tests (2 numbers)	**25 Marks**
Assignment/Quiz/Course project	**15 Marks**

End Semester Examination Pattern:

There will be two parts; Part A and Part B. Part A contain 10questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EC1U43E	SPEECH & AUDIO PROCESSING	PEC	3	0	0	3	2020

i) COURSE OVERVIEW

This course introduces students to the mechanism of speech production and the basic concepts of methods for speech analysis and parametric representation of speech. The course imparts ideas related to perception of sound, psycho-acoustic analysis, spatial audio perception and rendering and introduces audio compression schemes to the students.

ii) COURSE OUTCOMES

After the completion of the course, the student will be able to:

Course Outcomes	Description	Level
CO 1	Discuss the basic concepts of speech production, speech analysis, speech coding and parametric representation of speech	Understand
CO 2	Describe frequency domain analysis of speech and various applications of speech processing.	Understand
CO 3	Discuss signal processing models of sound perception and the application of perception models in audio signal processing	Understand
CO 4	Describe audio compression algorithms and standards	Understand
CO 5	Describe the concept of Spatial Audio Perception and audio quality analysis techniques	Understand

iii) SYLLABUS

Speech Production: Acoustic theory of speech production. Speech Analysis: Speech signal, Short-Time Speech Analysis, Time domain analysis (Short time energy, short time zero crossing Rate, ACF).LPC Analysis (LPC model, Auto correlation method).

Frequency domain analysis (Filter Banks, STFT, Spectrogram), Cepstral Analysis, MFCC. Probabilistic formulation of speech recognition, Speech coding: fundamentals, Comparison of waveform coding, vocoding and hybrid coding, Speech enhancement: fundamentals, basic types, Speaker verification (block diagram), Language Identification (block diagram)

Signal Processing Models of Audio Perception: Basic anatomy of hearing System. Auditory Filter Banks, Psycho-acoustic analysis: Critical Band Structure, Absolute Threshold of Hearing, Simultaneous Masking, Temporal Masking, MPEG psycho-acoustic model.

Audio compression methods: Sampling rate and bandwidth requirement for digital audio, Redundancy removal andperceptual irrelevancy removal, Transform coding of digitalaudio: MPEG2-AAC coding standard, MDCT and its properties,Pre-echo and pre-echo suppression, Loss less coding methods.

Spatial Audio Perception and rendering: The physical and psycho- acoustical basis of sound localization and space perception. Spatial audio standards. Audio quality analysis: Objective analysis methods- PEAQ, Subjective analysis methods - MOS score, MUSHRA score

iv) a) TEXT BOOKS

1) W. Fischer, Digital Video and Audio Broadcasting Technology: A Practical Engineering Guide (Signals and Communication Technology), Springer, 2020
2) Lars-Ingemar Lundström, Understanding Digital Television: An Introduction to DVB Systems with Satellite, Cable, Broadband and Terrestrial TV, Focal Press, Elsevier, 2006.
3) K F Ibrahim, Newnes Guide to Televeision and Video Technology, Newnes, 2007.
4) Jiun-Haw Lee, David N. Liu, Shin-Tson Wu, Introduction to Flat Panel Displays, Wiley, 2008.

b) REFERENCES

1) C. Poynton, "Digital Video and HD Algorithms and Interfaces,"Morgan Kaufmann, 2012.
2) Wolfgang Hoeg, Thomas Lauterbach, Digital audio broadcasting: principles and applications of DAB, DAB+ and DMB, Wiley, 2009.
3) John Watkinson, Introduction to Digital Audio, Focal Press, 1994.
4) John Watkinson, Art of Digital Video, Focal Press, 2008.
5) John Watkinson, Introduction to Digital Video, Focal Press, 2001.

v) COURSE PLAN

Module	Contents	No. of hours
I	Acoustic theory of speech production, Speech signal, Short-time analysis of speech, Time domain analysis (Short time energy, short time zero crossing Rate, ACF), LPC Analysis	9
II	Frequency domain analysis (Filter Banks, STFT, Spectrogram), Cepstral Analysis, MFCC, Fundamentals of Speech recognition, Speech coding, Speech Enhancement, Speaker Verification, Language Identification	9
III	Signal Processing Models of Audio Perception, Basic anatomy of hearing System. Auditory Filter Banks, Psycho-acoustic analysis. Critical Band	9

	Structure, Absolute Threshold of Hearing. Simultaneous Masking, Temporal Masking, MPEG psycho-acoustic model	
IV	Sampling rate and bandwidth requirement for digital audio, Redundancy removal and perceptual irrelevancy removal, Transform coding of digital audio: MPEG2-AAC coding standard, MDCT and its properties, Pre-echo and pre-echo suppression, Lossless coding methods.	**9**
V	Spatial Audio Perception and rendering, The physical and psycho- acoustical basis of sound localization and space perception. Spatial audio standards. Audio quality analysis: Objective analysis methods- PEAQ, Subjective analysis methods - MOS score, MUSHRA score	**9**
	tal hours	**45**

vi) ASSESSMENT PATTERN

Mark distribution

Total Marks	Continuous Internal Evaluation Marks	End Semester Evaluation Marks	End Semester Examination Duration
150	**50**	**100**	**3 Hours**

Continuous Internal Evaluation Pattern:

Attendance	**10 Marks**
Continuous Assessment Tests (2 numbers)	**25 Marks**
Assignment/Quiz/Course project	**15 Marks**

End Semester Examination Pattern:

There will be two parts; Part A and Part B. Part A contain 10questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EC1U43F	ANALOG CMOS DESIGN	PEC	2	1	0	3	2020

i) PREREQUISITE: EC1U20D- Analog Circuits, EC1U20A-Solid State Devices

ii) COURSE OVERVIEW

This course aims to impart the basic knowledge of CMOS analog circuits design and enable the students to design integrated circuits.

iii) COURSE OUTCOMES

After the completion of the course, the student will be able to:

Course Outcomes	Description	Level
CO 1	Analyse various single stage amplifiers and differential amplifiers with different types of loads	Analyse
CO 2	Design various types of current mirrors	Apply
CO 3	Plot the frequency response of single stage and differential amplifiers	Understand
CO 4	Analyse the effect of noise in single stage amplifiers	Analyse
CO 5	Implement PLL for various applications	Understand

iii) SYLLABUS

Basic MOS Device physics- Review of MOS Characteristics and Second order effects(only basic theoretical concepts). Single Stage Amplifiers. Common Source Stage with Different Load types , Source Follower,Common Gate and Cascode Stage. Differential Amplifiers - Single-ended and differential operation, Basic differential pair, Common-mode response, Differential pair with MOS load, Gilbert Cell. Current Mirror: Simple, Cascode and Basic concepts of active current Mirror. Frequency Response of Amplifiers: Miller Effect, Poles and Zeros, Frequency Response Analysis of Common Source, Source Follower, Common Gate and Differential Pair. Noise in Amplifiers: Noise in Single Stage amplifier (CS,CG,Source Follower), Noise in Differential Pair, Noise Band Width. Phase Locked Loops- Mathematical model of VCO, Phase Detector, Basic PLL Topology,Type I and Type II(Charge Pump) PLL, Stability Analysis of PLL, Non Ideal Effects in PLL,Application of PLL- Frequency Multiplication, Frequency synthesizer and Skew reduction.Block Diagram of Digital PLL

iv) a) TEXT BOOKS

1) Behzad Razavi, “Design of Analog CMOS Integrated Circuits”, McGraw-Hill, 2/e,2002

REFERENCES

1) Phillip E. Allen, Douglas R. Holbery, CMOS Analog Circuit Design, Oxford, 2004.
2) Razavi B., Fundamentals of Microelectronics, Wiley student Edition2014.
3) Baker, Li, Boyce, CMOS: Circuits Design, Layout and Simulation, PHI, 2000

v) COURSE PLAN

Module	Contents	No. of hours
I	Basic MOS Device physics- Review of MOS Characteristics and Second order effects(only basic theoretical concepts). Single Stage Amplifiers. Common Source Stage with Different Load types , Source Follower, Common Gate and Cascode Stage	**9**
II	Differential Amplifiers - Single-ended and differential operation, Basic differential pair, Common-mode response, Differential pair with MOS load, Gilbert Cell. Current Mirror: Simple, Cascode and Basic concepts of active current Mirror	**9**
III	Frequency Response of Amplifiers: Miller Effect, Poles and Zeros, Frequency Response Analysis of Common Source, Source Follower, Common Gate and Differential Pair	**9**
IV	Noise in Amplifiers: Noise in Single Stage amplifier (CS,CG,Source Follower), Noise in Differential Pair, Noise Band Width.	**9**
V	Phase Locked Loops- Mathematical model of VCO, Phase Detector, Basic PLL Topology, Type I and Type II(Charge Pump) PLL, Stability Analysis of PLL, Non Ideal Effects in PLL, Application of PLL-Frequency Multiplication, Frequency synthesizer and Skew reduction. Block Diagram of Digital PLL	**9**
	Total hours	**45**

vi) ASSESSMENT PATTERN

Mark distribution

Total Marks	Continuous Internal Evaluation Marks	End Semester Evaluation Marks	End Semester Examination Duration
150	**50**	**100**	**3 Hours**

Continuous Internal Evaluation Pattern:

Attendance	**10 Marks**
Continuous Assessment Tests (2 numbers)	**25 Marks**
Assignment/Quiz/Course project	**15 Marks**

End Semester Examination Pattern:

There will be two parts; Part A and Part B. Part A contain10questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EC1U43G	ROBOTICS	PEC	3	0	0	3	2020

i) COURSE OVERVIEW

The goal of this course is to introduce to the students the emerging field of robotics by imparting the fundamental knowledge on the design and control of robots, their multi-disciplinary engineering aspects and applications.

ii) COURSE OUTCOMES

After the completion of the course, the student will be able to:

Course Outcomes	Description	Level
CO 1	Explain different types of Robots and its applications	Understand
CO 2	Select appropriate sensors and actuators based on the robotic applications	Understand
CO 3	Perform kinematic and dynamic analyses for robots.	Apply
CO 4	Carry out the design and control of a simple robot..	Apply
CO 5	Integrate mechanical and electrical hardware for making a robotic device	Apply

ii) SYLLABUS

Introduction to Robotics: Definition and Origin of Robotics.- Robot Anatomy. Robot Specifications. Robot Characteristics - Classification of Robots - Robot Structure - Common Kinematic Arrangements. Degree of Freedom. **Introduction to Sensors and Actuation Systems for Robots**: Actuators - Sensors- Robotic Vision System **Introduction to Robot Kinematics and Dynamics**: Introduction to Kinematics - Kinematic Modelling - Velocity Kinematics – Forward and Inverse Dynamics- Equations of Motion using Euler-Lagrange formulation, Newton Euler Formulation. **Introduction to Robot Control:** Basics of Control Open Loop- Closed Loop, Transfer Functions, Control Laws: P, PD, PID, Linear and Non-linear Controls; Control Hardware and Interfacing; Embedded Systems - Actuators, Introduction to Robot Programming **Recent Developments in Robotics. Mobile Robots:** Mobile Robot Kinematics, Navigation. Humanoid Robotics -. Collaborative Robots - Artificial Intelligence in Robotics: Industrial Applications of Robots in Material Handling and Assembly

iii) (a) TEXTBOOKS

1. S.K. Saha, Introduction to Robotics, Tata McGraw Hill, 2nd Edition, 2014

2. Saeed B. Niku, Introduction to Robotics: Analysis, Systems, Applications, John Wiley & Sons, 2nd Edition, 2011.
3. Spong and Vidyasagar, Robot Dynamics and Control, John Wiley & Sons, 1990.
4. Mikell P. Groover, et al., Industrial Robotics – Technology, Programming and Applications, McGraw Hill, 2nd Edition, 2012

(b) REFERENCES

1. John. J.Craig, Introduction to Robotics: Mechanics and Control, PHI, 2005.
2. Ashitava Ghosal, Robotics, Fundamental concepts and analysis, OXFORD University Press, 2006
3. Fu, K.S,Gonzalez,R.C,Lee, C.S.G.,Robotics, Control, Sensing, Vision and Intelligence, McGraw-Hill, 1987.
4. Asada, H., and J. J. Slotine. Robot Analysis and Control. New York, NY: Wiley, 1986.
5. Robert J. Schilling, Fundamentals of Robotics: Analysis & Control, Pearson Education, 2000
6. Klafter, R.D., Chmielewski, T.A, Negin, M, Robotic Engineering An Integrated Approach, PHI, 2007
7. S. R. Deb, Robotics Technology and Flexible Automation, Tata McGraw Hill, New Delhi, 1994.

iv) COURSE PLAN

Module	Contents	No. of hours
I	**Introduction to Robotics:** Definition and Origin of Robotics. robot Anatomy. Robot Specifications. Robot Characteristics – Accuracy, Precision, and Repeatability. Classification of Robots. Advantages and Disadvantages of Robots. Robot Structure - Types of Joints and End Effectors, Mechanisms and Manipulators. Common Kinematic Arrangements. Degree of Freedom. Robot Coordinates. Reference Frames. Robot Workspace. Areas of Application for Robots.	**9**
II	**Introduction to Sensors and Actuation Systems for Robots**: Actuators: Types of Robotic Drive Systems and Actuators: Hydraulic, Pneumatic and Electric drives. Transmission: Gears, Timing Belts and Bearings. Parameters for selection of actuators. Specification. Areas of Application for: Stepper Motor, Servo Motor and Brushless DC Motor. Microprocessor Control of Motors. Speed Control using PWM and Direction Control using H- Bridge. Sensors: Types and Applications of Sensors in Robotics: Position, Displacement and Velocity Sensors. Tactile Sensors for Contact and Proximity Assessment. Strain Gauge based Force and Torque Sensors. Tachometers, etc. Robotic Vision Systems- Introduction to Cameras, Imaging, Sensing and Digitization. Vision Applications in Robotics.	**9**

III	**Introduction to Robot Kinematics and Dynamics**: Introduction to Kinematics: Position and Orientation of Objects. Rotation. Euler Angles. Rigid Motion Representation using Homogenous Transformation Matrix. Kinematic Modelling: Translation and Rotation Representation, Coordinate Transformation, Forward and Inverse Kinematics. Forward Kinematics-Link Coordinates, Denavit-Hartenberg Representation, Application of DH Convention to Different Serial Kinematic Arrangements. Inverse Kinematics – General Properties of Solutions, Kinematic Decoupling, Velocity Kinematics – Derivation of the Jacobian, Application of Velocity Kinematics for Serial Manipulators, Importance of Singularities. Introduction to Dynamic Modelling: Forward and Inverse Dynamics- Equations of Motion using Euler-Lagrange formulation, Newton Euler Formulation.	9
IV	**Introduction to Robot Control:** Basics of Control: Open Loop- Closed Loop, Transfer Functions, Control Laws: P, PD, PID, Linear and Non-linear Controls; Control Hardware and Interfacing; Embedded Systems: Microcontroller Architecture and Integration with Sensors, Actuators, Components.Introduction to Robot Programming – Programming Methods, Robot Language Classification, Robot Language Structure, Elements and its Functions. Motion, End-Effecter and Sensor Commands in VAL Programming Language. Simple Programs.	9
V	**Recent Developments in Robotics. Mobile Robots:** Mobile Robot Kinematics, Navigation. Humanoid Robotics: Biped Locomotion, Imitation Learning. Collaborative Robots: Collaborative Robot, Collaborative Operation, Applications. Artificial Intelligence in Robotics: Applications in Unmanned Systems, Defense, Medical, Industries, etc. Industrial Applications of Robots in Material Handling and Assembly. Robotics and Automation for Industry 4.0., Robot Safety. Social Robotics.	9
	Total hours	**45**

vi) ASSESSMENT PATTERN

Mark distribution

Total Marks	Continuous Internal Evaluation Marks	End Semester Evaluation Marks	End Semester Examination Duration
150	**50**	**100**	**3 Hours**

Continuous Internal Evaluation Pattern:

Attendance	**10 Marks**
Continuous Assessment Tests (2 numbers)	**25 Marks**
Assignment/Quiz/Course project	**15 Marks**

End Semester Examination Pattern:

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer

PROGRAMME ELECTIVE-V

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EC1U44A	MECHATRONICS	PEC	3	0	0	3	2020

i) COURSE OVERVIEW

This course introduces students to the rapidly emerging, multi-disciplinary, and exciting field of Mechatronics

ii) COURSE OUTCOMES

After the completion of the course, the student will be able to:

Course Outcomes	Description	Level
CO 1	Understand the working principles of various sensors and actuators in Mechatronics systems and be able to choose the suitable one for the real world application	Understand
CO 2	Formulate and simulate models of mechatronics systems	Apply
CO 3	Explain the implementation of PLC in mechatronics applications	Understand
CO 4	Explain the standard fabrication techniques and principle of operation of MEMS devices	Understand
CO 5	Design and analyse the commonly encountered mechatronics systems for real time application	Analyze

iii) SYLLABUS

Introduction to Mechatronics: Structure of Mechatronics system. Comparison between traditional and mechatronics approach. Sensors - Characteristics -Temperature, flow, pressure sensors. Displacement, position and proximity sensing by magnetic, optical, ultrasonic, inductive, capacitive and eddy current methods. Encoders: incremental and absolute. Resolvers and synchros. Piezoelectric sensors. Acoustic Emission sensors. vibration sensors. Force and tactile sensors. Range finders: ultrasonic and light base range finders

Actuators: Hydraulic and Pneumatic actuators - Directional control valves, pressure control valves, process control valves. Rotary actuators. Development of simple hydraulic and pneumatic circuits using standard Symbols. Electrical drives: DC, AC, brushless, servo and stepper motors. Harmonic drive. Magnetostrictive actuators and piezoelectric actuators.

System modelling - Mathematical models and basic building blocks of general mechanical, electrical, fluid and thermal systems. Typical elements of open and closed loop control systems. Adaptive controllers for machine tools. Programmable Logic Controllers (PLC) –Basic structure, input/ output processing. Programming: Timers, Internal Relays, Counters and Shift registers. Development of simple ladder programs for specific purposes.

Micro Electro Mechanical Systems (MEMS): Fabrication: Deposition, Lithography, Micromachining methods for MEMS -Surface and Bulk, Deep Reactive Ion Etching (DRIE) and LIGA processes. Principle, fabrication and working of MEMS based pressure sensor, accelerometer and gyroscope.
Mechatronics in Robotics- choice of Sensors and Actuators. Robotic vision system – Image acquisition: Vidicon, charge coupled device (CCD) and charge injection device (CID) cameras. Image processing techniques: histogram processing: sliding, stretching, equalization and thresholding. Case studies of Mechatronics systems: Automatic camera, bar code reader, simple weighing machine, pick and place robot, automatic car park barrier system, automobile engine management system.

iv) (a) TEXT BOOKS

1) Bolton W., Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering, Person Education Limited, New Delhi, 2007

2) Ramachandran K. P., G. K. Vijayaraghavan, M. S. Balasundaram, Mechatronics: Integrated Mechanical Electronic Systems, Wiley India Pvt. Ltd., New Delhi, 2008.

3) Saeed B. Niku, Introduction to Robotics: Analysis, Systems, Applications, Person Education, Inc., New Delhi, 2006.

4) Devdas Shetty, Richard A. Kolk, “Mechatronics System Design”, Thomson Learning Publishing Company, Vikas publishing house, Second edition, 2001.

(b) REFERENCES

1) David G. Aldatore, Michael B. Histand, Introduction to Mechatronics and Measurement Systems, McGraw-Hill Inc., USA, 2003.

2) Gordon M. Mair, Industrial Robotics, Prentice Hall International, UK, 1998.

3) HMT, Mechatronics, Tata McGraw-Hill Publishing Company Ltd., New Delhi, 2004.

4) Vijay K. Varadan, K. J. Vinoy, S. Gopalakrishnan, Smart Material Systems and MEMS: Design and Development Methodologies, John Wiley & Sons Ltd., England, 2006.

5) Bishop, Robert H. The Mechatronics Handbook-2 Volume Set. CRC press, 2002.

v) COURSE PLAN

Module	Contents	No. of hours
I	Introduction to Mechatronics: Structure of Mechatronics system. Comparison between traditional and mechatronics approach. Sensors - Characteristics -Temperature, flow, pressure sensors. Displacement, position and proximity sensing by magnetic, optical, ultrasonic, inductive, capacitive and eddy current methods. Encoders: incremental and absolute. Resolvers and synchros. Piezoelectric sensors. Acoustic Emission sensors. vibration sensors. Force and tactile sensors. Range finders: ultrasonic and light base range finders	**9**
II	Actuators: Hydraulic and Pneumatic actuators - Directional control valves, pressure control valves, process control valves. Rotary actuators. Development of simple hydraulic and pneumatic circuits using standard Symbols. Electrical drives: DC, AC, brushless, servo and stepper motors. Harmonic drive. Magnetostrictive actuators and piezoelectric actuators.	**9**
III	System modelling - Mathematical models and basic building blocks of general mechanical, electrical, fluid and thermal systems. Typical elements of open and closed loop control systems. Adaptive controllers for machine tools. Programmable Logic Controllers (PLC) –Basic structure, input/ output processing. Programming: Timers, Internal Relays, Counters and Shift registers. Development of simple ladder programs for specific purposes.	**9**
IV	Micro Electro Mechanical Systems (MEMS): Fabrication: Deposition, Lithography, Micromachining methods for MEMS - Surface and Bulk, Deep Reactive Ion Etching (DRIE) and LIGA processes. Principle, fabrication and working of MEMS based pressure sensor, accelerometer and gyroscope.	**9**
V	Mechatronics in Robotics- choice of Sensors and Actuators. Robotic vision system – Image acquisition: Vidicon, charge coupled device (CCD) and charge injection device (CID) cameras. Image processing techniques: histogram processing: sliding, stretching, equalization and thresholding. Case studies of Mechatronics systems: Automatic camera, bar code reader, simple weighing machine, pick and place robot, automatic car park barrier system, automobile engine management system.	
	Total hours	**45**

vi) ASSESSMENT PATTERN

Mark distribution

Total Marks	Continuous Internal Evaluation Marks	End Semester Evaluation Marks	End Semester Examination Duration
150	**50**	**100**	**3 Hours**

Continuous Internal Evaluation Pattern:

Attendance	**10 Marks**
Continuous Assessment Tests (2 numbers)	**25 Marks**
Assignment/Quiz/Course project	**15 Marks**

End Semester Examination Pattern:

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EC1U44B	OPTIMIZATION TECHNIQUES	PEC	2	1	0	3	2020

i) COURSE OVERVIEW

This course aims to provide a broad picture of various applications of optimization methods used in engineering.

ii) COURSE OBJECTIVES

Learn the different optimization techniques and how to apply them for engineering problems.

iii) COURSE OUTCOMES

After the completion of the course, the student will be able to:

Course Outcomes	Description	Level
CO 1	Formulate and classify different optimisation problems.	Apply
CO 2	Apply classical and numerical methods solving linear and non-linear optimization problems.	Apply
CO 3	Apply modern methods of optimisation for solving optimisation problems.	Apply

iv) SYLLABUS

Introduction to classical method: Engineering applications of optimization, Formulation of design problems as mathematical programming problems. Classification of optimization problems/techniques. Classical optimization: unconstrained single and multivariable optimisation, Constrained optimization. Linear, Convex and non-convex optimization problems. KKT conditions.

Linear programming problems: Mathematical formulation of LP Problems, Solving using Simplex method and Graphical method.

Game Theory, Network path models: Game Theory: Introduction, 2- person zero – sum game -Saddle point; Mini-Max and Maxi- Min Theorems (statement only)- Graphical solution (2x n, m x 2 game), dominance property. Introduction to network tree - Minimal Spanning Tree - Prim"s Algorithm. Shortest path problems- solution methods – Dijkstra"s Method.

Nonlinear unconstrained optimization: Single variable optimization methods- Fibonacci search method, Newton Raphson method Multi-variable methods- Hook-Jeeves pattern search method, Cauchy"s (steepest descent) method.

Modern methods of optimization: Introduction to Genetic algorithm, Basic GA framework GA operators: Encoding, Crossover, Selection, Mutation. Introduction to Fuzzy logic. Fuzzy sets and membership functions. Operations on Fuzzy sets. Optimization of Fuzzy Systems.

v) a) TEXT BOOKS

1. S.S.Rao, Engineering Optimization.; Theory and Practice; Revised 4th Edition, New Age International Publishers, New Delhi, 2004
2. H.A. Taha, "Operations Research", 5/e, Macmillan Publishing Company, 1992.
3. Kanti Swarup, P.K.Gupta and Man Mohan, Operations Research, Sultan Chand and Sons, 2017

b) REFERENCES

1. Kalynamoy Deb. "Optimization for Engineering Design- Algorithms and Examples", Prentice- Hall of India Pvt. Ltd., New Delhi, 2012
2. A. Ravindran, D. T. Phillips, J. J. Solberg, Operations Research – Principles and Practice, John Wiley and Sons, 2007
3. Ashok D Belegundu, Tirupathi R Chandrupatla, "Optimization concepts and Application in Engineering", Pearson Education, 2011
4. Hadley, G. "Linear programming", Narosa Publishing House, New Delhi,1972
5. J. S. Arora, Introduction to Optimum Design, McGraw-Hill Book Company, 2011

vi) COURSE PLAN

Module	Contents	No. of hours
I	Engineering applications of optimization, Formulation of design problems as mathematical programming problems, objective function, constraints, Classification of optimization problems/techniques. Linear, convex, and non-convex. **Unconstrained optimization**: Unconstrained one dimensional necessary and sufficient conditions for optimality Algorithms for one-dimensional unconstrained optimization problem –Fibonnacci, golden section	**9**
II	**Algorithms and Constrained Optimization** Unconstrained multi-dimensional necessary and sufficient conditions for optimality,Algorithms for multi-dimensional unconstrained optimization problems –Steepest Descent, Newton‟s methods. **Constrained optimization:** Lagrangian method - First order Necessary KKT Conditions, Second order sufficient conditions, Duality (Concept)	**9**
III	**Linear programming problems** Mathematical formulation of LP Problems Slack, surplus and artificial variables, Reduction of a LPP to the standard form, feasible solutions. Graphical solution method simplex algorithm and solution using tabular method, optimality conditions and degeneracy Duality in linear programming	**9**
IV	**Nonlinear unconstrained optimization** Single variable optimization methods- Fibonacci search method, Newton Raphson method, Multi-variable methods- Hook-Jeeves pattern search method	**9**
V	**Modern methods of optimization** Introduction to Genetic algorithm, Basic GA framework GA operators: Encoding, Crossover, Selection, Mutation, Introduction to Fuzzy logic.Fuzzy sets and membership functions.Operations on Fuzzy sets.Optimization of Fuzzy Systems	**9**
	Total hours	

vi) ASSESSMENT PATTERN

Mark distribution

Total Marks	Continuous Internal Evaluation Marks	End Semester Evaluation Marks	End Semester Examination Duration
150	**50**	**100**	**3 Hours**

Continuous Internal Evaluation Pattern:

Attendance	**10 Marks**
Continuous Assessment Tests (2 numbers)	**25 Marks**
Assignment/Quiz/Course project	**15 Marks**

End Semester Examination Pattern:

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EC1U44C	COMPUTER VISION	PEC	2	1	0	3	2020

i) PREREQUISITE: Nil

ii) COURSE OVERVIEW:

This course aims to develop the knowledge of various methods, algorithms and applications of Computer Vision.

iii) COURSE OUTCOMES

After the completion of the course, the student will be able to:

Course Outcomes	Description	Level
CO 1	Explain digital filtering operations for CV applications.	Understand
CO 2	Apply basic morphological and boundary operators for Computer vision applications.	Apply
CO 3	Apply edge, corner detection algorithms to locate objects in an image.	Apply
CO 4	Apply optical flow algorithms to detect moving objects in a video.	Apply
CO 5	Analyse a given scene using appropriate computer vision algorithms to detect/recognize objects and to implement it in real time practical applications.	Apply

iv) SYLLABUS

Review of image processing techniques - Digital filters, Mathematical morphology, connectedness, object labelling and counting, Boundary descriptors – Chain codes. Properties of Binary Regions, Feature Detection and Image Synthesis, Edge detection, Normalized cuts, Graph cuts, energy-based methods, Hough transform-Line and curve detection, Shape from X, Photometric stereo, Texture Occluding contour detection. Motion Analysis, Optical Flow, Structure from motion, Object recognition, Bayes rule and ML methods. Eigen faces,Face detection, Face recognition, Application, Examples of real time applications: In-vehicle vision system.

v) a) TEXT BOOKS

1) E. R .Davies, Computer and Machine Vision -Theory Algorithm and Practicalities, Academic Press, 2012
2) Richard Szeliski, Computer Vision: Algorithms and Applications, ISBN 978-1-84882-935-0, Springer 2011.

3) David Forsyth and Jean Ponce, Computer Vision: A Modern Approach, Pearson India,
2002.

b) REFERENCES

1) Simon Goodfellow, Bengio, and Courville, Deep Learning, MIT Press, 2006.
2) Daniel Lelis Baggio, Khvedchenia Ievgen, Shervin Emam, David Millan Escriva, Naureen Mahmoo, Jason Saragi, Roy Shilkrot, Mastering OpenCV with Practical Computer Vision Projects, Packt Publishing Limited, 2012
3) Simon J D Prince, Computer Vision: Models, Learning, and Inference, Cambridge University Press, 2012.
4) R. J. Schalkoff, Digital Image Processing and Computer Vision, John Wiley, 2004.
5) D. L. Baggio et al., ―Mastering OpenCV with Practical Computer Vision Projects, Packt Publishing, 2012.
6) Jan Erik Solem, ―Programming Computer Vision with Python: Tools and algorithms for analyzing images‖, O'Reilly Media, 2012.

vi) COURSE PLAN

Module	Contents	No. of hours
I	Review of image processing techniques: Digital filters, linear filters-Homomorphic filtering, Point operators- Histogram, neighbourhood operators, thresholding	10
II	Mathematical morphology, Binary shape analysis, Binary shape analysis, Erosion, Dilation, Opening and Closing, Hit-or-Miss Transform, connectedness, object labelling and counting, Boundary descriptors – Chain codes. Properties of Binary Regions, Geometric Features, Statistical Shape Properties.	9
III	Feature Detection and Image Synthesis, Edge detection – edges, lines, active contours, Split and merge, Mean shift and mode finding, Normalized cuts, Graph cuts, energy-based methods- Cranny‟s Algorithm, Corner detection, Harris corner detection algorithm. Hough transform-Line and curve detection.	9
IV	Shape from X - Shape from shading, Photometric stereo, Texture Occluding contour detection. Motion Analysis- Regularization theory,Optical Flow: brightness constancy equation, aperture problem, Horn-Shunck method, Lucas-Kanade method. Structure from motion	9
V	Object recognition-Shape correspondence and shape matching PCA, SVM, LDA, Bayes rule and ML methods. Eigen faces,Face detection, Face recognition, Application: Scene analysis. Examples of real time applications: In-vehicle vision system.	8
	Total hours	**45**

vii) ASSESSMENT PATTERN

Mark distribution

Total Marks	Continuous Internal Evaluation Marks	End Semester Evaluation Marks	End Semester Examination Duration
150	50	100	3 Hours

Continuous Internal Evaluation Pattern:

Attendance	**10 Marks**
Continuous Assessment Tests (2 numbers)	**25 Marks**
Assignment/Quiz/Course project	**15 Marks**

End Semester Examination Pattern:

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EC1U44D	LOW POWER VLSI	PEC	2	1	0	3	2020

i) PREREQUISITE: EC1U20A- Solid State Devices, EC1U30F- VLSI Design

ii) COURSE OVERVIEW

This course aims to impart the basic knowledge in designing of Low power VLSI Circuits.

iii) COURSE OUTCOMES

After the completion of the course, the student will be able to

Course Outcomes	Description	Level
CO 1	Identify various short channel effects and various sources of power dissipation in MOSFET.	Understand
CO 2	Apply various power reduction techniques to circuits.	Apply
CO 3	Apply various clocked and non-clocked design styles for logic implementation.	Apply
CO 4	Apply Adiabatic and reversible logic for circuit implementation.	Apply

iv) SYLLABUS

Physics of Power dissipation in MOSFET devices- MIS Structure, Short channel effects- Deep submicron transistor design issues.

Sources of power dissipation in CMOS- Dynamic Power Dissipation- Short Circuit Power- Glitching Power, Static Power Dissipation, Leakage Power Dissipation, Gate level power analysis.

Power Reduction Techniques- Supply voltage Scaling Approaches- leakage power reduction Techniques –Transistor and Gate Sizing for Dynamic and Leakage Power Reduction.

Circuit design style - Clocked design style- Non clocked circuit design style.

Adiabatic switching – Adiabatic charging, adiabatic amplification, One stage and two stage adiabatic buffer, Adiabatic logic gates, pulsed power supplies, Reversible logic basic concepts.

v) a) TEXT BOOKS

1) Gray Yeap, Practical low power digital VLSI design, Springer, 1998
2) Kaushik Roy, Sharat C Prasad, Low power CMOS VLSI circuit design, Wiley India, 2009

b) REFERENCES

1) Abdellatif Bellaouar, Mohamed I Elmasry, Low power digital VLSI design, Kluwer Academic, 1995
2) Anatha P Chandrakasan, Robert W Brodersen, Low power digital CMOS Design, Kluwer Academic, 1995
3) Christian Piguet, Low power CMOS circuits, Taylor & Francis, 2006.

4) Kiat Seng Yeo, Kaushik Roy, Low voltage, low power VLSI sub systems, Tata McGraw Hill, 2004

vi) COURSE PLAN

Module	Contents	No. of hours
I	**Physics of Power dissipation in MOSFET devices:** Need for low power circuit design, MIS Structure, Short channel effects-surface scattering, punch through, velocity saturation, impact ionization Hot electron effects, Drain Induced Barrier Lowering, Deep submicron transistor design issues.	7
II	**Sources of power dissipation in CMOS:** Dynamic Power Dissipation: Charging and Discharging capacitance power dissipation, Short Circuit Power: Short Circuit Current of Inverter, Short circuit current dependency with input and output load, Glitching Power, Static Power Dissipation, Leakage Power Dissipation, Gate level power analysis: Capacitive, internal and Static power dissipation of gate level circuit.	9
III	**Power Reduction Techniques**: Supply voltage Scaling Approaches**:** Multi VDD and Dynamic VDD, leakage power reduction Techniques – Transistor stacking, VTCMOS,MTCMOS, DTCMOS, Power gating, Clock gating for Dynamic power dissipation, Transistor and Gate Sizing for Dynamic and Leakage Power Reduction.	10
IV	**Circuit design style:** Clocked design style- Basic concept, Domino logic (domino NAND gate), Differential Current Switch Logic. Non clocked circuit design style-fully complementary logic. NMOS and pseudo –NMOS logic, differential cascade voltage switch logic(DCVS)	10
V	**Adiabatic switching** – Adiabatic charging, adiabatic amplification, One stage and two stage adiabatic buffer, Adiabatic logic gates, pulsed power supplies, Reversible logic basic concepts.	9
	Total hours	**45**

Simulation Assignments

At least one assignment should be simulation based using any simulation software. It can be the design of a circuit in any one of the clocked or non-clocked style and perform power analysis. Samples of simulation assignments are given below.

1. Implement NAND gate in conventional CMOS and domino logic and perform power analysis in each case.
2. Implement any sample logic function in DCVS.

3. Apply threshold voltage scaling method to a logic function implemented in conventional style and perform power analysis

vii) ASSESSMENT PATTERN

viii) Mark distribution

Total Marks	Continuous Internal Evaluation Marks	End Semester Evaluation Marks	End Semester Examination Duration
150	**50**	**100**	**3 Hours**

Continuous Internal Evaluation Pattern:

Attendance	**10 Marks**
Continuous Assessment Tests (2 numbers)	**25 Marks**
Assignment/Quiz/Course project	**15 Marks**

End Semester Examination Pattern:

There will be two parts; Part A and Part B. Part A contain 10questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EC1U44E	INTERNET OF THINGS	PEC	2	1	0	3	2020

i) PREREQUISITE: Students should have a basic knowledge in Embedded systems.

ii) COURSE OVERVIEW

This course aims to develop skills in IoT system development and to apply the same in real life applications.

iii) COURSE OUTCOMES

After the completion of the course the student will be able to:

Course Outcomes	Description	Level
CO 1	Understand the IoT fundamentals and architecture modelling	Understand
CO 2	Understand the smart things in IoT and functional blocks	Understand
CO 3	To understand the communication networks and protocols used in IoT.	Understand
CO 4	To understand the cloud resources, data analysis and applications.	Understand
CO 5	To apply the IoT processes in embedded applications.	Apply

iv) SYLLABUS

Introduction to IoT- Definitions and Characteristics, Architectural View, Logical Design of IoT-Functional blocks, Communication models, IoT Levels & Deployment Templates.

IoT and M2M- M2M, Difference between IoT and M2M, SDN and NFV for IoT, Smart Objects: Sensors, Actuators, and Smart Objects, Wireless Sensor Networks, Communication Protocols for Wireless Sensor Networks- Connecting Smart Objects

Unified Data Standards –Protocols –IEEE 802.15.4 -The Physical Layer, The Media-Access Control Layer, Uses of 802.15.4, Modbus, ZigBee-Zigbee Architecture- LoRaWAN - Standardization and Alliances, Physical Layer, MAC Layer, Topology, LTE-M, NB-IoT-Network layer. IP-based protocols -6LoWPAN and RPL

Data Collection, storage and computing Using a Cloud Platform-Introduction, Cloud Computing Paradigm for Data Collection, Storage and Computing, Cloud Deployment Models, Cloud based platforms. IoT Physical Devices & Endpoints-IoT Device –Raspberry- Pi -Board- Linux on Raspberry-Pi-Raspberry-Pi Interfaces. Raspberry Pi interfacing and Programming.

IoT privacy, security and vulnerabilities solutions, vulnerabilities, security requirements, threat analysis, security tomography, layered attacker model, Identity management. Smart and Connected Cities-An IoT Strategy for Smarter Cities, Smart City Security Architecture - Smart City Use-Case Examples

v) (a) TEXT BOOKS

1. Vijay Madisetti and ArshdeepBahga, “Internet of Things (A Hands-on- Approach)”, 1st Edition, VPT, 2014 (Module1,2,4)
2. David Hanes, Gonzalo Salgueiro, Patrick Grossetete, Rob Barton and Jerome Henry, IoT Fundamentals: Networking Technologies, Protocols and Use Cases for Internet of Things, Cisco Press, 2017. (Module2,3,5)
3. Rajkamal, “Internet of Things: Architecture and Design Principles”, McGraw Hill (India) Private Limited.
4. Raspberry Pi Cookbook, Software and Hardware Problems and solutions, Simon Monk, O'Reilly (SPD), 2016, ISBN.

(b) REFERENCES

1. Olivier Hersent, David Boswarthick, Omar Elloumi, “The Internet of Things –Key applications and Protocols”, Wiley, 2012 (Module 3)
2. Al-Fuqaha et al. Internet of things: A survey on enabling technologies, protocols, and applications. IEEE Communications Surveys & Tutorials (2015), pp. 2347- 2376.
3. The Internet of Things (The MIT Press Essential Knowledge series) Paperback – March 20, 2015 by Samuel Greengard
4. The Internet of Things: Converging Technologies for Smart Environments and Integrated Ecosystems, Ovidu Vermesan and Peter Friess, River Publishers.
5. Internet of Things - From Research and Innovation to Market Deployment-RIVER PUBLISHERS, PETER FRIESS, OVIDIU VERMESAN (Editors)
6. Internet of Things Security and Data Protection, Sébastien Ziegler, Springer International Publishing 2019.

vi) COURSE PLAN

Module	Contents	No. of hours
I	Introduction to IoT technology: Definitions and Characteristics of IoT, IoT Architectural View, Physical Design of IOT, Logical Design of IoT-IoT Functional blocks, IoT communication models, IoT Enabling Technologies, IoT Levels & Deployment Templates.	**9**
II	IoT and M2M- M2M, Difference between IoT and M2M, SDN and NFV for IoT, Smart Objects: The “Things” in IoT: Sensors, Actuators, and Smart Objects, Sensor Networks- Wireless Sensor Networks (WSNs), Communication Protocols for Wireless Sensor Networks- Connecting Smart Objects- Communication Criteria.	**9**
III	Unified Data Standards –Protocols –IEEE 802.15.4 -The Physical Layer, The Media-Access Control Layer, Uses of 802.15.4 ,The Future of 802.15.4: 802.15.4e and 802.15.4g–Modbus– ZigBee-Zigbee Architecture- LoRaWAN -Standardization and Alliances, Physical Layer, MAC Layer, Topology, LTE-M, NB-IoT-Network	**9**

	layer –The next generation: IP-based protocols - 6LoWPAN and RPL, Overview of the 6LoWPAN Adaptation Layer.	
IV	Data Collection, storage and computing Using a Cloud Platform-Introduction, Cloud Computing Paradigm for Data Collection, Storage and Computing-Cloud Computing Paradigm, Cloud Deployment Models-Everything as a Service and Cloud Service Models-SaaS, PaaS, IaaS, DaaS. Cloud based platforms-XIVELY, NIMBITS. IoT Physical Devices & Endpoints-IoT Device-Building blocks – Raspberry-Pi -Board-Linux on Raspberry-Pi-Raspberry-Pi Interfaces (serial, SPI, I2C). Raspberry Pi interfacing and programming examples using python (LED, switch, sensor, serial, SPI, I2C devices). Controlling GPIO outputs and displaying sensor readings using web interface/cloud. (Python programming is required only for assignments and projects and not for examinations. Other end nodes and platforms can also be used).	**9**
V	IoT privacy, security and vulnerabilities solutions, vulnerabilities, security requirements, threat analysis, security tomography, layered attacker model, Identity management, access control, secure message communication. Smart and Connected Cities-An IoT Strategy for Smarter Cities- Vertical IoT Needs for Smarter Cities, Global vs. Siloed Strategies- Smart City IoT Architecture-Street Layer, City Layer, Data Center Layer, Services Layer- Smart City Security Architecture. Smart City Use-Case Examples – Street lighting, smart parking, smart traffic and air pollution monitoring	**9**
	Total hours	**45**

vii) ASSESSMENT PATTERN

Mark distribution

Total Marks	Continuous Internal Evaluation Marks	End Semester Evaluation Marks	End Semester Examination Duration
150	**50**	**100**	**3 Hours**

Continuous Internal Evaluation Pattern:

Attendance	**10 Marks**
Continuous Assessment Tests (2 numbers)	**25 Marks**
Assignment/Quiz/Course project	**15 Marks**

End Semester Examination Pattern:

There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EC1U44F	RENEWABLE ENRGY SYSTEM	PEC	3	0	0	3	2020

i) PREREQUISITE: NIL

ii) COURSE OVERVIEW

This course helps the students to understand environmental issues with conventional fuels, the new methodologies/technologies for the effective utilization of renewable energy sources. They will be conversant with the characteristics of solar PV and wind power sources. Also, they will have an in-depth understanding of electronic conversion systems application to renewable energy generation systems and the synchronization with smart grid systems. The courses equip the students to pursue further specialized areas of study such as renewable energy and green consumer electronics, industrial control systems and smart grid, and renewable energy system which are essentially based on this course.

iii) COURSE OUTCOMES

After the completion of the course, the student will be able to

Course Outcomes	Description	Level
CO 1	Understand the need, importance and scope of various Non-Conventional sources of energy	Understand
CO 2	Outline the concepts and technologies related to renewable energy systems using wind and Solar-PV	Understand
CO 3	Understand the integration of smart grid with renewable energy systems	Understand
CO 4	Explain the concept of distribution management system	Understand
CO 5	Describe the fundamentals of Smart metering	Understand

iv) SYLLABUS

Introduction to Renewable Energy (RE)Sources: World energy scenario, Over view of conventional energy sources, Renewable energy in India, An overview of types of renewable energy systems, Solar Energy: Introduction to photovoltaic (PV) systems, Grid interfacing-with isolation, without isolation, Maximum power point trackingMethods(MPPT), Wind Energy: Sources and potentials, Evaluation of Wind Intensity, Topography, General Classification of Wind Turbines, Electronic conversion systems application to renewable energy generation systems: Basic schemes and functional advantages, Issues in integration of converter based sources; Network voltage management; Introduction to grid connectivity of RE systems, smart grid and emerging technologies, Supervisory control and data acquisition (SCADA).

v) a) TEXT BOOKS

1) Nayak J. K. and Sukhatme S. P. (2006), Solar Energy: Principles of Thermal Collection and Storage, Tata McGraw Hill.
2) Muhannad H. R. (2004); Power Electronics: Circuits, Devices and Applications, Pearson Prentice Hall.
3) Nick Jenkins, JanakaEkanayake, [et al.] Smart Grid Technology and Applications, Wiley India Ltd.
4) Ali Keyhani, Design of Smart Power Grid Renewable Energy Systems, Wiley-IEEE Press 2016.

b) REFERENCES

1) Non-Conventional Energy Sources /G.D. Rai
2) Renewable Energy Technologies /Ramesh & Kumar /Narosa
3) Integration of alternative sources of energy /Felix A. Farret, M. Godoy simoes
4) Wind power plants and projects developments, Joshua Earnest and T Wizelius, PHI, New Delhi, 2011.
5) Handbook of renewable energy technology, World Scientific, Singapore, 2011.
6) Garg H. P. and Prakash S. (2000); Solar Energy: Fundamental and Application, Tata McGraw Hill
7) Goswami D. Y. (2015); Principles of Solar Engineering, Taylor and Francis
8) Gellings C. W. (2009); The Smart Grid: Enabling Energy Efficiency and Demand Response, First Edition, CRC Press
9) Teodorescu R. Liserre M. Rodriguez P. (2011); Grid Converters for Photovoltaic and Wind Power Systems, First Edition, Wiley-IEEE Press
10) Ali Keyhani, Muhammad Marwali, Smart Power Grids 2011, Springer-Verlag Berlin Heidelberg 2012.

vi) COURSE PLAN

Module	Contents	No. of hours
I	Introduction to Renewable Energy (RE)Sources: World energy scenario, Over view of conventional energy sources, their limitation, need of renewable energy, potential & development of renewable energy sources, Renewable energy in India, An overview of types of renewable energy systems - Wind power, Hydropower (micro and mini), Solar energy, Biomass, Bio-fuel, Geothermal Heat energy, Pros and cons; Applications.	9
II	Solar Energy: Introduction to photovoltaic (PV) systems - Principle of PV conversion; Commercial solar cell, Thin film PV device fabrication - LPCVD, APCVD, PECVD; Tandem Solar cell fabrication; Solar power extraction using PV-Cells, I-V Characteristics, PV-Inverters without D.C. to D.C. converters, stand alone and grid collected PV systems, Grid	10

	interfacing-with isolation, without isolation, Maximum power point trackingMethods(MPPT), PV-Inverters with D.C. to D.C. converters-on low frequency side and high frequency side with isolation, without isolation.	
III	Wind Energy: Sources and potentials, Evaluation of Wind Intensity, Topography, General Classification of Wind Turbines-Rotor Turbines, Multiple-Blade Turbines, Drag Turbines, Lifting Turbines, System Toroidal Rotor Amplifier Platform (TARP)–Wind amplified rotor platform (WARP), Generators and speed control used in wind power energy: Fixed speed with capacitor bank, Rotor resistance control, SCIG and DFIG, Synchronous Generatorexternal magnetized, Synchronous Generator-permanent magnets	**8**
IV	Electronic conversion systems application to renewable energy generation systems: Basic schemes and functional advantages, Power control and management systems for grid integration, island detection systems, synchronizing with the grid; Issues in integration of converter-based sources; Network voltage management; Power quality management and Frequency management; Influence of PV/WECS on system transient response	**8**
V	Introduction to grid connectivity of RE systems, smart grid and emerging technologies, operating principles and models of smart gird components, key technologies for generation, networks, loads and their control capabilities; Evolution of electricity metering, key components of smart metering, overview of the hardware used for smart meters, smart metering protocols. Structure and main components of a distribution management system, Supervisory control and data acquisition (SCADA), distribution system modelling, new trends for smart grids, topology analysis, power flow analysis.	**10**
	Total hours	**45**

vii) ASSESSMENT PATTERN

Mark distribution

Total Marks	Continuous Internal Evaluation Marks	End Semester Evaluation Marks	End Semester Examination Duration
150	50	100	3 Hours

Continuous Internal Evaluation Pattern:

Attendance	**10 Marks**
Continuous Assessment Tests (2 numbers)	**25 Marks**
Assignment/Quiz/Course project	**15 Marks**

End Semester Examination Pattern:

There will be two parts; Part A and Part B. Part A contain10questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EC1U44G	ORGANIC ELECTRONICS	PEC	3	0	0	3	2020

i) PREREQUISITE: PH0U10A -Engineering Physics, EC1U20A -Solid State Devices

ii) COURSE OVERVIEW: The goal of the course is to provide an insight into the theory behind organic electronics. It will give students the awareness of the largest alternative form of energy and how organic / polymer solar cells, photovoltaic cells and organic LEDs work.

iii) COURSE OUTCOMES

After the completion of the course the student will be able to:

Course Outcomes	Description	Level
CO 1	Describe the principle of charge transport in organic semiconductors.	Understand
CO 2	Explain the structure and working of multilayer OLEDs, OFETs and OPVs	Understand
CO 3	Distinguish the action of different layers used in organic devices with reference to the materials used.	Understand
CO 4	Explain different techniques employed in making organic electronic devices like OLEDs, OPVs and OFETs	Understand

iv) SYLLABUS

Conducting Polymers - conduction mechanism, Pi and Sigma electron band theory, Polymers fundamentals,Physics of organic semiconductors

Organic Electronic Devices - Basic device architecture inorganic devices, Multilayer architecture, Fabrication and characterization.

Organic Solar Cells - Plastic solar cells, Basic principles, Charge transport and exciton formation–effects, Processing of organic solar cells.

Organic Electronics-Materials Essential characteristics of electrode materials for organic electronic devices, Effect of ITO oxidative properties on efficiency and shelf life of organic electronic devices, Buffer organic layer protection to the active layer.

Techniques in Device making - Techniques in Organic electronic Device materials, Vapor deposition.

v) a) TEXT BOOKS

1. Bernier. Advanced synthetic metals, Elsevier (1999).
2. R.Farchioni(Editor)G.Grosso(Editor) Organic Electronic Materials. Conjugated polymers and low molecular weight organic solids, Springer series in materials science (2007).
3. Gregory Crawford. Flexible flat panel display, Wiley series in display technology(2005).
4. Klauk Hagen(ED), Wiley VCH. Organic electronics (2006).

b) REFERENCES

1. Gil. Semiconductors and Organic Materials for Opto electronic Application. Elsevier (1997).

2. Nalwa. Supra molecular photosensitive and electro–active materials Elsevier(2001).

3. Equer. Thin film materials for large area electronics. Elsevier(1999).

vi) COURSE PLAN

Module	Contents	No. of hours
I	Conducting polymer, Organic semiconductor, conduction mechanism, Pi and Sigma electron band theory. Polymers fundamentals-conducting polymers. Organic semiconductors, charge transport in conjugated polymers. Conduction mechanism in doped polymeric semiconductors. Physics of organic semiconductors (Luminescence, injection and transports properties), Methods of developing organic semiconductors.	9
II	Basic device architecture in organic devices. Historical review. Organic light emitting diodes(OLED) and Polymer light emitting diodes (PLED). Multilayer architecture. Single layer architecture. Bulk hetero-junctions. Operating characteristics and electrical characterization. Flexible electronics : new display media. Flexible displays device architecture. Fabrication and characterization. Organic transistors. FETs: Principle and device architecture.	9
III	Plastic solar cells. Basic principles. Multilayer and heterojunction structures, cell architecture. Charge transport and exciton formation–effects of exciton diffusion, dissociation and luminescence. Photogeneration process in organic heterojunction photovoltaic cells. Processing of organic solar cells. Dye Sensitization– dye sensitized solar cell.	9

IV	Essential characteristics of electrode materials for organic electronic devices – work function. Conductivity and transparency factors. Indium Tin Oxide (ITO) as anode material. Effect of ITO oxidative properties on efficiency and shelf life of organic electronic devices, novel inorganic anode materials and their limitations. Buffer organic layer protection to the active layer. Doping the device and annealing the device for increased efficiency and shelf life– architecture.	9
V	Techniques in Organic electronic Device materials. Thin film coating techniques for device fabrication. Spin coating, dip coating, doctor blading screen printing, inkjet printing, vapor deposition. R.F and microwave plasma assisted film coating.	9
	Total hours	**45**

vii) ASSESSMENT PATTERN

Mark distribution

Total Marks	Continuous Internal Evaluation Marks	End Semester Evaluation Marks	End Semester Examination Duration
150	**50**	**100**	**3 Hours**

Continuous Internal Evaluation Pattern:

Attendance	**10 Marks**
Continuous Assessment Tests (2 numbers)	**25 Marks**
Assignment/Quiz/Course project	**15 Marks**

End Semester Examination Pattern:

There will be two parts; Part A and Part B. Part A contain10questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EC1U40C	COMPREHENSIVE VIVA VOCE	PCC	1	0	0	1	2020

i) COURSE OVERVIEW

The objective of this Course viva is to ensure the basic knowledge of each student in the most fundamental core courses in the curriculum. The viva voce shall be conducted based on the core subjects studied from third to eighth semester. This course helps the learner to become competent in placement tests and other competitive examinations.

ii) GUIDELINES

1) The course should be mapped with a faculty and classes shall be arranged for practicing questions based on the core courses listed in the curriculum.

2) The viva voce will be conducted by the same three-member committee assigned for final project phase II evaluation. It comprises of Project coordinator, expert from Industry/research Institute and a senior faculty from a sister department.

3) The pass minimum for this course is 25.

4) The mark will be treated as internal and should be uploaded along with internal marks of other courses.

5) Comprehensive Viva should be conducted along with final project evaluation by the three-member committee.

iii) MARK DISTRIBUTION

Total marks: 50, only CIE, minimum required to pass: 25 Marks

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EC1U49C	PROJECT PHASE II	PWS	0	0	12	4	2020

i) **PREAMBLE:** The course „Project Work‟ is mainly intended to evoke the innovation and invention skills in a student. The course will provide an opportunity to synthesize and apply the knowledge and analytical skills learned, to be developed as a prototype or simulation. The project extends to 2 semesters and will be evaluated in the 7th and 8th semester separately, based on the achieved objectives. One third of the project credits shall be completed in 7th semester and two third in 8th semester. It is recommended that the projects may be finalized in the thrust areas of the respective engineering stream or as interdisciplinary projects. Importance should be given to address societal problems and developing indigenous technologies

ii) COURSE OVERVIEW:

The aim of this course is to apply engineering knowledge in solving practical problems, to foster innovation in design of products, processes or systems, and to develop creative thinking in finding viable solutions to engineering problems.

iii) COURSE OUTCOMES

After the completion of the course, the student will be able to:

Course Outcomes	Description	Level
CO 1	Model and solve real world problems by applying knowledge across domains (Cognitive knowledge level: Apply).	Apply
CO 2	Develop products, processes or technologies for sustainable and socially relevant applications (Cognitive knowledge level: Apply).	Apply
CO 3	Function effectively as an individual and as a leader in diverse teams and to comprehend and execute designated tasks (Cognitive knowledge level: Apply).	Apply
CO 4	Plan and execute tasks utilizing available resources within timelines, following ethical and professional norms (Cognitive knowledge level: Apply).	Apply
CO 5	Identify technology/research gaps and propose innovative/creative solutions (Cognitive knowledge level: Analyze).	Analyse
CO 6	Organize and communicate technical and scientific findings effectively in written and oral forms (Cognitive knowledge level: Apply).	Apply

iv) TARGETS:

- In depth study of the topic assigned in the light of the report prepared under Phase - I;
- Review and finalization of the approach to the problem relating to the assigned topic.
- Preparing a detailed action plan for conducting the investigation, including teamwork.
- Detailed Analysis/ Modeling / Simulation/ Design/ Problem Solving/Experiment as needed.
- Final development of product/ process, testing, results, conclusions and future directions.
- Preparing a paper for Conference Presentation/ Publication in Journals, if possible.
- Presenting projects in Project Expos conducted by the University at the cluster level and/ or state level as well as others conducted in India and abroad.
- Filing Intellectual Property Rights (IPR) if applicable.
- Preparing a report in the standard format for being evaluated by the Department Assessment Board.
- Final project presentation and viva voce by the assessment board including the external expert.

v) EVALUATION GUIDELINES & RUBRICS

Total: 150 marks (Minimum required to pass: 75 marks).

- Project progress evaluation by guide: 30 Marks.
- Two interim evaluations by the Evaluation Committee: 50 Marks (25 marks for each evaluation).
- Final evaluation by the Final Evaluation committee: 40 Marks
- Quality of the report evaluated by the evaluation committee: 30 Marks

(The evaluation committee comprises HoD or a senior faculty member, Project coordinator and project supervisor. The final evaluation committee comprises of Project coordinator, expert from Industry/research/academic Institute and a senior faculty from a sister department).

MINORS

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EC0M 49B	MINI PROJECT	VAC	0	1	6	4	2020

i) COURSE OVERVIEW

The course aims

To estimate the ability of the students in transforming the theoretical knowledge studied in to a working model of an electronic system
For enabling the students to gain experience in organisation and implementation of small projects.
Design and development of Small electronic project based on hardware or acombination of hardware and software for electronics systems.

ii) COURSE OUTCOMES

After the completion of the course, the student will be able to:

Course Outcomes	Description	Level
CO 1	Practice acquired knowledge within the selected area of technology for project development.	Apply
CO 2	Identify, discuss and justify the technical aspects and design aspects of the project with a systematic approach.	Apply
CO 3	Reproduce, improve and refine technical aspects for engineering projects.	Apply
CO 4	Work as a team in development of technical projects.	Apply
CO 5	Communicate and report effectively project related activities and findings.	Apply

iii) COURSE PLAN

In this course, each group consisting of three/four members is expected to design and develop a moderately complex electronic system with practical applications, this should be a working model. The basic concept of product design may be taken into consideration.

Students should identify a topic of interest in consultation with Faculty/Advisor. Review the literature and gather information pertaining to the chosen topic. State the objectives and develop a methodology to achieve the objectives. Carryout the design/fabrication or develop codes/programs to achieve the objectives. Demonstrate the novelty of the project through the results and outputs. The progress of the mini project is evaluated based on a minimum of two reviews.

The review committee may be constituted by the Head of the Department. A project report is required at the end of the semester. The product has to be demonstrated for its full design specifications. Innovative design concepts, reliability considerations, aesthetics/ergonomic aspects taken care of in the project shall be given due weight.

vi) ASSESSMENT PATTERN

Mark distribution

Total Marks	Continuous Internal Evaluation Marks	End Semester Evaluation Marks	End Semester Examination Duration
150	**75**	**75**	**1 Hours**

Evaluation

The internal evaluation will be made based on the product, the report and a viva- voce examination, conducted by a 3-member committee appointed by Head of the Department comprising HoD or a senior faculty member, Academic coordinator for that program, project guide/coordinator.

The Committee will be evaluating the level of completion and demonstration of functionality/specifications, presentation, oral examination, work knowledge and involvement.

Split-up of CIE

Component	Marks
Attendance	10
Marks awarded based on guide‟s Evaluation	15
Project Report	10
Evaluation by Committee	40

Split-up of ESE

Component	Marks
Level of completion	10
Demonstration of functionality	25
Project Report	10
Viva-voce	20
Presentation	10

HONOURS

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EC1H49A	MINI PROJECT	VAC	0	1	6	4	2020

i) COURSE OVERVIEW

The course aims

To estimate the ability of the students in transforming the theoretical knowledge studied in to a working model of an electronic system
For enabling the students to gain experience in organisation and implementation of small projects.
Design and development of Small electronic project based on hardware or a combination of hardware and software for electronics systems.

ii) COURSE OUTCOMES

After the completion of the course, the student will be able to:

Course Outcomes	Description	Level
CO 1	Practice acquired knowledge within the selected area of technology for project development.	Apply
CO 2	Identify, discuss and justify the technical aspects and design aspects of the project with a systematic approach.	Apply
CO 3	Reproduce, improve and refine technical aspects for engineering projects.	Apply
CO 4	Work as a team in development of technical projects.	Apply
CO 5	Communicate and report effectively project related activities and findings.	Apply

iii) COURSE PLAN

In this course, each group consisting of three/four members is expected to design and develop a moderately complex electronic system with practical applications, this should be a working model. The basic concept of product design may be taken into consideration.

Students should identify a topic of interest in consultation with Faculty/Advisor. Review the literature and gather information pertaining to the chosen topic. State the objectives and develop a methodology to achieve the objectives. Carryout the design/fabrication or develop codes/programs to achieve the objectives. Demonstrate the novelty of the project through the results and outputs. The progress of the mini project is evaluated based on a minimum of two reviews.

The review committee may be constituted by the Head of the Department. A project report is required at the end of the semester. The product has to be demonstrated for its full design specifications. Innovative design concepts, reliability considerations, aesthetics/ergonomic aspects taken care of in the project shall be given due weight.

vi) ASSESSMENT PATTERN

Mark distribution

Total Marks	Continuous Internal Evaluation Marks	End Semester Evaluation Marks	End Semester Examination Duration
150	**75**	**75**	**1 Hours**

Evaluation

The internal evaluation will be made based on the product, the report and a viva- voce examination, conducted by a 3-member committee appointed by Head of the Department comprising HoD or a senior faculty member, Academic coordinator for that program, project guide/coordinator.

The Committee will be evaluating the level of completion and demonstration of functionality/specifications, presentation, oral examination, work knowledge and involvement.

Split-up of CIE

Component	Marks
Attendance	10
Marks awarded based on guide‟s Evaluation	15
Project Report	10
Evaluation by Committee	40

Split-up of ESE

Component	Marks
Level of completion	10
Demonstration of functionality	25
Project Report	10
Viva-voce	20
Presentation	10