CURRICULUM AND DETAILED SYLLABI

FOR

B. TECH DEGREE PROGRAMME

IN

ELECTRONICS AND COMMUNICATION ENGINEERING

SEMESTERS V & VI

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.
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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 (S5-S6)

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

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 1/2	BSC	PH0U10A	Engineering Physics A	3-1-0	4	4
		CY0U10A	Engineering Chemistry A	3-1-0	4	4
C 1/2	ESC	ES0U10A	Engineering Mechanics	2-1-0	3	3
		ES0U10B	Engineering Graphics	2-0-2	4	3
D 1/2	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 1/2	BSC	PH0U18A	Engineering Physics Lab	0-0-2	2	1
		CY0U18A	Engineering Chemistry Lab	0-0-2	2	1
T 1/2	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 1/2	BSC	PH0U10A	Engineering Physics A	3-1-0	4	4
		CY0U10A	Engineering Chemistry	3-1-0	4	4
C 1/2	ESC	ES0U10A	Engineering Mechanics	2-1-0	3	3
		ES0U10B	Engineering Graphics	2-0-2	4	3
D 1/2	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 1/2	BSC	PH0U18A	Engineering Physics Lab	0-0-2	2	1
		CY0U18A	Engineering Chemistry Lab	0-0-2	2	1
T 1/2	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 and 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 Communi cation	4-0-0	4	EC0M 20C	Introductio n to Signals and Systems	3-1-0	4
S4	EC0M 20D	Microcont rollers	3-1-0	4	EC0M 20E	Digital Communi cation	3-1-0	4	EC0M 20F	Introductio n to Digital Signal Processing	3-1-0	4
S5	EC0M 30A	Embedded System Design	3-1-0	4	EC0M 30B	Communi cation 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 V

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EC1U30A	LINEAR INTEGRATED CIRCUITS	PCC	3	1	0	4	2020

i) PREREQUISITE:EC1U20D - Analog Circuits

ii) COURSE OVERVIEW

Goal of this course is to develop the skill to design circuits using operational amplifiers and other linear ICs for various applications.

iii) COURSE OUTCOMES

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

Course Outcomes	Description	Level
CO 1	Explain the Op Amp fundamentals and differential amplifier configurations	Understand
CO 2	Design operational amplifier circuits for various applications	Apply
CO 3	Design Oscillators and active filters using op amps	Apply
CO 4	Explain the working and applications of timer, VCO and PLL ICs	Understand
CO 5	Describe the working of Voltage regulator IC’s and Data converters	Understand

iv) SYLLABUS

Operational amplifiers (Op Amps): The 741 Op Amp, Block diagram, Ideal op-amp parameters, typical parameter values for 741, Equivalent circuit, Open loop configurations

Differential Amplifiers: Differential amplifier, DC and AC Analysis, CMRR, input and output resistance, Voltage gain. Constant current bias, constant current source.

Op-amp with negative feedback: General concept of Voltage Series, current series and current shunt negative feedback, Op Amp circuits with voltage series and voltage shunt feedback, Virtual ground Concept.

Op-amp applications: Summer, Voltage Follower-loading effects, Integrator, Differentiator, Precision rectifiers, Comparators, Schmitt Triggers, Log and antilog amplifiers.

Op-amp Oscillators and Multivibrators: Phase Shift and Wien-bridge Oscillators, Triangular and Sawtooth waveform generators, Astable and monostablemultivibrators.

Active filters: Comparison with passive filters, First and second order low pass, High pass, Band pass and band reject active filters, state variable filters.

Timer and VCO: Timer IC 555- Functional diagram, Astable and monostable operations. Voltage Controlled Oscillator and applications, Phase Locked Loop – PLL IC 565, Applications of PLL.
Voltage Regulators: Fixed and Adjustable voltage regulators, IC 723, Current boosting, Current limiting, Short circuit and Fold-back protection.
Data Converters: Digital to Analog converters, Specifications, Weighted resistor type and R-2R Ladder type.
Analog to Digital Converters: Specifications, Flash type and Successive approximation type.

v) a) TEXT BOOKS

1) Roy D. C. and S. B. Jain, Linear Integrated Circuits, 5/e, New Age International, 2018

b) REFERENCES

2) DFranco S., *Design with Operational Amplifiers and Analog Integrated Circuits*, 4/e, Tata McGraw Hill, 2016
3) Gayakwad R. A., *Op-Amps and Linear Integrated Circuits*, 4/e, Prentice Hall, 2010
4) Salivahanan S. and V. S. K. Bhaaskaran, *Linear Integrated Circuits*, 3/e, Tata McGrawHill, 2018
5) Botkar K. R., *Integrated Circuits*, 10/e, Khanna Publishers, 2010
6) C.G. Clayton, *Operational Amplifiers*, Butterworth & Company Publ. Ltd. Elsevier,1971
7) David A. Bell, *Operational Amplifiers & Linear ICs*, 3/e, Oxford University Press, 2011
8) R.F. Coughlin & Fredrick Driscoll, *Operational Amplifiers & Linear Integrated Circuits*, 6/e, PHI, 2001
9) Sedra A. S. and K. C. Smith, *Microelectronic Circuits*, 7/e, Oxford University Press, 2017

vi) COURSE PLAN

Module	Contents	No. of hours
I	**Operational amplifiers (Op Amps):** The 741 Op Amp, Block diagram, Ideal op-amp parameters, typical parameter values for 741, Equivalent circuit, Open loop configurations, Voltage transfer curve, Frequency response curve. **Differential Amplifiers:** Differential amplifier configurations using BJT, DC Analysis- transfer characteristics; AC analysis- differential and common mode gains, CMRR, input and output resistance, Voltage gain. Constant current bias, constant current source; Concept of current	12

	mirror-the two-transistor current mirror, Wilson and Widlar current mirrors.	
II	**Op-amp with negative feedback:** General concept of Voltage Series, Voltage Shunt, current series and current shunt negative feedback, Op Amp circuits with voltage series and voltage shunt feedback, Virtual ground Concept; analysis of practical inverting and non-inverting amplifiers for closed loop gain, Input Resistance and Output Resistance. **Op-amp applications:** Summer, Voltage Follower-loading effects, Differential and Instrumentation Amplifiers, Voltage to current and Current to voltage converters, Integrator, Differentiator, Precision rectifiers, Comparators, Schmitt Triggers, Log and antilog amplifiers.	**12**
III	**Op-amp Oscillators and Multivibrators:** Phase Shift and Wien-bridge Oscillators, Triangular and Sawtooth waveform generators, Astable and monostablemultivibrators. **Active filters:** Comparison with passive filters, First and second order low pass, High pass, Band pass and band reject active filters, state variable filters.	**12**
IV	**Timer and VCO:** Timer IC 555- Functional diagram, Astable and monostable operations. Basic concepts of Voltage Controlled Oscillator and application of VCO IC LM566, Phase Locked Loop – Operation, Closed loop analysis, Lock and capture range, Basic building blocks, PLL IC 565, Applications of PLL.	**12**
V	**Voltage Regulators:** Fixed and Adjustable voltage regulators, IC 723 – Low voltage and high voltage configurations, Current boosting, Current limiting, Short circuit and Fold-back protection. **Data Converters:** Digital to Analog converters, Specifications, Weighted resistor type and R-2R Ladder type. **Analog to Digital Converters:** Specifications, Flash type and Successive approximation type.	**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**

It is mandatory that a *course project* shall be undertaken by a student for this subject. The course project must be performed as a software simulation of a typical op-amp based application circuit. Instead of two assignments, two evaluations will be performed on the course project along with continuous assessment tests, each carrying 5 marks. Upon successful completion of the project, a brief report must be submitted by the student which will be evaluated for 5 marks.

End Semester Examination:

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
EC1U30B	DIGITAL SIGNAL PROCESSING	PCC	3	1	0	4	2020

i) PREREQUISITE: EC1U20E - Signals and systems

ii) COURSE OVERVIEW

This course aims to provide an understanding of the principles, algorithms and applications of DSP.

iii) COURSE OUTCOMES

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

Course Outcomes	Description	Level
CO 1	Analyze discrete time signals and systems in time and frequency domains.	Apply
CO 2	Design digital FIR filters for specific applications using various techniques.	Apply
CO 3	Design analog and digital IIR filters for specific applications using various techniques.	Apply
CO 4	Design digital filter structures using different realization techniques.	Apply
CO 5	Explain the basic design aspects of DSP systems using TMS320C6713 processor.	Understand
CO 6	Analyze multirate digital signal processing systems.	Apply

iv) SYLLABUS

Discrete Fourier Transform and its Properties, Linear Filtering methods based on the DFT, Frequency analysis of signals using the DFT, Computation of DFT, FFT Algorithms, IDFT computation using Radix-2 FFT Algorithms, Efficient computation of DFT of two real sequences and a 2N-Point real sequence, Design of FIR Filters, Design of linear phase FIR Filters using window methods and frequency sampling method, Design of IIR Digital Filters From Analog Filters, IIR Filter Design, Frequency Transformations, FIR Filter Structures, IIR Filter Structures, Introduction to TMS320C67xx digital signal processor, Multi-rate Digital Signal Processing, Finite word length effects in DSP systems, IIR digital filters, FFTalgorithms.

v) a) TEXT BOOKS

1) Proakis J. G. and Manolakis D. G., *Digital Signal Processing, 4/e*, Pearson Education, 2007
2) Alan V Oppenheim, Ronald W. Schafer, *Discrete-Time Signal Processing*, 3rd Edition, Pearson, 2010
3) Mitra S. K., Digital Signal Processing: *A Computer Based Approach, 4/e*, McGraw Hill (India), 2014

b) REFERENCES

1) Ifeachor E.C. and Jervis B. W., *Digital Signal Processing: A Practical Approach, 2/e* Pearson Education, 2009
2) Lyons, Richard G., *Understanding Digital Signal Processing, 3/e*. Pearson Education India, 2004
3) Salivahanan S, *Digital Signal Processing*,*4e*, McGraw Hill Education New Delhi, 2019
4) Chassaing, Rulph.,*DSP applications using C and the TMS320C6x DSK*. Vol. 13. John Wiley & Sons, 2003
5) Vinay.K.Ingle, John.G.Proakis, *Digital Signal Processing: Bookware Companion Series*,Thomson,2004
6) Chen, C.T., "*Digital Signal Processing: Spectral Computation & Filter Design*, Oxford Univ. Press, 2001
7) Monson H Hayes, *"Schaums outline: Digital Signal Processing",* McGraw Hill Professional, 1999

vi) COURSE PLAN

Module	Contents	No. of hours
I	Basic Elements of a DSP system, Typical DSP applications, Finite- length discrete transforms, Orthogonal transforms – The Discrete Fourier Transform: DFT as a linear transformation (Matrix relations), Relationship of the DFT to other transforms, IDFT, Properties of DFT and examples. Circular convolution, Linear Filtering methods based on the DFT, linear convolution using circular convolution, Filtering of long data sequences, overlap save and overlap add methods, Frequency Analysis of Signals using the DFT (concept only required)	**13**
II	Efficient Computation of DFT: Fast Fourier Transform Algorithms-Radix-2 Decimation in Time and Decimation in Frequency FFT Algorithms, IDFT computation using Radix-2 FFT Algorithms, Application of FFT Algorithms, Efficient computation of DFT of Two Real Sequences and a 2N-Point Real Sequence	**13**
III	Design of FIR Filters - Symmetric and Anti-symmetric FIR Filters, Design of linear phase FIR filters using Window methods, (rectangular,	**13**

	Hamming and Hanning) and frequency sampling method, Comparison of design methods for Linear Phase FIR Filters. Design of IIR Digital Filters from Analog Filters (Butterworth), IIR Filter Design by Impulse Invariance, and Bilinear Transformation, Frequency Transformations in the Analog and Digital Domain.	
IV	Structures for the realization of Discrete Time Systems - Block diagram and signal flow graph representations of filters, FIR Filter Structures: Linear structures, Direct Form, CascadeForm, IIR Filter Structures: Direct Form, Transposed Form, Cascade Form and Parallel Form, Computational Complexity of Digital filter structures. Multi-rate Digital Signal Processing: Decimation and Interpolation (Time domain and Frequency Domain Interpretation), Anti- aliasing and anti-imaging filter	**11**
V	Computer architecture for signal processing: Harvard Architecture, pipelining, MAC, Introduction to TMS320C67xx digital signal processor, Functional Block Diagram. Finite word length effects in DSP systems: Introduction (analysis not required), fixed-point and floating-point DSP arithmetic, ADC quantization noise, Finite word length effects in IIRdigital filters: coefficient quantization errors. Finite word length effects in FFT algorithms: Round off errors	**10**
	Total hours	**60**

Simulation Assignments

The following simulations may be done in Scilab/ Matlab/ LabView/GNU Octave:

1. Consider a signal given by x(n)=[1,1,1,1].

   a. Compute the DTFT of the given sequence and plot its magnitude and phase
   b. Compute the 4 point DFT of the above signal and plot its magnitude and phase
   c. Compare the above plots and obtain the relationship?

1. Zero pad the sequence x(n) by 4 and compute the 8 point DFT and find the corresponding magnitude and phase plots. Compare the spectra with that in (b) and comment on it.

3. The first five values of the 8 point DFT of a real valued sequence x(n) are given by {0.25, 0.125-j0.3, 0, 0.125-j0.06, 0.5}. Determine the DFT of each of the following sequences using properties (others may be included). Hint :IDFT may not be computed.
   a. x1(n)=x((2-n))8
   b. x3(n)=x (n)

4. Develop a function to implement the over-lap add method using circular convolution operation.

5. Simulate rational sampler

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
EC1U30C	ANALOG AND DIGITAL COMMUNICATION	PCC	3	1	0	4	2020

i) PREREQUISITE:EC1U20E - Signals and Systems, MA0U20C - Probability, Random Process and Numerical Methods

ii) COURSE OVERVIEW

Goal of this course is to provide an insight into the concepts of analog and digital communication system.

iii) COURSE OUTCOMES

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

Course Outcomes	Description	Level
CO 1	Compute various parameters of analog modulation systems.	Apply
CO 2	Apply the concepts of random processes to LTI systems.	Apply
CO 3	Apply waveform coding techniques in digital transmission	Apply
CO 4	Apply the knowledge of GS procedure to develop digital receivers.	Apply
CO 5	Apply signal modelling techniques in the design of digital receivers	Apply
CO 6	Apply digital modulation techniques in signal transmission	Apply

iv) SYLLABUS

Block diagram of a communication system. Need for analog modulation. Amplitude modulation. Equation and spectrum of AM signal. DSB-SC and SSB systems. Block diagram of SSB transmitter and receiver. Frequency and phase modulation.Narrow and wide band FM and their spectra.FM transmitter and receiver.

Review of random variables – both discrete and continuous. CDF and PDF, statistical averages. (Only definitions, computations and significance) Entropy, differential entropy.Differential entropy of a Gaussian RV.Conditional entropy, mutual information. Stochastic processes, Stationarity. Conditions for WSS and SSS.Autocorrelation and power spectral density.LTI systems with WSS as input.
Source coding theorems I and II (Statements only).Waveform coding.Sampling and Quantization. Pulse code modulation, Transmitter and receiver. Companding. Practical 15

level A and mu-law companders. DPCM transmitter and receiver.Design of linear predictor.Wiener-Hopf equation.Delta modulation. Slope overload.

Gram-Schmitt procedure. Signal space.Baseband transmission through AWGN channel. Mathematical model of ISI.Nyquit criterion for zero ISI. Signal modeling for ISI, Raised cosine and Square-root raised cosine spectrum, Partial response signalling and duobinary coding. Equalization.Design of zero forcing equalizer.Vector model of AWGN channel.Matched filter and correlation receivers. MAP receiver, Maximum likelihood receiver and probability of error. Capacity of an AWGN channel (Expression only) -- significance in the design of communication schemes.

Digital modulation schemes.Baseband BPSK system and the signal constellation.BPSK transmitter and receiver. Base band QPSK system and Signal constellations. Plots of BER Vs SNR with analysis.QPSK transmitter and receiver. Quadrature amplitude modulation and signal constellation.

v) a) TEXT BOOKS

1) Simon Haykin, *Digital Communication Systems*, 4th edition, Wiley, 2000.
2) DSklar, Digital Communications: Fundamentals and Applications, 3/e, Pearson
3) John C. Bellamy, *Digital Telephony*,Wiley
4) Kennedy, Davis, *Electronics communication Systems*, 4/e

b) REFERENCES

1) R. Gallager, *Principles of Digital Communication*, Oxford University Press
2) John G Proakis, *Digital Communication*,4/e, Wiley

vi) COURSE PLAN

Module	Contents	No. of hours
I	Block diagram of communication system, analog and digital systems, need for modulation. Amplitude modulation, model and spectrum and index of modulation DSB-SC and SSB modulation. SSB transmitter and receiver. Frequency and phase modulation. Model of FM, spectrum of FM signal	11
II	Review of random variables, CDF and PDF, examples Entropy of RV, Differential entropy of Gaussian RV, Expectation, conditional expectation, mutual information Stochastic processes, Stationarity, WSS and SSS. Autocorrelation and power spectral density. Response of LTI systems to WSS	12
III	Source coding theorems PCM, Transmitter and receiver, companding Practical A and mu law companders DPCM, Linear predictor, Wiener Hopf equation Delta modulator	12

IV	G-S procedure ISI, Nyquist criterion, RS and SRC, PR signalling and duobinary coding Equalization, design of zero forcing equalizer Vector model of AWGN channel, Correlation receiver, matched filter MAP receiver, ML receiver, probability of error Channel capacity, capacity of Gaussian channel, Its significance in design of digital communication schemes	**16**
V	Need of digital modulation in modern communication. Baseband BPSK system and the signal constellation. Baseband QPSK system, signal constellation. Effect of AWGN, probability of error (with derivation). BER-SNR curve, QPSK transmitter and receiver. QAM system	**9**
	Total hours	**60**

The simulation assignments can be done with Python/MATLAB/ SCILAB/LabVIEW The following simulations can be done in MATLAB, Python,R or LabVIEW.

1. A-Law and μ-Law Characteristics
2. Practical A-Law compander
3. Practical μ-Law compander
4. BPSK Transmitter and Receiver
5. QPSK Transmitter and Receiver
6. Matched Filter Receiver

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
EC1U30D	CONTROL SYSTEMS	PCC	3	1	0	4	2020

i) PREREQUISITE: EC1U20E - Signals and Systems

ii) COURSE OVERVIEW

This course aims to develop the skills for mathematical modelling of various control systems and stability analysis using time domain and frequency domain approaches.

iii) COURSE OUTCOMES

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

Course Outcomes	Description	Level
CO 1	Analyze electromechanical systems by mathematical modeling and derive their transfer functions.	Analyse
CO 2	Analyze the time and frequency domain responses of any control systems for any standard input	Apply
CO 3	Analyze the stability of a system using various techniques	Apply
CO 4	Design a system using controllers to achieve the desired specifications.	Apply
CO 5	Analyze a system using state space analysis	Apply

iv) SYLLABUS

Introduction: Basic Components of a Control System, Open-Loop Control Systems and Closed-Loop Control Systems, Examples of control system, Applications.
Feedback and its effects: Types of Feedback Control Systems, Linear versus Nonlinear Control Systems, Time-Invariant versus Time-Varying Systems.
Mathematical modelling of control systems: Electrical Systems and Mechanical systems.
Transfer Function from Block Diagrams and Signal Flow Graphs:. Block diagram representation and reduction methods, Signal flow graph reduction using Mason's gain formula.
Time Domain Analysis of Control Systems: Introduction- Standard Test signals, Time response specifications. Time response of first and second order systems to unit step input and ramp inputs, time domain specifications.Steady state error and static error coefficients.
Frequency domain analysis: Frequency domain specifications, correlation between time and frequency responses.
Stability of linear control systems: Concept of BIBO stability, absolute stability, Routh's Hurwitz Criterion.

Root Locus Techniques: Introduction, properties and its construction, Application to system stability studies. Illustration of the effect of addition of a zero and a pole.
Nyquist stability criterion: Fundamentals and analysis.
Relative stability: Gain Margin and Phase Margin. Stability analysis with Bode plot. **Design of Compensators:** Need of compensators, design of lag and lead compensators using Bode plots. Effect of P, PI & PID controllers
State Variable Analysis of Linear Dynamic Systems: State variables, state equations, state variable representation of electrical and mechanical systems. Transfer function from State Variable Representation, Solutions of the state equations, state transition matrix. Concept of Controllability and Observability, Kalman's Test, Gilbert's test.

v) a) TEXT BOOKS

1) FaridGolnaraghi, Benjamin C. Kuo, *Automatic Control Systems*, 9/e, Wiley India
2) I.J. Nagarath, M.Gopal, *Control Systems Engineering*, 5/e, New Age International Pub. Co., 2007
3) Ogata K., *Discrete-time Control Systems*, 2/e, Pearson Education

b) REFERENCES

1) I.J. Nagarath, M.Gopal: Scilab Text Companion for Control Systems Engineering (3rd-Edition) —New Age International Pub. Co., 2007
2) Norman S. Nise, *Control System Engineering*, 5/e, Wiley India
3) M. Gopal, *Digital Control and State Variable Method*, 4/e, McGraw Hill Education India, 2012
4) Ogata K., *Modern Control Engineering*, Prentice Hall of India,4/e, Pearson Education, 2002
5) Richard C Dorf and Robert H. Bishop, *Modern Control Systems*, 9/e, Pearson Education, 2001

vi) COURSE PLAN

Module	Contents	No. of hours
I	**Introduction:** Basic Components of a Control System, Open-Loop Control Systems and Closed-Loop Control Systems, Examples of control system, Applications. **Feedback and its effects:** Types of Feedback Control Systems, Linear versus Nonlinear Control Systems, Time-Invariant versus Time-Varying Systems. **Mathematical modelling of control systems:** Electrical Systems and Mechanical systems. Force Voltage Analogy **Transfer Function from Block Diagrams and Signal Flow Graphs:** Block diagram representation and reduction Methods. Signal flow graph reduction usingMason's gain formula.	**12**

II	**Time Domain Analysis of Control Systems:** Introduction- Standard Test signals, Time response Specifications. Time response of first and second order systems to unit step input and ramp inputs, time domain specifications. Steady state error and static error coefficients. **Frequency domain analysis:** Frequency domain specifications, correlation between time and frequency responses.	**11**
III	**Stability of linear control systems:**Stability of linear control systems: concept of BIBO stability, absolute stability, Routh's Hurwitz Criterion. **Root Locus Techniques** Introduction, properties and its construction, Application to system stability studies. Illustration of the effect of addition of a zero and a pole.	**10**
IV	Nyquist stability criterion:Fundamentals and analysis Relative stability: Gain Margin and Phase Margin. Stability analysis with Bode plot. Design of Compensators: Need of compensators, design of lag and lead compensators using Bode plots. Effect of P, PI & PID controllers.	**12**
V	**State Variable Analysis of Linear Dynamic Systems:**State variables, state equations, State variable representation of electrical and mechanical systems. State Variable representation from Transfer Function.Transfer function from State Variable Representation, Solutions of the state equations, state transition matrix, Concept of Controllability and Observability and techniquesto test them - Kalman's Test, Gilbert's test.	**15**
	Total hours	**60**

Simulation Assignment

The following simulations can be done in Python/ Scilab/ Matlab

1. Plot the pole-zero configuration in s-plane for the given transfer function.
2. Determine the transfer function for given closed loop system in block diagram representation.
3. Plot unit step response of given transfer function and find delay time, rise time, peak time and peak overshoot.
4. Determine the time response of the given system subjected to any arbitrary input.
5. Plot root locus of given transfer function, locate closed loop poles for different values of k.
6. Plot bode plot of given transfer function and determine the relative stability by measuring gain and phase margins.
7. Determine the steady state errors of a given transfer function.
8. Plot Nyquist plot for given transfer function and determine the relative stability.

9. Create the state space model of a linear continuous system.
10. Determine the state space representation of the given transfer function.

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
HS0U30A	INDUSTRIAL ECONOMICS FOREIGN TRADE	HSC	3	0	0	3	2020

i) PRE REQUISITE: NIL

ii) COURSE OVERVIEW:

The course enables students to make better economic decisions in wage employment and entrepreneurship using economic alternatives and investment alternatives.

iii) COURSE OUTCOMES

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

Course Outcomes	Description	Level
CO 1	Explain the problem of scarcity of resources, consumer behaviour and the equilibrium condition of demand and supply.	Understand
CO 2	Demonstrate the production function and equilibrium condition of a producer	Understand
CO 3	Survey the impact of market competition in the functional requirement of a firm and pricing of goods and services.	Analyse
CO 4	Infer the overall performance of the economy, the regulation of economic fluctuations and its impact on various sections in the society.	Analyse
CO 5	Compare the profitability of projects and economic performance of business with the help of capital budgeting methods.	Evaluate
CO 6	Determine the current impact of global economic policies on the business opportunities of a firm	Analyse

iv) SYLLABUS

Scarcity and choice - Basic economic problems- PPC – Firms and its objectives – types of firms – Utility – Law of diminishing marginal utility – Demand and its determinants – law of demand – elasticity of demand – measurement of elasticity and its applications – Supply, law of supply and determinants of supply – Equilibrium – Changes in demand and supply and its effects – Consumer surplus and producer surplus (Concepts) – Taxation and deadweight loss.

Production function – law of variable proportion – economies of scale – internal and external economies – Isoquants, isocost line and producer's equilibrium – Expansion path – Technical progress and its implications – Cobb-Douglas production function - Cost concepts – Social cost: private cost and external cost – Explicit and implicit cost – sunk cost - Short run cost curves - long run cost curves – Revenue (concepts) – Shutdown point – Break-even point.

Perfect and imperfect competition – monopoly, regulation of monopoly, monopolistic completion (features and equilibrium of a firm) – oligopoly – Kinked demand curve – Collusive oligopoly (meaning) – Non-price competition – Product pricing – Cost plus pricing – Target return pricing – Penetration pricing – Predatory pricing – Going rate pricing – Price skimming. Principles of taxation - Direct Tax – Indirect Tax – GST.Concepts of demonetization.Cryptocurrency

Circular flow of economic activities – Stock and flow Gross. National Income – Concepts - Methods of measuring national income – Inflation- causes and effects – Measures to control inflation. Monetary and fiscal policies – Business financing- Bonds and shares -Money market and Capital market – Stock market – Demat account and Trading account - SENSEX and NIFTY. Capital Budgeting - Methods of Investment analysis - Pay back, ARR, NPV, IRR and B/C ratio

Advantages and disadvantages of international trade - Absolute and Comparative advantage theory - Heckscher - Ohlin theory - Balance of payments – Components – Balance of Payments deficit and devaluation – Trade policy – Free trade versus protection – Tariff and non-tariff barriers

v) REFERENCE BOOKS

1) Gregory N Mankiw, ‘Principles of Micro Economics’, Cengage Publications 2015
2) Gregory N Mankiw, ‘Principles of Macro Economics’, Cengage Publications 2012
3) Dwivedi D.N., ‘Macro Economics’, Tata McGraw Hill, New Delhi 2018
4) Mithani D M, ‘Managerial Economics’, Himalaya Publishing House, Mumbai 2017
5) Tulsian, ‘Financial Management’ S Chand & Company 2017
6) Francis Cherunilam, ‘International Economics’, McGraw Hill, New Delhi 2017

vi) COURSE PLAN

Module	Contents	No. of hours
I	Scarcity and choice - Basic economic problems- PPC – Firms and its objectives – types of firms – Utility – Law of diminishing marginal utility – Demand and its determinants – law of demand – elasticity of demand – measurement of elasticity and its applications – Supply, law of supply and determinants of supply – Equilibrium – Changes in demand and supply and its effects – Consumer surplus and producer surplus (Concepts) – Taxation and deadweight loss.	**8**
II	Production function – law of variable proportion – economies of scale – internal and external economies – Isoquants, isocost line and producer’s equilibrium – Expansion path – Technical progress and its implications – Cobb-Douglas production function - Cost concepts – Social cost: private cost and external cost – Explicit and implicit cost – sunk cost - Short run cost curves - long run cost curves – Revenue (concepts) – Shutdown point – Break-even point.	**8**

III	Perfect and imperfect competition – monopoly, regulation of monopoly, monopolistic completion (features and equilibrium of a firm) – oligopoly – Kinked demand curve – Collusive oligopoly (meaning) – Non-price competition – Product pricing – Cost plus pricing – Target return pricing – Penetration pricing – Predatory pricing – Going rate pricing – Price skimming. Principles of taxation - Direct Tax – Indirect Tax – GST. Concepts of demonetization. Crypto-Currency	**9**
IV	Circular flow of economic activities – Stock and flow Gross. National Income – Concepts - Methods of measuring national income – Inflation-causes and effects – Measures to control inflation. Monetary and fiscal policies – Business financing- Bonds and shares -Money market and Capital market – Stock market – Demat account and Trading account - SENSEX and NIFTY. Capital Budgeting - Methods of Investment analysis - Pay back, ARR, NPV, IRR and B/C ratio	**11**
V	Advantages and disadvantages of international trade - Absolute and Comparative advantage theory - Heckscher - Ohlin theory - Balance of payments – Components – Balance of Payments deficit and devaluation – Trade policy – Free trade versus protection – Tariff and non-tariff barriers	**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
HSOU30B	MANAGEMENT FOR ENGINEERS	HSC	3	0	0	3	2020

i) COURSE OVERVIEW:

Objective of the course is to learn the basic concepts and functions of management and its role in the performance of an organization and to understand various decision- making approaches available for managers to achieve excellence.

ii) COURSE OUTCOMES:

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

Course Outcomes	Description	Level
CO1	Explain the characteristics of management in the contemporary context	Understand
CO2	Summarize the functions of management	Understand
CO3	Infer the decision making process and productivity analysis	Understand
CO4	Demonstrate project management technique and develop a project schedule	Apply
CO5	Explain the functional areas of management and the concept of entrepreneurship	Understand

iii) SYLLABUS:

ntroduction to management theory- Characteristic of Management, System approaches o Management, Task and Responsibilities of a professional Manager.

Management and organization-Management Process, Planning types, Principles of rganisation, Organisation Structures.

roductivity and decision making- Concept of productivity and its measurement; ecision making process; Decision trees; Models of decision making.

Project management- Network construction, CPM and PERT Networks, Scheduling computations, PERT time estimates, Probability of completion of project.

Functional areas of management- Operations management, Human resources management, Marketing management, Financial management, Entrepreneurship, Business plans, Corporate social responsibility, Patents and Intellectual property rights.

iv a) TEXTBOOKS

1) H. Koontz, and H. Weihrich, Essentials of Management: An International Perspective. 10th ed., McGraw-Hill, 2015
2) P. Kotler, K. L. Keller, A. Koshy, and M. Jha, Marketing Management: A South Asian Perspective. 15th ed., Pearson, 2016.
3) R. D. Hisrich, and M. P. Peters, Entrepreneurship: Strategy, Developing, and Managing a New Enterprise, 11th ed., McGraw-Hill Education, 2020.
4) M. Y. Khan, and P. K. Jain, Financial Management, Tata-McGraw Hill, 2020.

b) REFERENCES

1) R. B. Chase, Ravi Shankar and F. R. Jacobs, Operations and Supply Chain Management, 15th ed. McGraw Hill Education (India), 2018.
2) P C Tripathi and P N Reddy, Principles of management, TMH, 5th edition, 2012
3) K.Ashwathappa, 'Human Resources and Personnel Management', TMH, 7th edition, 2011.
4) D. J. Sumanth, Productivity Engineering and Management, McGraw-Hill Education, 2019

v) COURSE PLAN

Module	Contents	No. of hours
I	Introduction to management theory, Management Defined, Characteristic of Management, Management as an art-profession, System approaches to Management, Task and Responsibilities of a professional Manager, Levels of Manager and Skill required.	**8**
II	Management Process, Planning types , Mission, Goals, Strategy, Programmes, Procedures, Organising, Principles of Organisation, Delegation, Span of Control, Organisation Structures, Directing, Leadership, Motivation, Controlling.	**8**

III	Concept of productivity and its measurement; Competitiveness; Decision making process; decision making under certainty, risk and uncertainty; Decision trees; Models of decision making	**9**
IV	Project Management, Network construction, Arrow diagram, Redundancy. CPM and PERT Networks, Scheduling computations, PERT time estimates, Probability of completion of project, Introduction to crashing.	**10**
V	Introduction to functional areas of management, Operations management, Human resources management, Marketing management, Financial management, Entrepreneurship, Business plans, Corporate social responsibility, Patents and Intellectual property rights.	**10**
	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
NC0U30A	DISASTER MANAGEMENT	HSC	2	0	0	Nil	2020

i) COURSE OVERVIEW

The goal of this course is to expose the students to the fundamental concepts of hazards and disaster management. The course details the various phases of disaster risk management and the measures to reduce disaster risks.

ii) COURSE OUTCOMES

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

Course Outcomes	Description	Level
CO 1	Explain the fundamental concepts and terminology related to disaster management cycle	Understand
CO 2	Explain hazard and vulnerability types and disaster risk assessment	Understand
CO 3	Describe the process of risk assessment and appropriate methodologies to assess risk	Understand
CO 4	Explain the core elements and phases of disaster risk management and measures to reduce disaster risks across sector and community	Apply
CO 5	Discuss the factors that determine the nature of disaster response and the various disaster response actions	Understand
CO 6	Explain the legislations and best practices for disaster management and risk reduction at national and international level	Understand

iii) SYLLABUS

Introduction- Systems of Earth, Key concepts and terminology in disaster risk reduction and management

Hazard types, Vulnerability types and their assessment, Disaster risk assessment

Disaster risk management- Phases of disaster risk management, Measures for disaster risk reduction- prevention, mitigation, preparedness, Disaster response, Relief

Participatory stakeholder engagement, Disaster communication, Capacity building

Common disaster types in India, Legislations in India on Disaster Management, National Disaster Management Policy, Institutional arrangements for disaster management in India, The Sendai Framework for Disaster risk reduction.

iv)(a) TEXT BOOKS

1) Coppola, D.P., *Introduction to International Disaster Management*, Elsevier Science (B/H), London, 2020
2) Srivastava, H.N., Gupta,G.D., *Management of Natural Disasters in developing countries*, Daya Publishers, Delhi, 2007
3) Subramanian, R., *Disaster Management*, Vikas Publishing House, 2018
4) Sulphey, M.M., Disaster *Management*, PHI Learning, 2016

(b) REFERENCES

1) NDMA*, National Policy on Disaster Management*,Ministry of Home Affairs, Government of India,2009.
2) National Disaster Management Division, *Disaster Management in India - A Status Report*, Ministry of Home Affairs, Government of India, New Delhi,2004.
3) *National Disaster Management Plan*, NDMA, Ministry of Home Affairs, Government of India,2019.
4) *Disaster Management Training Manual*, UNDP, 2016
5) United Nations Office for Disaster Risk Reduction, *Sendai Framework for Disaster Risk Reduction 2015-2030*, 2015

v) COURSE PLAN

Module	Contents	No. of hours
I	Introduction about various systems of earth, Lithosphere- composition, rocks, soils; Atmosphere- layers, ozone layer, greenhouse effect. Weather, cyclones, atmospheric circulations, Indian monsoon; Hydrosphere- oceans, inland water bodies; Biosphere Definition and meaning of key terms in Disaster risk reduction and Management – disaster, hazard, exposure, vulnerability, risk, risk assessment, risk mapping, capacity, resilience, disaster risk reduction, disaster risk management, early warning systems, disaster preparedness, disaster prevention, disaster mitigation, disaster response, damage assessment, crisis counselling, needs assessment	**6**
II	Various hazard types, hazard mapping; Different types of vulnerability types and their assessment- Physical, social, economic and environmental vulnerability. Core elements of disaster risk assessment Components of a comprehensive disaster preparedness strategy approaches, procedures Different disaster response actions	**6**

III	Introduction to disaster risk management, core elements of disaster risk management Phases of disaster risk management, Measures for disaster risk reduction Measures for disaster prevention, mitigation, and preparedness Disaster response- objectives, requirements. Disaster response planning; types of responses Disaster relief, International relief organisations	**7**
IV	Participatory stakeholder engagement, Importance of disaster communication, Disaster communication- methods, barriers, Crisis counselling Introduction to capacity building, Concept- Structural measures, Non-structural measures Introduction to Capacity assessment, Capacity assessment- Strengthening, Capacity for reducing risk	**5**
V	Introduction- common disaster types in India Common disaster legislations in India on disaster management National disaster management policy, Institutional arrangements for disaster management in India. The Sendai Framework for Disaster risk reduction and targets- priorities for action, guiding principles	**6**
	Total hours	**30**

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
EC1U38A	ANALOG INTEGRATED CIRCUITS AND SIMULATION LAB	PCC	0	0	3	2	2020

i) PREREQUISITE: EC1U28C - Analog Circuits and Simulation Lab

ii) COURSE OVERVIEW:

This course aims to (i) familiarize students with the Analog Integrated Circuits and Design and implementation of application circuits using basic Analog Integrated Circuits (ii) familiarize students with simulation of basic Analog Integrated Circuits.

iii) COURSE OUTCOMES

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

Course Outcomes	Description	Level
CO 1	Implement various linear circuits using op amp.	Apply
CO 2	Implement various nonlinear circuits using analog ICs	Apply
CO 3	Simulate the analog integrated circuits using simulation tool.	Apply

iv) SYLLABUS

Fundamentals of operational amplifiers and basic circuits

Application circuits of 555 Timer/565 PLL

Simulation experiments

v) REFERENCES

1. Roy D. C. and S. B. Jain, *Linear Integrated Circuits*, 5/e, New Age International, 2018.

2. M. H. Rashid, *Introduction to Pspice Using Orcad for Circuits and Electronics*, 3/e, Prentice Hall, 2003

vi) COURSE PLAN

Experiment No.	List of exercises/experiments	No. of hours
I	1. Familiarization of Operational amplifiers - Inverting and Non inverting amplifiers, frequency response, Adder, Integrator, Comparators. 2. Measurement of Op-Amp parameters. 3. Difference Amplifier and Instrumentation amplifier. 4. Schmitt trigger circuit using Op–Amps. 5. Astable and Monostable multivibrator using Op-Amps. 6. Wien bridge oscillator using Op-Amp - without & with amplitude stabilization. 7. RC Phase shift Oscillator. 8. Astable and Monostable multivibrator using Timer IC NE555. 9. D/A Converters - R-2R ladder circuit. 10. Study of PLL IC: free running frequency lock range capture range	36
III	Simulation experiments[The experiments shall be conducted using SPICE] 1. Astable and Monostable multivibrator using Op-Amps. 2. RC Phase shift Oscillator. 3. Precision rectifiers using Op-Amp. 4. D/A Converters- R2R ladder circuit.	9
	Total hours	**45**

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**

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EC1U38B	DIGITAL SIGNAL PROCESSING LAB	PCC	0	0	3	2	2020

i) PREREQUISITE: ES0U10E - Programming in C, EC1U28A - Scientific Computing Lab, EC1U20E - Signals and Systems, EC1U30B - Digital Signal Processing

ii) COURSE OVERVIEW

To enable the students to explore the concepts of design, simulation and implementation of various systems using MATLAB/SciLab/OCTAVE and DSP kit.

iii) COURSE OUTCOMES

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

Course Outcomes	Description	Level
CO 1	Generate digital signals using simulation tool.	Understand
CO 2	Analyse the properties of DFT using simulation tool.	Apply
CO 3	Design real time filters using DSP hardware.	Analyse
CO 4	Analyse LTI systems using convolution.	Apply
CO 5	Analyse real time signals using FFT and IFFT.	Analyze
CO 6	Analyse speech signals using FIR low pass filter	Analyse
CO 7	Design real time LTI systems with block convolution and FFT.	Analyse

iv) SYLLABUS

Simulation of Signals

Verfication of the Properties of DFT.

Familarization of DSP Hardware

LTI System with Linear Convolution

FFT Computation

Implementation of FIR Filter

LTI Systems by Block Convolution

v) REFERENCES

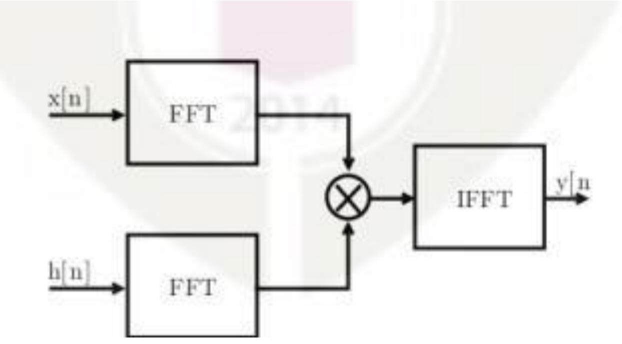
1) Vinay K. Ingle, John G. Proakis, *Digital Signal Processing Using MATLAB.*
2) Allen B. Downey, *Think DSP: Digital Signal Processing using Python.*
3) RulphChassaing, *DSP Applications Using C and the TMS320C6x DSK* (Topics in Digital Signal Processing)

vi) COURSE PLAN

Experiment No.	List of exercises/experiments	No. of hours
I	Simulation of Signals Simulate the following signals using Python/ Scilab/MATLAB. 1. Unit impulse signal 2. Unit pulse signal 3. Unit ramp signal 4. Bipolar pulse 5. Triangular signal	**3**
II	Verification of the Properties of DFT • Generate and appreciate a DFT matrix. 1. Write a function that returns the N point DFT matrix VN for a given N. 2. Plot its real and imaginary parts of VN as images using matshow or imshow commands (in Python) for N = 16, N = 64 and N = 1024 3. Compute the DFTs of 16 point, 64 point and 1024 point random sequences using the above matrices. 4. Observe the time of computations for $N = 2^{\gamma}$ for $2 \leq \gamma \leq 18$ (You may use the time module in Python). 5. Use some iterations to plot the times of computation against γ. Plot and understand this curve. Plot the times of computation for the fft	**5**

<table>
<tr><td></td><td>function over this curve and appreciate the computational saving with FFT.
• Circular Convolution.
1. Write a python function circcon.py that returns the circular convoluton of an N1 point sequence and an N2 point sequence given at the input. The easiest way is to convert a linear convolution into circular convolution with N = max(N1, N2).
• Parseval's Theorem
For the random sequences $x_1[n]$ and $x_2[n]$.
$$\sum_{n=0}^{N-1} x_1[n]x_2^*[n] = \frac{1}{N}\sum_{k=0}^{N-1} X_1[k]X_2^*[k]$$
1. Generate two random complex sequences of say 5000 values.
2. Prove the theorem for these signals.</td><td></td></tr>
<tr><td>III</td><td>3. Familarization of DSP Hardware
1. Familiarization of the code composer studio (in the case of TI hardware)
or Visual DSP (in the case of Analog Devices hardware) or any equivalent cross compiler for DSP programming.
2. Familiarization of the analog and digital input and output ports of the DSP board.
3. Generation and cross compilation and execution of the C code to connect the input digital switches to the output LEDs.
4. Generation and cross compilation and execution of the C code to connect the input analog port to the output. Connect a microphone, speak into it and observe the output electrical signal on a DSO and store it.
5. Document the work.</td><td>5</td></tr>
<tr><td>IV</td><td>Linear convolution
1. Write a C function for the linear convolution of two arrays.
2. The arrays may be kept in different files and downloaded to the DSP hardware.</td><td>3</td></tr>
</table>

	3. Store the result as a file and observe the output. 4. Document the work.	
V	FFT of signals 1. Write a C function for N - point FFT. 2. Connect a precision signal generator and apply 1 mV , 1 kHz sinusoid at the analog port. 3. Apply the FFT on the input signal with appropriate window size and observe the result. 4. Connect microphone to the analog port and read in real time speech. 5. Observe and store the FFT values. 6. Document the work.	**6**
VI	IFFT with FFT 1. Use the FFT function in the previous experiment to compute the IFFT of the input signal. 2. Apply IFFT on the stored FFT values from the previous experiments and observe the reconstruction. 3. Document the work.	**6**
VII	FIR low pass filter 1. Use Python/scilab to implement the FIR filter $response\ h[n] = \frac{sin(\omega cn)}{\pi n}$ for a filter size N = 50, ωc = 0.1π and ωc = 0.3π . 2. Realize the hamming(wH [n]) and kaiser (wK[n]) windows. 3. Compute h[n]w[n] in both cases and store as file. 4. Observe the low pass response in the simulator. 5. Download the filter on to the DSP target board and test with 1 mV sinusoid from a signal generator connected to the analog port. 6. Test the operation of the filters with speech signals. 7. Document the work.	**6**
VIII	Overlap Save Block Convolution 1. Use the file of filter coefficients From the previos experiment.	**6**

	2. Realize the system shown below for the input speech signal x[n].  3. Segment the signal values into blocks of length N = 2000. Pad the last block with zeros, if necessary. 4. Implement the overlap save block convolution method 5. Document the work.	
IX	Overlap Add Block Convolution 1. Use the file of filter coefficients from the previous experiment. 2. Realize the system shown in the previous experiment for the input speech signal x[n]. 3. Segment the signal values into blocks of length N = 2000. Pad the last block with zeros, if necessary. 4. Implement the overlap add block convolution method 5. Document the work.	**5**
	Total hours	**45**

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

MINORS

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EC0M30A	EMBEDDED SYSTEM DESIGN	VAC (MINOR)	3	1	0	4	2020

i) PREREQUISITE: EC1U20B - Logic Circuit Design, EC1U20F - Computer Architecture and Microcontrollers

ii) COURSE OVERVIEW

Goal of this course is to introduce embedded systems, various protocols used for communication between peripheral devices and processor, Embedded programming, the ARM processor organization and programming, and the basic concepts of real time operating systems.

iii) 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 embedded systems and different phases in the embedded system design process/EDLC.	Understand
CO 2	Describe the peripheral devices and their interfacing with the processor.	Understand
CO 3	Prepare the programs using high-level languages for embedded systems.	Apply
CO 4	Explain the ARM processor architecture and pipeline processor organization. .	Understand
CO 5	Prepare programs in assembly and highlevel languages for ARM processor	Apply

iv) SYLLABUS

Introduction to Embedded Systems:
Complex Systems and Microprocessors, The Embedded System Design Process, Formalisms for System Design , Embedded product development cycle (EDLC).

Embedded system interfacing and peripherals:
Serial Communication Standards and Devices, Serial Bus Protocols, Parallel communication standards, Memory, DMA, I/O Device- Interrupts.

Embedded Programming:
Programming languages, Embedded C programming.
ARM Processor fundamentals:

ARM Processor architecture, ARM Assembly Language Programming, ARM Organization and Implementation.

ARM Programming:
Architectural Support for High Level Languages, The Thumb Instruction Set , Architectural Support for System Development- The ARM memory interface, The Advanced Microcontroller Bus Architecture (AMBA).

v) a) TEXT BOOKS

1) K.V. Shibu, *Introduction to Embedded Systems*, 2e, McGraw Hill Education India, 2016.
2) Wayne Wolf, *Computers as Components: Principles of Embedded Computing System Design*, Morgan Kaufman Publishers - Elsevier 3e, 2008.
3) Steve Furber, *ARM system-on-chip architecture*, Addison Wesley, Second Edition, 2000.
4) Raj Kamal,*Embedded Systems Architecture, Programming and Design*, TMH, Third Edition, 2017.

b) REFERENCES

1) David E. Simon, *An Embedded Software Primer*, First IndianReprint, Pearson Education Asia, 2000.
2) Steve Heath, *Embedded Systems Design*, Newnes – Elsevier 2/ed, 2002.
3) Andrew N. Sloss, Dominic Symes, Chris Wright, *ARM System Developer's Guide Designing Optimizing System Software*, Morgan Kaufmann Publishers, 2004
4) Frank Vahid and Tony Givargis,*Embedded Systems Design – A Unified Hardware /Software Introduction*, John Wiley, 2002.
5) Tammy Noergaard, *Embedded Systems Architecture, A Comprehensive Guide for Engineers and Programmers*, Newnes – Elsevier 2/ed, 2013.
6) Iyer - *Embedded Real time Systems*, 1/e, McGraw Hill Education New Delhi, 2003
7) Lyla B. Das,*Embedded Systems: An Integrated Approach*, 1/e, 2012.
8) SarmadNaimi, Muhammad Ali Mazidi, SepehrNaimi, *The STM32F103 Arm Microcontroller and Embedded Systems: Using Assembly and C*, MicroDigitalEd.,2020
9) Shujen Chen, Muhammad Ali Mazidi, EshraghGhaemi, *STM32 Arm Programming for Embedded Systems*, 2018.

vi) COURSE PLAN

Module	Contents	No. of hours
I	**Complex Systems and Microprocessors:** Embedding Computers, Characteristics of Embedded Computing Applications, Application of Microprocessors, The Physics of Software, Challenges in Embedded Computing System, Characteristics and quality attributes of an embedded system, Performance in Embedded Computing. **The**	**11**

	Embedded System Design Process: Requirements, Specification, Architecture Design, Designing Hardware and Software Components and System Integration. **Formalisms for System Design:** Structural Description, Behavioral Description, An embedded system design example. **Embedded product development cycle (EDLC):** Different phases of EDLC and EDLC models	
II	**Communication devices:** Serial Communication Standards and Devices - UART, HDLC and SPI. Serial Bus Protocols - I 2C Bus, CAN Bus and USB Bus, Parallel communication standards-ISA, PCI and PCI-X Bus. **Memory:** Memory devices and systems:– ROM-Flash, EEPROM: RAM-SRAM, DRAM, Cache memory, memory mapping and addresses, memory management unit– DMA. **I/O Device:** Interrupts:-Interrupt sources, recognizing an interrupt, ISR – Device drivers for handling ISR, Interrupt latency.	**12**
III	**Programming languages**:-Assembly Languages, High level languages, Embedded C, Object oriented programming, C++, JAVA. **Embedded C programming**: Keywords and Identifiers, Data Types, Storage Class, operators, branching, looping, arrays, pointers, characters, strings, functions, function pointers, structures, unions, pre-processors and macros, constant declaration, volatile type qualifier, delay generation, infinite loops, bit manipulation, ISR, direct memory allocation	**13**
IV	**ARM Processor architecture**:The Acorn RISC Machine- Architectural inheritance, The ARM programmer's model, ARM development tools. **ARM Assembly Language Programming**:Data processing instructions, Data transfer instructions, Control flow instructions, writing simple assembly language programs. **ARM Organization and Implementation**: 3 stage pipeline ARM organization, 5-stage pipeline ARM organization, ARM instruction execution, ARM implementation, The ARM coprocessor interface	**12**
V	**Architectural Support for High Level Languages**: Abstraction in software design, Data types, Floating-point data types, The ARM floating-point architecture, Expressions, Conditional statements, Loops, Functions and procedures, Use of memory, Run-time environment. **The Thumb Instruction Set**: The Thumb bit in the CPSR, The Thumb programmer's model, Thumb branch instructions, Thumb software interrupt instruction, Thumb data processing instructions, Thumb single register data transfer instructions, Thumb multiple register data transfer instructions, Thumb breakpoint instruction, Thumb implementation, Thumb applications. **Architectural Support for System Development**: The ARM memory interface, The Advanced Microcontroller Bus Architecture (AMBA).	**12**
	Total hours	**60**

Simulation Assignments

1. At least one assignment should be of programming (Both assembly and C languages) of embedded processor with simulation tools like Keil, Eclipse.

2. Another assignment should be an embedded system design mini project like, Programming assignments can be the following. a) Print "HELLO WORLD" or any text, b)Data transfer, copy operations c)Arithmetic operations d)Sorting operations, e)Input/output control, f)Programs using functions, g) Interrupts and ISR h) controller design

3. Mini project can be done in the following areas. a) Elevator controller design (b) Chocolate vending machine design (c) Industrial controller using sensors (d) IOT applications using sensors, communication devices and actuators

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
EC0M30B	COMMUNICATION SYSTEMS	VAC (MINOR)	4	0	0	4	2020

i) COURSE OVERVIEW

The goal of this course to give awareness about various communication systems using in real life.

ii) COURSE OUTCOMES

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

Course Outcomes	Description	Level
CO 1	Explain the components required for an Optical Communication Systems	Understand
CO 2	Discuss the principle involved in RADAR and Navigation	Understand
CO 3	Explain the concept and subsystems for Cellular Communication networks	Understand
CO 4	Describe the requirement for Satellite communication systems	Understand
CO 5	Discuss the role of different layers in TCP/IP protocol stack in communication networks	Understand

iii) SYLLABUS

Optical Communication System – Block Diagram – Advantages Of Optical Fiber Communication Systems – Principles Of Light Transmission in a Fiber using Ray Theory – Types of Fibers, Attenuation in Optical Fibers, Optical transmitters: LED and semiconductor LASER, characteristics, transmitter design. Optical receivers: Common photo detectors. Receiver design.

Basic Radar System– Applications – Radar Range Equation (Qualitative Treatment Only) – Factors Influencing Maximum Range – Basic Pulsed Radar System – Block Diagram – Display Methods- A - Scope, PPI Display - Instrument Landing System – Ground Controlled Approach System.

Cellular Communication, Hand off, Frequency Reuse, Principles of Multicarrier communication, Multiple Access techniques, CDMA Systems: General aspects of CDMA cellular systems, IS-95 standard, Downlink and uplink, GSM standard and service aspects – GSM architecture, Evolution to Third Generation systems, WCDMA and CDMA-2000 standards,4G, 5G

Basic concept of satellite communication, Keppler's law, Satellite orbits, Geosynchronous satellites, Active and Passive satellite, Block diagram for Satellite uplink, Transponder and earth station receiver.

Study of OSI and TCP/IP protocol suit: The Model, Functions of each layer, TCP/IP Protocol Suites. Wireless Ad Hoc Networks: Issues and Challenges, Wireless Sensor Networks: Architecture, Data dissemination, Data gathering, MAC Protocols, Location discovery, Quality of a sensor network 6LoWPAN

iv) a) TEXT BOOKS

1) Wayne Tomasi, *Electronic communication system fundamentals*, 5/e, Pearson Education, Jan 2008
2) Behrouz A. Forouzan, *Data Communication and Networking*, 4/e, Tata McGraw Hill

b) REFERENCES

1) T S Rappaport, *Wireless communication principles and practice*, 2e/d, Pearson Education, 2002
2) G. E. Keiser, *Optical Fibre Communication*, McGraw Hill Publication.
3) D. C. Agarwal ,*Satellite Communication*, Khanna Publications, 1989.
4) Jochen Schiller, *Mobile Communications*, 2e/d, Pearson Education, 2008.
5) Siva ram Murthy, B S Manoj,*Ad Hoc Wireless Networks*, Printice Hall, 2004.

v) COURSE PLAN

Module	Contents	No. of hours
I	Optical Communication System – Block Diagram – Advantages Of Optical Fiber Communication Systems – Principles Of Light Transmission In A Fiber Using Ray Theory – Single Mode Fibers, Multimode Fibers – Step Index Fibers, Graded Index Fibers (Basic Concepts Only) – Attenuation In Optical Fibers – Absorption Losses, Scattering Losses, Bending Losses, Core And Cladding Losses. Optical transmitters: LED and semiconductor LASER, characteristics, transmitter design. Optical receivers: Common photo detectors. Receiver design	**11**
II	Basic Radar System– Applications – Radar Range Equation (Qualitative Treatment Only) – Factors Influencing Maximum Range – Basic Pulsed Radar System – Block Diagram – Display MethodsA - Scope, PPI Display, Instrument Landing System – Ground Controlled Approach System	**11**
III	Cellular Communication, Hand off, Frequency Reuse, Principles of Multicarrier communication, Multiple Access techniques, CDMA Systems: General aspects of CDMA cellular systems, IS-95 standard, Downlink and uplink, GSM standard and service aspects – GSM	**12**

	architecture, Evolution to Third Generation systems, WCDMA and CDMA-2000 standards,4G, 5G	
IV	Basic concept of satellite communication, Keppler's law, Satellite orbits, Geosynchronous satellites, Active and Passive satellite, Block diagram for Satellite uplink, Transponder and earth station receiver	**13**
V	Study of OSI and TCP/IP protocol suit: The Model, Functions of each layer, TCP/IP Protocol Suites, Issues and challenges in Wireless Ad Hoc Networks, Vehicular Ad Hoc Networks, Wireless Sensor Networks: Architecture, Data dissemination, Data gathering, MAC Protocols, Location discovery, Quality of a sensor network, 6LoWPAN	**13**
	Total hours	**60**

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
EC0M30C	TOPICS IN DIGITAL IMAGE PROCESSING	VAC (MINOR)	3	1	0	4	2020

i) PREREQUISITE: EC0M20F - Introduction to Digital Signal Processing

ii) COURSE OVERVIEW:
This course aims to develop the skills for methods of various transformation and analysis of image enhancement, image reconstruction, image compression, image segmentation and image representation.

iii) COURSE OUTCOMES

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

Course Outcomes	Description	Level
CO 1	Explain the various basic concepts of digital image processing	Understand
CO 2	Apply the concepts to analyse a 2D discrete signal in time and frequency domain	Apply
CO 3	Explain two-dimensional sampling and quantization	Understand
CO 4	Apply the concepts to enhance and restore digital images using various filtering techniques	Apply
CO 5	Explain various image compression techniques	Understand

iv) SYLLABUS

Digital Image Fundamentals-Elements of visual perception, image sensing and acquisition, image sampling and quantization, basic relationships between pixels – neighbourhood, adjacency, connectivity, distance measures.Brightness, contrast, hue, saturation, mach band effect, Colour image fundamentals-RGB, CMY, HIS models, 2D sampling, quantization.
Image Enhancement: Spatial domain methods: point processing-intensity transformations, histogram processing, image subtraction, image averaging, geometric transformation Sharpening filters – first and second derivative, two-dimensional DFT and its inverse, frequency domain filters – low-pass and high-pass.

Image segmentation: Classification of Image segmentation techniques, region approach, clustering techniques Classification of edges, edge detection, Hough transform, active contour Thresholding – global and adaptive
Image restoration: Restoration Models, Linear Filtering Techniques: Inverse and Wiener, Non-linear filtering: Mean, Median, Max and Min filters Noise Models: Gaussian, Uniform, Additive, Impulse Image restoration applications

Image Compression- Need for compression, redundancy, classification of image compression schemes, Huffman coding, arithmetic coding Redundancy–inter-pixel and psycho-visual; Lossless compression – predictive, entropy; Lossy compression- predictive and transform coding – DST, DCT, wavelet transform (basics only); Still image compression standards – JPEG and JPEG-2000

v) a) TEXT BOOKS

1) Farid Gonzalez Rafel C., *Digital Image Processing*, 3/e, Pearson Education, 2017
2) S. Jayaraman, S. Esakkirajan, T. Veerakumar, *Digital image processing*, Tata McGraw Hill, 2015

b) REFERENCES

1) Jain Anil K, *Fundamentals of digital image processing*, PHI, US edition, 1988
2) Kenneth R Castleman, *Digital image processing*, 2/e, Pearson Education, 2003
3) Pratt William K, *Digital Image Processing*, 4/e, John Wiley, 2007

vi) COURSE PLAN

Module	Contents	No. of hours
I	Digital Image Fundamentals-Elements of visual perception, image sensing and acquisition, Image sampling and quantization, basic relationships between pixels – neighbourhood, adjacency, connectivity, distance measures, Brightness, contrast, hue, saturation, mach band effect, Impulse response and its relation with transfer function of linear systems. Block diagram representation and reduction methods, 2D sampling, quantization	**12**
II	Image Enhancement: Spatial domain intensity transformations, Histogram processing, image subtraction, image averaging, geometric transformations, Sharpening filters, First and second derivative, two-dimensional DFT and its inverse, frequency domain filters – low-pass and high-pass.	**12**
III	Image segmentation: Spatial domain methods: point processing- intensity transformations, Classification of Image segmentation techniques, region approach, clustering techniques, Classification of edges, edge detection, Hough transform, active contour, Thresholding – global and adaptive.	**12**
IV	Image Restoration: Restoration Models -Noise Models: Gaussian, Uniform, Additive, Impulse and Erlang, Linear Filtering Techniques: Inverse and Wiener, Non-linear filtering:	**12**

	Mean, Median, Max and Min filters, Applications of Image restoration	
V	Image Compression: Need for compression, redundancy, classification of image compression schemes, Huffman coding, arithmetic coding, Redundancy–inter-pixel and psycho-visual, Lossless compression – predictive, entropy, Lossy compression- predictive and transform coding DST, wavelet, Still image compression standards – JPEG and JPEG2000	**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.

HONOURS

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EC1H30A	FPGA BASED SYSTEM DESIGN	VAC (HONOUR)	4	0	0	4	2020

i) PREREQUISITE: EC1U20B - Logic Circuit Design

ii) COURSE OVERVIEW

Goal of this course is to develop the skill for designing digital systems using FPGA.

iii) COURSE OUTCOMES

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

Course Outcomes	Description	Level
CO 1	Design simple digital systems using programmable logic devices	Apply
CO 2	Describe the architecture and characteristics of FPGA	Understand
CO 3	Discuss the design considerations of FPGA	Understand
CO 4	Design simple combinational and sequential circuits using FPGA	Apply

iv) SYLLABUS

Introduction: Digital system design options and tradeoffs, Design methodology, High Level System Architecture and Specification, Hardware description languages (emphasis on Verilog), State machine design, Test benches.

Programmable Logic Devices: ROM, PLA, PAL, CPLD, FPGA, Implementation of MSI circuits using PLDs.

FPGA Architecture: FPGA Architectural options, granularity of function and wiring resources, coarse V/s fine grained, vendor specific issues (emphasis on Xilinx and Altera), Logic block architecture, Timing models, Power dissipation, I/O block architecture.

Placement and Routing: Programmable interconnect, Routing resources. Embedded system design using FPGAs, DSP using FPGAs.

Commercial FPGAs: Xilinx, Altera, Actel. Case study and implementation of circuits using Xilinx Virtex.

v) a) TEXT BOOKS

1) Wayne Wolf, *FPGA-Based System Design*, Prentice Hall Modern Semiconductor Design Series,Pearson, 2004
2) Wayne Wolf, *Modern VLSI Design: System-on-Chip Design*, 3rd Edition,Pearson, 2002

3) Samir Palnikar, *Verilog HDL: A Guide to Digital Design and Synthesis*, 2nd edition, Prentice Hall, 2003

b) REFERENCES

1) S.Trimberger, Edr., *Field Programmable Gate Array Technology*, Kluwer Academic Publications, 1994
2) P.K.Chan& S. Mourad, *Digital Design Using Field Programmable Gate Array* , Prentice Hall (Pte), 1994
3) S.Brown, R.Francis, J.Rose, Z.Vransic, *Field Programmable Gate Array*, Kluwer Publications, 2007

vi) COURSE PLAN

Module	Contents	No. of hours
I	**Introduction:** Digital system design options and tradeoffs, Design methodology and technology overview, High Level System Architecture and Specification: Behavioural modelling and simulation, Hardware description languages, combinational and sequential design, State machine design, synthesis issues, test benches	14
II	**Programmable Logic Devices**: ROM, PLA, PAL, CPLD, FPGA Features, Limitations, Architectures and Programming. Implementation of MSI circuits using Programmable logic Devices.	13
III	**FPGA Architecture**: FPGA Architectural options, Granularity of function and wiring resources, coarse V/s fine grained, vendor specific issues (emphasis on Xilinx and Altera), Logic block architecture: FPGA logic cells, timing models, power dissipation, I/O block architecture: Input and Output cell characteristics, clock input, Timing, Power dissipation.	10
IV	**Placement and Routing**: Programmable interconnect - Partitioning and Placement, Routing resources, delays. Applications - Embedded system design using FPGAs, DSP using FPGAs	10
V	**Commercial FPGAs:** Xilinx, Altera, Actel (Different series description only). **Case study**: Xilinx Virtex - Implementation of simple combinational and sequential circuits	13
	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
EC1H30B	DETECTION AND ESTIMATION THEORY	VAC (HONOUR)	3	1	0	4	2020

i) PREREQUISITE: MA0U10A - Linear Algebra and Calculus, MA0U20C - Probability, Random Process, and Numerical Methods, ECT 204 - Signals and Systems

ii) COURSE OVERVIEW

Goal of this course is to provide an insight into the fundamentals of detection and estimation theory in engineering applications.

iii) COURSE OUTCOMES

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

Course Outcomes	Description	Level
CO 1	Describe the fundamentals of statistical detection and estimation principles used in various engineering problems	Understand
CO 2	Apply various types of statistical decision rules in engineering applications.	Apply
CO 3	Apply different types of estimation methods in engineering applications.	Apply

iv) SYLLABUS

Fundamentals of detection and estimation theory and its applications, classical and Bayesian approach in detection and estimation theory, different types of statistical decision rules, different types of estimation algorithms and its applications.

v) a) TEXT BOOKS

1. S.M. Kay, *Fundamentals of Statistical Signal Processing, Vol I: Estimation Theory*, 3/e, Pearson, 2010.
2. S.M. Kay, *Fundamentals of Statistical Signal Processing Vol II: Detection Theory*, 3/e, Pearson, 2010.

b) REFERENCES

1. H. L. Van Trees, *Detection, Estimation, and Modulation Theory*, Vol. I, John Wiley & Sons, 1968
2. Monson H. Hayes ,*Statistical Digital Signal Processing and Modelling*, John Wiley & Sons, 2002.

vi) COURSE PLAN

Module	Contents	No. of hours
I	Fundamentals of detection theory, the mathematical detection problem. Fundamentals of estimation theory, the mathematical estimation problem. Review of Gaussian distribution. Application examples.	**11**
II	Hypothesis testing, classical approach, Neyman-Pearson theorem, likelihood ratio test, receiver operating characteristics, Bayesian approach, minimum probability of error, Bayes risk, multiple hypothesis testing.	**13**
III	Detection of deterministic signals, matched filters, detection of random signals, estimator-correlator, linear model, application examples.	**11**
IV	Minimum variance unbiased estimation, basics of Cramer-Rao Lower Bound, linear models, best linear unbiased estimation, application examples.	**13**
V	Maximum likelihood estimation, least squares, Bayesian philosophy, minimum mean square error estimation, application examples.	**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
EC1H30C	COMPUTATIONAL TOOLS FOR SIGNAL PROCESSING	VAC (HONOUR)	3	1	0	4	2020

i) PREREQUISITE: EC1U28A - Scientific Computing Lab, EC1U20E - Signals and Systems, EC1U30B - Digital Signal Processing

ii) COURSE OVERVIEW

This course aims to use the computational tools in signal processing to solve industry problems.

iii) COURSE OUTCOMES

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

Course Outcomes	Description	Level
CO 1	Explain different computational tools used for signal processing	Understand
CO 2	Analyse regression and Bayesian models using pymc3	Analyse
CO 3	Apply the concept to analyse different statistical models for signal processing	Apply
CO 4	Implement Kalman filters	Analyse
CO 5	Implement particle filters for practical applications	Analyse

iv) SYLLABUS

Statistical Modelling using pymc3, Probability concepts, Bayes theorem, Bayesian Statistics and modelling, Modelling Coin flipping as Bayesian, Choosing the likelihood and prior, Posterior computation, Posterior predictive analysis, Posterior plots. Likelihood theory and Estimation.

Modelling Linear Regression, Polynomial Regression, Multiple Linear Regression, Logistic Regression, Poisson Regression using pymc3.

Bayesian analysis using pymc3, Posterior predictive checks, Model specifications using pymc3, Examples of Bayesian Analytics. Bayes factor, Sequential Monte Carlo to compute Bayes factors, Recursive state estimation, Modelling functions using pymc3, Covariance functions and kernels, Bayesian Regression Models.

GH filter, Choosing G and H factors, Simple simulation models using GH filters, Discrete Bayes Filter for predicting the random movement, Recursive estimation and prediction, Effect of noisy environment. Kalman filter- updation using measurements and observations, Kalman Gain calculation and Prediction, Process noise and Measurement noise.Kalman Filter Equations implementation in python.

Multivariate Kalman Filter-Modelling and Designing, Effect of Nonlinearity, Nonlinear Filters, Smoothing, Adaptive Filtering. Markov concepts, Monte Carlo integration, Basics of Markov chain Monte Carlo, Implementation using filterpy module. Particle Filter algorithm and Implementation.

v) a) TEXT BOOKS AND REFERENCES

1) Osvaldo Martin, *Bayesian Analysis with python*,2/e, PACKT Open Source Publishing, 2018
2) SergiosTheodoridis, *Machine Learning: A Bayesian and Optimization Perspective*, 2/e, Academic Press, 2020
3) https://github.com/rlabbe/Kalman-and-Bayesian-Filters-in-Python
4) CyrilleRossant, *Ipython Interactive Computing and Visualization Cookbook*, 2/e, PACKT Open Source Publishing, 2018
5) JamesV. Candy, Bayesian, *Signal Processing: Classical, Modern, and Particle Filtering Methods*, 2/e, Wiley-IEEE Press, 2016

vi) COURSE PLAN

Module	Contents	No. of hours
I	Probabilistic Programming: Statistical Modelling using pymc3, Probability concepts, Bayes theorem, Bayesian Statistics and modelling, Modelling Coin flipping as Bayesian, Choosing the likelihood and prior, Posterior computation, Posterior predictive analysis, Posterior plots. Likelihood theory and Estimation	**12**
II	Modelling Linear and Logistic Regression: Modelling Linear Regression, Polynomial Regression, Multiple Linear Regression, Logistic Regression, Poisson Regression using pymc3.	**12**
III	Bayesian Modelling: Bayesian analysis using pymc3, Posterior predictive checks, Model specifications using pymc3, Examples of Bayesian Analytics, Bayes factor, Sequential Monte carlo to compute Bayes factors, Recursive state estimation, Modeling functions using pymc3, Covariance functions and kernels. Bayesian Regression Models	**12**
IV	GH and Kalman Filter: GH filter, Choosing G and H factors, Simple simulation models using GH filters, Discrete Bayes Filter for predicting the random movement, Recursive estimation and prediction, Effect of noisy environment, Kalman filter- updation using measurements and observations, Kalman Gain calculation and Prediction, Process noise	**12**

	and Measurement noise. Kalman Filter Equations implementation in python.	
V	Particle Filter: Multivariate Kalman Filter - Modelling and Designing, Effect of Nonlinearity, Nonlinear Filters, Smoothing, Adaptive Filtering, Markov concepts, Monte carlo integration, Basics of Markov chain Monte Carlo, Implementation using filterpy module. Particle Filter algorithm and Implementation.	**12**
	Total hours	**60**

SIMULATION ASSIGNMENTS

1) Create a noisy measurement system. Design a g-h filter to filter out the noise and plot it. Write a code to filter 100 data points that starts at 5, has a derivative of 2, a noise scaling factor of 10, and uses g=0.2 and h=0.02. Set your initial guess for x to be 100.
2) Design a filter to track the position of a train. Its position is expressed as its position on the track in relation to some fixed point which we say is 0 km. I.e., a position of 1 means that the train is 1 km away from the fixed point. Velocity is expressed as meters per second. Measurement of position is doeonce per second, and the error is ± 500 meters.The train is currently at 23 kilometer, moving at 15 m/s,accelerating at 0.2 m/secˆ2. Plot the results.
3) Using Discrete Bayes Filter, predict the movemet of a dog. The current position of the dog is 17 m. The epoch is 2 seconds long, and the dog is traveling at 15 m/s. Where will the dog be in two seconds?
4) Compute the statistics of a Gaussian function using filterpy() module
5) Design a Kalman filter to track the movement of a dog(parameters same as previous one) in a Noisy environment
6) Prove that the binomial and beta distributions are conjugate pairs with respect to the mean value.
7) Show that the conjugate prior of the multivariate Gaussian with respect to the precision matrix, Q, is a Wishart distribution.
8) Prove that if a probability distribution p satisfies the Markov condition, as implied by a BN, hen p is given as the product of the conditional distributions given the values of the parents.
9) Suppose that n balls are thrown independently and uniformly at random into n bins.

a. Find the conditional probability that bin 1 has one ball given that exactly one ball fell into the first three bins.

b. Find the conditional expectation of the number of balls in bin 1 under the condition that bin 2 received no balls

c. Write an expression for the probability that bin 1 receives more balls than bin 2.

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.

SEMESTER VI

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EC1U30E	ELECTROMAGNETICS	PCC	3	1	0	4	2020

i) PREREQUISITE: MA0U10B - Vector Calculus

ii) COURSE OVERVIEW

This course aims to impart knowledge on the basic concepts of electric and magnetic fields and its applications.

iii) COURSE OUTCOMES

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

Course Outcomes	Description	Level
CO 1	Summarize the basic mathematical concepts related to electromagnetic vector fields.	Apply
CO 2	Apply Maxwell's equation to engineering problems.	Analyse
CO 3	Analyse electromagnetic wave propagation and wave polarization in different media.	Analyse
CO 4	Analyse the parameters of transmission lines using Smith chart.	Analyse
CO 5	Analyse the different modes of propagation in Waveguides.	Analyse

iv) SYLLABUS

Introduction to Electromagnetic Theory, Review of vector calculus, Expression of curl divergence and Laplacian in cartesian, cylindrical and spherical coordinate system. Electric field and magnetic field, Review of Coulomb's law, Gauss law and Amperes current law. Poisson and Laplace equations, Determination of E and V using Laplace equation.

Derivation of capacitance and inductance of two wire transmission line and coaxial cable, Energy stored in Electric and Magnetic field.Displacement current density, continuity equation.Magnetic vector potential.Relation between scalar potential and vector potential.Maxwell's equation from fundamental laws. Boundary condition of electric field and magnetic field from Maxwells equations. Solution of wave equation.

Propagation of plane EM wave in perfect dielectric, lossy medium, good conductor, media attenuation, phase velocity, group velocity, skin depth.Reflection and refraction of plane electromagnetic waves at boundaries for normal & oblique incidence (parallel and perpendicular polarization), Snell's law of refraction, Brewster angle.
Power density of EM wave, Poynting vector theorem.Polarization of electromagnetic wave-linear, circular and elliptical polarisation. Uniform lossless transmission line – line parameters. Transmission line equations, Voltage and Current distribution of a line

terminated with load. Reflection coefficient and VSWR.Derivation of input impedance of transmission line.

Transmission line as circuit elements (L and C). Development of Smith chart - calculation of line impedance and VSWR using smith chart. The hollow rectangular wave guide – modes of propagation of wave-dominant mode, group velocity and phase velocity - derivation and simple problems only

v) a) TEXT BOOKS

1) John D. Kraus, *Electromagnetics*, 5/e, TMH, 2010.
2) Mathew N O Sadiku, *Elements of Electromagnetics*, Oxford University Press, 6/e, 2014.
3) William, H. Hayt, and John A. Buck, *Engineering Electromagnetics*, McGraw-Hill, 8/e McGraw-Hill, 2014.

b) REFERENCES

1) Edminister, *Schaum's Outline of Electromagnetics*, 4/e, McGraw-Hill, 2014.
2) Jordan and Balmain, *Electromagnetic waves and Radiating Systems*, PHI, 2/e,2013
3) Martin A Plonus, *Applied Electromagnetics*, McGraw Hill, 2/e,1978.
4) NannapaneniNarayanaRao, *Elements of Engineering Electromagnetics*, Pearson, 6/e, 2006.
5) Umran S. Inan and Aziz S. Inan, *Engineering Electromagnetics*, Pearson, 2010.

vi) COURSE PLAN

Module	Contents	No. of hours
I	Introduction to Electromagnetic Theory. Review of vector calculus- curl, divergence gradient. Rectangular, cylindrical and spherical coordinate systems. Expression of curl divergence and Laplacian in cartesian, cylindrical and spherical coordinate system. Electric field and magnetic field. Review of Coulomb's law, Gauss law and Amperes current law. Poisson and Laplace equations, Determination of E and V using Laplace equation.	**13**
II	Derivation of capacitance and inductance of two wire transmission line and coaxial cable. Energy stored in Electric and Magnetic field. Displacement current density, continuity equation. Magnetic vector potential. Relation between scalar potential and vector potential. Maxwell's equation from fundamental laws. Boundary condition of electric field and magnetic field from Maxwell's equations. Solution of wave equation	**11**
III	Propagation of plane EM wave in perfect dielectric, lossy medium, good conductor, media-attenuation, phase velocity, group velocity, skin depth. Reflection and refraction of plane electromagnetic waves at boundaries	**12**

	for normal & oblique incidence (parallel and perpendicular polarization), Snell's law of refraction, Brewster angle.	
IV	Power density of EM wave, Poynting vector theorem. Polarization of electromagnetic wave-linear, circular and elliptical polarisation. Uniform lossless transmission line - line parameters. Transmission line equations Voltage and Current distribution of a line terminated with load. Reflection coefficient and VSWR. Derivation of input impedance of transmission line	**11**
V	Transmission line as circuit elements (L and C). Development of Smith chart - calculation of line impedance and VSWR using smith chart. The hollow rectangular wave guide –modes of propagation of wave dominant mode, group velocity and phase velocity -derivation and simple problems only	**13**
	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
EC1U30F	VLSI CIRCUIT DESIGN	PCC	3	1	0	4	2020

i) PREREQUISITE: EC1U20A - Solid State Devices, EC1U20D - Analog Circuits, EC1U20B - Logic Circuit Design

ii) COURSE OVERVIEW

This course aims to impart the knowledge of VLSI design methodologies and Digital VLSI circuit design.

iii) COURSE OUTCOMES

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

Course Outcomes	Description	Level
CO 1	Explain the various methodologies in ASIC and FPGA design.	Understand
CO 2	Design various static and dynamic logic circuits using CMOS design	Apply
CO 3	Realize different types of memory elements	Understand
CO 4	Describe the function of various arithmetic units like adders and multipliers	Understand
CO 5	Explain MOSFET fabrication techniques and layout design rules.	Understand

iv) SYLLABUS

Introduction: Moore’s law. ASIC design, Full custom ASICs, Standard cell based ASICs, Gatearray based ASICs, SoCs, FPGA devices, ASIC and FPGA Design flows, Top-Down and Bottom-Up design methodologies. Logical and Physical design. Speed power and area considerations in VLSI design.
MOSFET Logic Design - NMOS Inverter (Static analysis only), basic logic gates, CMOS logic, Static and transient analysis of CMOS inverter, Switching power dissipation and delays. Realization of logic functions with static CMOS logic, Pass transistor logic, and transmission gate logic.
Dynamic Logic Design-Pre charge- Evaluate logic, Domino Logic, NP domino logic.
Read Only Memory-4x4 MOS ROM Cell Arrays (OR,NOR,NAND)
Random Access Memory –SRAM-Six transistor CMOS SRAM cell, DRAM –Three transistor and One transistor Dynamic Memory Cell.
Adders: Static adder, Carry-Bypass adder, Linear Carry- Select adder, Square- root carry-select adder. Multipliers: Array multiplier.

Material Preparation-Purification and Crystal growth (CZ process), wafer preparation Thermal Oxidation- Growth mechanisms, Dry and Wet oxidation. Diffusion and ion implantation techniques.Epitaxy : molecular beam epitaxy. Lithography - Photo lithographic sequence, Electron Beam Lithography, Etching and metal deposition techniques. MOSFET Fabrication techniques - Twin-Tub fabrication sequence, Fabrication process flow.
Layout Design and Design rules, Stick Diagram and Design rules-micron rules and Lambda rules. (definitions only).layout of CMOS Inverter, two input NAND and NOR gates.

v) a) TEXT BOOKS

1. S.M. SZE, *VLSI Technology*, 2/e, Indian Edition, McGraw-Hill,2003
2. Jan M. Rabaey, *Digital Integrated Circuits- A Design Perspective*, Second Edition , Prentice Hall,2005
3. Michael John Sebastian Smith, *Application Specific Integrated Circuits*, 1/e, Pearson Education,2001

c) REFERENCES

1. Sung –Mo Kang & Yusuf Leblebici, *CMOS Digital Integrated Circuits- Analysis & Design*, Third Ed., McGraw-Hill, 2003
2. Neil H.E. Weste, Kamran Eshraghian, *Principles of CMOS VLSI Design- A Systems Perspective*, Second Edition.Pearson Publication, 2005.
3. Wayne Wolf, *Modern VLSI design*, Third Edition, Pearson Education,2002.
4. Razavi, *Design of Analog CMOS Integrated Circuits*, 2/e, McGraw Hill Education India Education, New Delhi, 2003.
5. M.S.Tyagi, *Introduction to Semiconductor Materials*, 1/e, Wiley India, 2008

vi) COURSE PLAN

Module	Contents	No. of hours
I	**VLSI Design Methodologies** Introduction: Moore's law, ASIC design, Full custom ASICs, Standard cell based ASICs, Gate array based ASICs, SoCs, FPGA devices, ASIC and FPGA Design flows, Top-Down and Bottom-Up design methodologies. Logical and Physical design. Speed power and area considerations in VLSI design.	13
II	**Static CMOS Logic Design** MOSFET Logic Design - NMOS Inverter (Static analysis only), basic logic gates, CMOS logic, Static and transient analysis of CMOS inverter, Switching power dissipation and delays. Realization of logic functions with static CMOS logic, Pass transistor logic, and transmission gate logic	13
III	**Dynamic logic Design and Storage Cells**	13

	Dynamic Logic Design-Pre charge- Evaluate logic, Domino Logic, NP domino logic. Read Only Memory-4x4 MOS ROM Cell Arrays(OR,NOR,NAND) Random Access Memory –SRAM-Six transistor CMOS SRAM cell, DRAM –Three transistor and One transistor Dynamic Memory Cell.	
IV	**Arithmetic circuits** **A**dders: Static adder, Carry-Bypass adder, Linear Carry- Select adder, Square- root carry- select adder. Multipliers: Array multiplier	**8**
V	**Fabrication techniques and MOSFET physical Design** Material Preparation - Purification and Crystal growth (CZ process), wafer preparation Thermal Oxidation- Growth mechanisms, Dry and Wet oxidation. Diffusion and ion implantation techniques. Epitaxy : molecular beam epitaxy. Lithography- Photo lithographic sequence, Electron Beam Lithography, Etching and metal deposition techniques. MOSFET Fabrication techniques Twin-Tub fabrication sequence, Fabrication process flow. Layout Design and Design rules, Stick Diagram and Design rules- micron rules and Lambda rules. (Definitions only). Layout of CMOS Inverter, two input NAND and NOR gates.	**13**
	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
EC1U30G	INFORMATION THEORY AND CODING	PCC	3	1	0	4	2020

i) PREREQUISITE: MA0U10A - Linear Algebra and Calculus, MA0U20C - Probability, Random Process and Numerical Methods, EC1U20E - Signals and Systems

ii) COURSE OVERVIEW

This course aims to lay down the foundation of information theory introducing both source coding and channel coding. It also aims to expose students to algebraic and probabilistic error-control codes that are used for reliable transmission

iii) COURSE OUTCOMES

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

Course Outcomes	Description	Level
CO 1	Compute information, entropy and mutual information related with different components in a communication system	Apply
CO 2	Apply Shannon's source coding theorem for data compression	Apply
CO 3	Apply the concept of channel capacity to characterize the limits of error-free transmission.	Apply
CO 4	Design linear block encoders and decoders for error detection and correction.	Apply
CO 5	Apply algebraic codes with reduced structural complexity for error correction.	Apply
CO 6	Perform error detection and correction using convolutional and LDPC codes.	Apply

iv) SYLLABUS

Information, Entropy, Mutual Information – formulation & properties. Discrete Memory-less source, Average codelength, Construction of Instantaneous codes – Kraft's inequality. Discrete Memoryless channels – capacity, channel coding theorem, Gaussian channels, differential entropy. Groups, rings and fields. Block codes – Error detection and correction capability, Generator and parity matrix. Cyclic codes - Polynomial and matrix description, Systematic encoding and decoding, Hamming Codes, BCH codes, Reed-Solomon Codes. Convolutional - State diagram. Trellis diagram. Maximum likelihood decoding.Viterbi algorithm, LDPC Codes.

v) REFERENCE BOOKS

1) Joy A Thomas and Thomas M Cover, *Elements of Information Theory*, 2nd edition, Wiley-Interscience, 2005.
2) David JC McKay, *Information Theory, Inference and Learning Algorithms,* Cambridge University Press, 2005
3) R. G Gallager, *Principles of digital communication*, Cambridge University Press, 2008
4) Simon Haykin, *Digital Communication Systems*, 4th edition, Wiley, 2000.
5) Ron M Roth, *Introduction to Coding Theory*, Cambrdige University Press, 2006
6) Shu Lin & Daniel J. Costello. Jr., *Error Control Coding : Fundamentals and Applications*, 2nd Edition, 2001.
7. RüdigerUrbanke and TJ Richardson, *Modern Coding Theory*, Cambdridge University, 2008

vi) COURSE PLAN

Module	Contents	No. of hours
I	Entropy, Properties of Entropy, Joint and Conditional Entropy, Mutual Information, Properties of Mutual Information. Discrete memoryless sources, Source code, Average length of source code, Bounds on average length, Uniquely decodable and prefix-free source codes. Kraft Inequality (with proof), Huffman code. Shannon's source coding theorem (both achievability and converse) and operational meaning of entropy.	**13**
II	Discrete memoryless channels. Capacity of discrete memoryless channels. Binary symmetric channels (BSC), Binary Erasure channels (BEC). Capacity of BSC and BEC. Channel code. Rate of channel code. Shannon's channel coding theorem (both achievability and converse without proof) and operational meaning of channel capacity. Modeling of Additive White Gaussian channels. Continuous-input channels with average power constraint. Differential entropy. Differential Entropy of Gaussian random variable. Relation between differential entropy and entropy. Shannon-Hartley theorem (with proof – mathematical subtleties regarding power constraint may be overlooked). Inferences from Shannon Hartley theorem – spectral efficiency versus SNR per bit, power-limited and bandwidth-limited regions, Shannon limit, Ultimate Shannon limit..	**13**
III	Overview of Groups, Rings, Finite Fields, Construction of Finite Fields from Polynomial rings, Vector spaces.	**13**

	Block codes and parameters. Error detecting and correcting capability. Linear block codes. Two simple examples -- Repetition code and single parity-check code. Generator and parity-check matrix. Systematic form. Maximum likelihood decoding of linear block codes. Bounded distance decoding. Syndrome. Standard array decoding.	
IV	Cyclic codes. Polynomial and matrix description. Interrelation between polynomial and matrix view point. Systematic encoding. Decoding of cyclic codes. (Only description, no decoding algorithms) Hamming Codes, BCH codes, Reed-Solomon Codes.	**11**
V	Convolutional Codes. State diagram. Trellis diagram. Maximum likelihood decoding. Viterbi algorithm. Low-density parity check (LDPC) codes. Tanner graph representation. Message-passing decoding for transmission over binary erasure channel.	**10**
	Total hours	**60**

Simulation assignments may be conducted on different coding schemes

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
EC1U30H	COMPREHENSIVE COURSE WORK	PCC	1	0	0	1	2020

i) PREREQUISITE:

EC1U20D - Analog Circuits
EC1U20B - Logic Circuit Design
EC1U30A - Linear Integrated Circuits
EC1U30B - Digital Signal processing
EC1U30C - Analog and Digital Communication

ii) COURSE OVERVIEW

The objective of this Course work is to ensure the comprehensive knowledge of each student in the most fundamental Program core courses in the curriculum. Five core courses credited from Semesters 3, 4 and 5 are chosen for the detailed study in this course work. This course has an End Semester Objective Test conducted by the University for 50 marks. One hour is assigned per week for this course for conducting mock tests of objective nature in all the listed five courses.

iii) COURSE OUTCOMES

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

Course Outcomes	Description	Level
CO 1	Apply the knowledge of circuit theorems and solid state physics to solve the problems in electronic Circuits	Apply
CO 2	Design a logic circuit for a specific application	Apply
CO 3	Design linear IC circuits for linear and non-linear circuit applications.	Apply
CO 4	Explain basic signal processing operations and filter designs	Understand
CO 5	Explain existent analog and digital communication systems	Understand

iv) SYLLABUS

Full syllabus of all the five subjects

v) COURSE PLAN

No	Topics	No. of hours
1	EC1U20D - Analog Circuits	
1.1	Mock Test on Module 1 and Module 2	**2**
1.2	Mock Test on Module 3, Module 4 and Module 5	
2	EC1U20B - Logic Circuit Design	
2.1	Mock Test on Module 1 and Module 2	**2**
2.2	Mock Test on Module 3, Module 4 and Module 5	
3	EC1U30A - Linear Integrated Circuits	
3.1	Mock Test on Module 1 and Module 2	**2**
3.2	Mock Test on Module 3, Module 4 and Module 5	
4	EC1U30B - Digital Signal processing	
4.1	Mock Test on Module 1 and Module 2	**2**
4.2	Mock Test on Module 3, Module 4 and Module 5	
5	EC1U30C - Analog and Digital Communication	
5.1	Mock Test on Module 1 and Module 2	**2**
5.2	Mock Test on Module 3, Module 4 and Module 5	
	Revisions and Remedial	**5**
	Total hours	**15**

vi) ASSESSMENT PATTERN

Mark distribution

Total Marks	Continuous Internal Evaluation Marks	End Semester Evaluation Marks	End Semester Examination Duration
50	**0**	**50**	**1 hour**

End Semester Examination Pattern:

Objective Questions with multiple choice (Four). Question paper include Fifty Questions of One mark each covering the five identified courses

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EC1U38C	COMMUNICATION LAB	PCC	0	0	3	2	2020

i) PREREQUISITE: EC1U30C - Analog and Digital Communication**,** EC1U30B - Digital Signal Processing.

ii) COURSE OVERVIEW

Objective of the course is to simulate the system performance parameter of a digital communication system and to emulate a communication system with software-designed-radio.

iii) COURSE OUTCOMES

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

Course Outcomes	Description	Level
CO 1	Implement simple prototype circuits for analog and digital modulation techniques.	Apply
CO 2	Use matlab program to Simulate the error performance of standard binary and M -ary modulation schemes.	Apply
CO 3	Develop hands-on skills to emulate a communication system with software-designed-radio.	Apply

iv) SYLLABUS

FM generation and demodulation using PLL, Generation and Detection of PCM/ BPSK/ 16-QPSK/Delta modulated signals.
Performance of Waveform Coding Using PCM, Pulse Shaping and Matched Filtering, Eye Diagram, Error Performance of BPSK, Error Performance of QPSK.
Familiarization with Software Defined Radio, FM Transmission and Reception

v) REFERENCES

1) Carl Laufer, *The Hobbyist's Guide to the RTL-SDR: Really Cheap Software Defined Radio*,4/e, Createspace Independent Publishing Platform,2015.
2) Neel Pandeya, *Implementation of a Simple FM Receiver in GNU Radio*, https://kb.ettus.com/
3) WH Tranter, KS Shanmugan, TS Rappaport, KL Kosbar, *Principles of Communication Systems Simulation with Wireless Applications*, Prentice Hall, 2004.
4) Michael Ossmann, *Software Defined Radio with HackRF*, YouTube Tutorial
5) MathuranathanViswanathan, *Digital Modulations using Python*, 2019.

vi) COURSE PLAN

<table>
<tr><th>Experiment No.</th><th>List of exercises/experiments</th><th>No. of hours</th></tr>
<tr><td></td><td>Part A
The students shall design and setup simple prototype circuits with the help of available ICs. They can observe waveforms produced by these circuits for standard ideal inputs.</td><td></td></tr>
<tr><td>I</td><td>FM generation and demodulation using PLL</td><td rowspan="2">6</td></tr>
<tr><td>II</td><td>Generation and Detection of BPSK</td></tr>
<tr><td></td><td>Part B
The experiments in Part B are software simulations and can be done usingGNU Octave or Python. Other software such as MATLAB/ SCILAB/LabVIEW can also be used.

The students shall write scripts to simulate components of communication systems. They shall plot various graphs that help to appreciate and compare performance.</td><td></td></tr>
<tr><td>I</td><td>Performance of Waveform Coding Using PCM
1. Generate a sinusoidal waveform with a DC offset so that it takes only positive amplitude value.
2. Sample and quantize the signal using an uniform quantizer with number of representation levels L. Vary L. Represent each value using decimal to binary encoder.
3. Compute the signal-to-noise ratio in dB.
4. Plot the SNR versus number of bits per symbol. Observe that the SNR increases linearly.</td><td>3</td></tr>
<tr><td>II</td><td>Pulse Shaping and Matched Filtering
1. Generate a string of message bits.
2. Use root raised cosine pulse $p(t)$ as the shaping pulse and generate the corresponding baseband signal with a fixed bit duration T_b. You may use roll-off factor as $\alpha = 0.4$.
3. Simulate transmission of baseband signal via an AWGN channel.
4. Apply matched filter with frequency response $P_r(f) = P*(f)$ to the received signal.
5. Sample the signal at mT_b and compare it against the message sequence.</td><td>3</td></tr>
</table>

III	**Eye Diagram** 1. Generate a string of message bits. 2. Use rasied cosine pulse *p(t)* as the shaping pulse and generate the corresponding baseband signal with a fixed bit duration T_b. You may use roll-off factor as $\alpha = 0.4$. 3. Use various roll off factors and plot the eye diagram in each case for the received signal. Make a comparison study among them.	**3**
IV	**Error Performance of BPSK** 1. Generate a string of message bits. 2. Encode using BPSK with energy per bit E_b and represent it using points in a signal-space. 3. Simulate transmission of the BPSK modulated signal via an AWGN channel with variance $N_0/2$. 4. Detect using an ML decoder and plot the probability of error as a function of SNR per bit E_b/N_0.	**3**
V	**Error Performance of QPSK** 1. Generate a string of message bits. 2. Encode using QPSK with energy per symbol E_s and represent it using points in a signal-space. 3. Simulate transmission of the QPSK modulated signal via an AWGN channel with variance $N_0/2$ in both I-channel and Q-channel. 4. Detect using an ML decoder and plot the probability of error as a function of SNR per bit $E_b/N_0$where $E_s = 2E_b$.	**3**
	Part C The students shall emulate communication systems with the help of software-defined-radio hardware and necessary control software. Use available blocks in GNU Radio to implement all the signal processing. These experiments will help students to appreciate better how theoretical concepts are translated into practice.	
I	**Familiarization with Software Defined Radio (Hardware and Control Software)** 1. Familiarize with an SDR hardware for reception and transmission of RF signal. 2. Familiarize how it can be interfaced with computers. 3. Familiarize with GNU Radio (or similar software's like Simulink/ Lab-View) that can be used to process the signals received through the SDR hardware. 4. Familiarize available blocks in GNU Radio. Study how signals can be generated and spectrum (or power spectral density) of	**6**

	signals can be analysed. Study how filtering can be performed.	
III	**FM Reception** 1. Receive digitized FM signal (for the clearest channel in the lab) using the SDR board. 2. Set up an LPF and FM receiver using GNU Radio. 3. Use appropriate sink in GNU Radio to display the spectrum of signal. 4. Resample the voice to make it suitable for playing on a computer speaker.	**6**
	Total hours	**33**

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**

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EC1U39A	MINIPROJECT	PWS	0	0	3	2	2020

i) COURSE OVERVIEW:

The objective of this course is to estimate the ability of the students in transforming the theoretical knowledge studied in to a working model of an electronic system. Is aims at enabling the students to gain experience in organisation and implementation of small projects. Also, focuses on the 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	Identify the functional aspects and design requirements of the project.	Apply
CO 2	Design the circuit/system to meet the requirements.	Apply
CO 3	Implement the prototype of the circuit/system.	Apply
CO 4	Practice professional ethics.	Apply
CO 5	Work effectively as an individual and as a member of a team in the development of technical projects..	Apply
CO 6	Communicate effectively, the project-related activities and findings.	Apply

iii) COURSE PLAN

Module	Contents	No. of hours
	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.	
	Total hours	**45**

iv) 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	**10 Marks**
Marks awarded based on guide's evaluation	**15 Marks**
Project Report	**10 Marks**
Evaluation by Committee	**40 Marks**

End Semester Examination Pattern:

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

PROGRAMME ELECTIVE -I

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EC1U31A	DIGITAL SYSTEM DESIGN	PEC	2	1	0	3	2020

i) PREREQUISITE: EC1U20B - Logic Circuit Design

ii) COURSE OVERVIEW

This course aims to design hazard free synchronous and asynchronous sequential circuits and implement the same in the appropriate hardware device

iii) COURSE OUTCOMES

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

Course Outcomes	Description	Level
CO 1	Analyze clocked synchronous sequential circuits	Understand
CO 2	Analyze asynchronous sequential circuits	Understand
CO 3	Design hazard free circuits	Apply
CO 4	Diagnose faults in digital circuits	Apply
CO 5	Summarize the architecture of FPGA and CPLDs	Understand

iv) SYLLABUS

Analysis of clocked Synchronous Sequential Networks (CSSN), Modelling of CSSN – State assignment and reduction, Design of CSSN, ASM Chart and its realization.

Analysis of Asynchronous Sequential Circuits (ASC), Flow table reduction- Races in ASC, State assignment problem and the transition table- Design of AS, Design of ALU.

Hazards – static and dynamic hazards – essential, Design of Hazard free circuits – Data synchronizers, Mixed operating mode asynchronous circuits, Practical issues- clock skew and jitter, Synchronous and asynchronous inputs – switch bouncing.

Fault table method – path sensitization method – Boolean difference method, Kohavi algorithm, Automatic test pattern generation – Built in Self Test (BIST).

CPLDs and FPGAs - Xilinx XC 9500 CPLD family, functional block diagram– input output block architecture - switch matrix, FPGAs – Xilinx XC 4000 FPGA family – configurable logic block - input output block, Programmable interconnect.

v) a) TEXT BOOKS

1) Donald G Givone, *Digital Principles & Design*, Tata McGraw Hill, 2017
2) John F Wakerly, *Digital Design | With an Introduction to the Verilog HDL, VHDL, and SystemVerilog*, 6th Edition, Pearson Education Delhi, 2018
3) John M Yarbrough, *Digital Logic Applications and Design*, Thomson Learning

b) REFERENCES

1) MironAbramovici, Melvin A. Breuer and Arthur D. Friedman, Digital Systems Testing and Testable Design, John Wiley & Sons Inc.
2) Morris Mano, M.D.Ciletti, Digital Design, 5th Edition, PHI
3) N. N. Biswas, Logic Design Theory, PHI
4) Richard E. Haskell, Darrin M. Hanna, Introduction to Digital Design Using Digilent
5) FPGA Boards, LBE Books- LLC
6) Samuel C. Lee, Digital Circuits and Logic Design, PHI
7) Z. Kohavi, Switching and Finite Automata Theory, 2nd ed., TMH, 2001

vi) COURSE PLAN

Module	Contents	No. of hours
I	**Clocked Synchronous Networks:** Analysis of clocked Synchronous Sequential Networks (CSSN), Modelling of CSSN – State assignment and reduction, Design of CSSN, ASM Chart and its realization.	9
II	**Asynchronous Sequential Circuits:** Analysis of Asynchronous Sequential Circuits (ASC), Flow table reduction- Races in ASC, State assignment problem and the transition table- Design of AS, Design of ALU.	10
III	**Hazards:** Hazards – static and dynamic hazards – essential, Design of Hazard free circuits – Data synchronizers, Mixed operating mode asynchronous circuits, Practical issues- clock skew and jitter, Synchronous and asynchronous inputs – switch bouncing	9
IV	**Faults:** Fault table method – path sensitization method – Boolean difference method, Kohavi algorithm, Automatic test pattern generation – Built in Self Test (BIST)	9
V	**CPLDs and FPGA:** CPLDs and FPGAs - Xilinx XC 9500 CPLD family, functional block diagram– input output block architecture - switch matrix, FPGAs – Xilinx XC 4000 FPGA family – configurable logic block - input output block, Programmable interconnect	8
	Total hours	**45**

i) 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
EC1U31B	POWER ELECTRONICS	PEC	3	0	0	3	2020

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

ii) COURSE OVERVIEW

Goal of this course is to provide an insight into the basic concepts of various power electronic circuits and their applications.

iii) COURSE OUTCOMES

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

Course Outcomes	Description	Level
CO 1	Describe the characteristics of important power semiconductor switches	Understand
CO 2	Apply the principle of drive circuits and snubber circuits for power semiconductor switches	Apply
CO 3	Explain the concept of diode bridge rectifiers and Controlled rectifiers	Understand
CO 4	Explain DC – DC Switch-Mode Converters	Understand
CO 5	Illustrate the principle of DC – AC Switch-Mode Inverter	Apply
CO 6	Explain the principle of power electronics for various applications	Understand

iv) SYLLABUS

Power diodes, Power BJT, Power MOSFET and IGBT - static and dynamic characteristics, SCR and GTO

BJT and MOSFET drive circuits, Snubber circuits, Three phase diode bridge rectifiers, Single phase and three phase controlled rectifiers.

Buck, Boost and Buck-boost DC-DC converters

Waveforms and expression of DC-DC converters for output voltage, voltage and current ripple under continuous conduction mode. (No derivation required)

Isolated converters: Flyback, Forward, Push Pull, Half bridge and Full bridge converters – Waveforms and governing equations (No derivation required)

Inverter topologies, Driven Inverters: Push-Pull, Half bridge and Full bridge configurations, Three phase inverter, Pulse width modulation

DC Motor Drives, Induction Motor Drives, Residential and Industrial applications.

v) a) TEXT BOOKS

1) Umanand L, *Power Electronics: Essentials & Applications*, Wiley India, 2015
2) Ned Mohan, Tore M Undeland, William P Robbins., *Power Electronics: Converters, Applications, and Design*, 3/e, Wiley India Pvt. Ltd, 2015

b) REFERENCES

1) Muhammad H. Rashid., *Power Electronics: Circuits, Devices, and Applications*, 4/e, Pearson Education India, 2014.
2) Daniel W. Hart, *Power Electronics*, McGraw Hill, 2011.

vi) COURSE PLAN

Module	Contents	No. of hours
I	Power diodes and Bipolar power transistors – structure, static and dynamic characteristics Power MOSFET and IGBT – structure, static and dynamic characteristics SCR and GTO – construction and characteristics	**9**
II	BJT and MOSFET driver circuits (*at least two circuits each) *Snubber circuits – ON and OFF snubbers Three phase diode bridge rectifiers – basic principles only *Single phase and three phase Controlled rectifiers (with R, RL & RLE loads) – basic principles only. (*Simulate the basic circuits)	**9**
III	Buck, Boost and Buck-Boost DC-DC converters Waveforms and expression of DC-DC converters for output voltage, voltage and current ripple under continuous conduction mode (No derivation required) Isolated converters: Flyback, Forward, Push Pull, Half bridge and Full bridge converters – Waveforms and governing equations (No derivation required) DC-AC Switch Mode Inverters	**10**
IV	Inverter topologies Driven Inverters: Push-Pull, Half bridge and Full bridge configurations Three phase inverter Sinusoidal and Space vector modulation PWM in three phase inverters	**9**
V	DC Motor Drives – Adjustable-speed DC drive Induction Motor Drives – Variable frequency PWM-VSI drives Residential and Industrial applications	**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 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
EC1U31C	DATA ANALYSIS	PEC	2	1	0	3	2020

i) COURSE OVERVIEW

Goal of this course is to set the foundation for students to develop new-age skills pertaining to analysis of large-scale data using modern tools.

ii) COURSE OUTCOMES

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

Course Outcomes	Description	Level
CO 1	Interpret the data by reading the data from spreadsheets and databases.	Understand
CO 2	Use pandas library to process data frames.	Apply
CO 3	Compute the principal components and perform cluster analysis on data frames.	Apply
CO 4	Apply Bayesian analysis on data frames.	Apply
CO 5	Apply machine learning in data analysis problems.	Apply
CO 6	Explain methods in high performance computing for data analysis.	Understand

iii) SYLLABUS

Numpy and Scipy Python modules, reading and processing spreadsheets and csv files with Python, data visualization with Matplotlib, three dimensional visualization using Mayavi module, reading data from sql and mongodb databases with Python, Reading and writing pandas dataframes, Reading and writing .txt, .csv, .pdf, .html and json files with pandas, Use of pivot tables. Pickling of data frames in Python, Dimensionality reduction with PCA , Hierarchical and K-means clustering, Bayesian analysis, Use of pymc3 module to compute the posterior probability. MAP Estimation, Kernel density estimation, Supervised and unsupervised learning, scikit-learn, Deep learning with convolutional neural networks, Use of Keras and Tensorflow. Machine learning with pytorch, Reading and writing images with openCV. Case study of character recognition with MNIST dataset.High performance computing for machine learning.

iv) a) TEXT BOOKS

1) Fabio Nelli, *Python Data Analytics: With Pandas, NumPy, and Matplotlib*,2/e, Apress, 2018
2) Wes McKinney, *Python for Data Analysis: Data Wrangling with Pandas, NumPy, and IPython,* 2/e, O'Reilly, 2017

b) REFERENCES

1) CyrilleRossant, *IPython Interactive Computing and Visualization Cookbook,* 2/e, PACKT Open Source Publishing, 2018
2) Francois Chollet, *Deep Learning with Python*, 1/e, Manning, 2017
3) Peters Morgan, *Data Analysis from Scratch with Python*, AI Sciences, 2018

v) COURSE PLAN

Module	Contents	No. of hours
I	**Overview of Data Analysis and Python:**Numpy and Scipy Python modules for data analysis. Reading and processing spreadsheets and csv files with Python using xlrd, xlwt and openpyxl. Data visualization with Matplotlib. Two dimensional charts and plots. Scatter plots with matplotlib. Three dimensional visualization using Mayavi module. Reading data from sql and mongodb databases with Python.	9
II	**Big Data Arrays with Pandas:** Familiarization of the python pandas. Reading and writing pandasdataframes. Reading rows and columns from pandasdataframe. Handling NaN values. Reading and writing .txt, .csv, .pdf, .html and json files with pandas. Merging, concatenating and grouping of data frames. Use of pivot tables. Pickling of data frames in Python.	8
III	**PCA and Cluster Analysis:** Singular value decomposition of a matrix/array. Eigen values and eigen vectors. Principal component analysis of a data frame. Scree plot. Dimensionality reduction with PCA. Loadings for principal components. Case study with Python. Cluster analysis. Hierarchical and K-means clustering. Interpretation of dendrograms.	8
IV	**Statistical Data Analysis:** Hypothesis testing. Bayesian analysis. Meaning of prior, posterior and likelihood functions. Use of pymc3 module to compute the posterior probability. MAP Estimation. Credible interval, conjugate distributions. Contingency table and chi square test. Kernel density estimation.	10
V	**Machine Learning:** Supervised and unsupervised learning. Use of scikit-learn. Regression using scikit-learn. Deep learning with convolutional neural networks. Structure of CNN. Use of Keras and	10

	Tensorflow. Machine learning with pytorch. Reading and writing images with openCV. Case study of character recognition with MNIST dataset. High performance computing for machine learning. Use of numba, jit and numexpr for faster Python code. Use of Ipython-parallel.	
	Total hours	**45**

Simulation Assignments

1. Download the iris data set and read into a pandas data frame. Extract the header and replace with a new header. Extract columns and rows. Extract pivot tables. Filter the data based on the labels. Store a pivot table as a pickle and retrieve it.

2. For the same data set, perform principal component analysis. Observe the scree plot. Identify the principal components. Obtain a low dimensional data, with only the principal components and compute the mean square error between the original data and the approximated one. Compute the loadings for the principal components.

3. For the same data, perform hierarchical and K-means clustering with Python codes. Obtain dendrograms in each case and appreciate the clusters.

4. Download the MNIST letter data set. Construct a CNN network with appropriate layers using Keras and Tensorflow. Train the CNN with the MNIST data set. Appreciate the selection and use of training, test and cross-validation data sets. Save the model and weights and use the model to identify letter images. You may use openCV for reading images.

5. Write a Python script to generate alphanumeric images (26 upper case, 26 lowercase and 10 numbers each 12 point in size) of say 16x16 dimension out of windows .ttf files. Create 62 folders each containing a data set of every alphanumeric character. Create a new CNN with Keras and Tensorflow. Create a cross validation data set by taking 10 images out of every 62 folder. Use 80% of the total data for training and 20% for testing the CNN. Use an HPCC like system to train the model and save the model and weight. Test this model to recognize letter images. You may use openCV for reading images.

6. Repeat assignment 4 using pytorch instead of Keras.

7. Repeat assignment 5 using pytorch instead of Keras.

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
EC1U31D	EMBEDDED SYSTEM	PEC	3	0	0	3	2020

i) PREREQUISITE:EC1U20B - Logic Circuit Design, EC1U20D - Analog Circuits, EC1U20F - Computer Architecture and Microcontrollers

ii) COURSE OVERVIEW

This course is designed to introduce embedded systems, various protocols used for communication between peripheral devices and processors, the ARM processor organization and programming, and the basic concepts of real time operating systems.

iii) 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 embedded systems and different phases in the embedded system design process/EDLC.	Understand
CO 2	Describe the different ways of communicating with I/O devices and standard I/O interfaces.	Understand
CO 3	Explain the ARM processor organization and to write programs in assembly and high-level languages for ARM processors.	Understand
CO 4	Explain the basics of real time operating systems and their use in embedded systems.	Understand
CO 5	Apply the knowledge for solving real-life problems with the help of an embedded system.	Apply

iv) SYLLABUS

Introduction to Embedded Systems- Complex Systems and Microprocessors- The Embedded System Design Process - Formalisms for System Design- Embedded product development cycle (EDLC).

Embedded system interfacing and peripherals- Serial Communication Standards and Devices- Serial Bus Protocols - Parallel communication standards- Memory- DMA- I/O Device- Interrupts.

ARM Processor fundamentals- ARM Processor architecture- ARM Assembly Language Programming- ARM Organization and Implementation, ARM Programming, The Thumb Instruction Set, The ARM memory interface, The Advanced Microcontroller Bus Architecture (AMBA).

Real Time Operating Systems - Kernel, types of operating systems, Tasks, process, threads, multiprocessing and multi-tasking, task scheduling, types, threads and process scheduling, task communication, task synchronization, device drivers, choosing an RTOS.

v) a) TEXT BOOKS

1) K.V. Shibu, *Introduction to Embedded Systems*, 2/e, McGraw Hill Education India, 2016.
2) Wayne Wolf, *Computers as Components: Principles of Embedded Computing System Design*, Morgan Kaufman Publishers - Elsevier 3ed, 2008.
3) Steve Furber, *ARM system-on-chip architecture*, Addison Wesley, Second Edition, 2000.
4) Raj Kamal,*Embedded Systems Architecture*, Programming and Design, TMH, 2003.

b) REFERENCES

1) David E. Simon, *An Embedded Software Primer*, Pearson Education Asia, First Indian Reprint 2000.

2) Steve Heath,*Embedded Systems Design*, Newnes – Elsevier 2ed, 2002.

3) Andrew N. Sloss, Dominic Symes, Chris Wright, *ARM System Developer's Guide Designing Optimizing System Software*, Morgan Kaufmann Publishers 2004

4) Frank Vahid and Tony Givargis,*Embedded Systems Design – A Unified Hardware / Software Introduction*, John Wiley, 2002.

5) Tammy Noergaard,*Embedded Systems Architecture, A Comprehensive Guide for Engineersand Programmers*,Newnes – Elsevier 2ed, 2013.

6) Iyer - *Embedded Real time Systems*, 1/e, McGraw Hill Education New Delhi, 2003

7) Lyla B. Das,*Embedded Systems: An Integrated Approach*, 1/e, 2012.

8) SarmadNaimi, Muhammad Ali Mazidi, SepehrNaimi,*The STM32F103 ArmMicrocontroller and Embedded Systems: Using Assembly and C*, MicroDigitalEd.,2020

9) Shujen Chen, Muhammad Ali Mazidi, EshraghGhaemi,*STM32 Arm Programmingfor Embedded Systems*, 2018.

vi) COURSE PLAN

Module	Contents	No. of hours
I	**Introduction to Embedded Systems** **Complex Systems and Microprocessors-** Embedding Computers, Characteristics of Embedded Computing Applications, Application of Microprocessors, Challenges in Embedded Computing System, Characteristics and quality attributes of an embedded system, Performance in Embedded Computing. **The Embedded System Design Process -**Requirements, Specification, Architecture Design, Designing Hardware and Software Components, System Integration, An embedded system design example. **Formalisms for System Design-** Structural Description, Behavioral Description. **Embedded product development cycle (EDLC) -**Different phases of EDLC, EDLC models	6
II	**Embedded system interfacing and peripherals** **Communication devices:** Serial Communication Standards and Devices - UART, HDLC and SPI. Serial Bus Protocols -I2C Bus, CAN Bus and USB Bus. Parallel communication standards -ISA, PCI and PCI-X Bus. **Memory:** Memory devices and systems – ROM-Flash, EEPROM, RAM-SRAM, DRAM, memory mapping and addresses, memory management unit–DMA, I/O Device,Interrupts-Interrupt sources, recognizing an interrupt, ISR – Device drivers for handling ISR, Interrupt latency.	9
III	**ARM Processor fundamentals** **ARM Processor architecture** The Acorn RISC Machine, Architectural inheritance, The ARM programmer's model, ARM development tools. **ARM Assembly Language Programming** Data processing instructions, Data transfer instructions, Control flow instructions, writing simple assembly language programs. **ARM Organization and Implementation** Three stage pipeline ARM organization, Five stage pipeline ARM organization, ARM instruction execution, ARM implementation, The ARM coprocessor interface.	8
IV	**ARM Programming** **Architectural Support for High-Level Languages** Abstraction in software design, Data types, Floating-point data types, The ARM floating-point architecture, Expressions, Conditional	10

	statements, Loops, Functions and procedures, Use of memory, Run-time environment. **The Thumb Instruction Set** The Thumb bit in the CPSR, The Thumb programmer's model, Thumb branch instructions, Thumb software interrupt instruction, Thumb data processing instructions, Thumb single register data transfer instructions, Thumb multiple register data transfer instructions, Thumb breakpoint instruction, Thumb implementation, Thumb applications. **Architectural Support for System Development** The ARM memory interface, The Advanced Microcontroller Bus Architecture (AMBA). **Programming** Assembly and C language programming applications of embedded systems.	
V	**Real Time Operating Systems** **Operating system basics** Kernel, types of operating systems. **Real time operating systems** Tasks, process, threads, multiprocessing and multi-tasking, task scheduling, types, threads and process scheduling, task communication, task synchronization, device drivers, choosing an RTOS.	**12**
	Total hours	**45**

Simulation Assignments

1. At least one assignment should be of programming (Both assembly and C languages) of embedded processor with simulation tools like Keil, Eclipse.
   Programming assignments can be the following
   (a) Print “HELLO WORLD” or any text
   (b) Data transfer, copy operations
   (c)Arithmetic operations
   (d) Sorting operations
   (e) input/output control
   (f) programs using functions
   (g) Interrupts and ISR
   (h) controller design
2. Another assignment should be an embedded system design mini project.
   Mini project can be done in the following areas.

   (a) Elevator controller design
   (b) Chocolate vending machine design
   (c) Industrial controller using sensors
   (d) IOT applications using sensors, communication devices and actuators

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
EC1U31E	DIGITAL IMAGE PROCESSING	PEC	2	1	0	3	2020

i) PREREQUISITE: EC1U30B – Introduction to Digital Signal Processing

ii) COURSE OVERVIEW

This course aims to develop the skills for methods of various transformation and analysis of image enhancement, image reconstruction, image compression, image segmentation and image representation.

iii) COURSE OUTCOMES

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

Course Outcomes	Description	Level
CO 1	Explain the various basic concepts of digital image processing	Understand
CO 2	Apply the concepts to analyse a 2D discrete signal in time and frequency domain	Apply
CO 3	Explain two-dimensional sampling and quantization	Understand
CO 4	Apply the concepts to enhance and restore digital images using various filtering techniques	Apply
CO 5	Explain various image compression techniques	Understand

iv) SYLLABUS

Digital Image Fundamentals: Image representation, basic relationship between pixels, elements of DIP system, elements of visual perception-simple image formation model. Vidicon and Digital Camera working principles Brightness, contrast, hue, saturation, mach band effect Colour image fundamentals-RGB, CMY, HIS models, 2D sampling, quantization Review of matrix theory: row and column ordering- Toeplitz, Circulant and block matrix 2D Image transforms: DFT, its properties, Walsh transform, Hadamard transform, Haar transform, DCT, KL transform and Singular Value Decomposition. Image Compression: Need for compression, Basics of lossless compression – bit plane coding, run length encoding and predictive coding, Basics of lossy compression – uniform and non-uniform quantization techniques used in image compression, Concept of transform coding, JPEG Image compression standard

Image Enhancement: Spatial domain methods: point processing- intensity transformations, histogram processing, image subtraction, image averaging. Spatial filtering- smoothing

filters, sharpening filters. Frequency domain methods: low pass filtering, high pass filtering, homomorphic filter
Image Restoration: Degradation model, Unconstraint restoration- Lagrange multiplier and constraint restoration Inverse filtering- removal of blur caused by uniform linear motion, Weiner filtering, Geometric transformations-spatial transformations
Image segmentation: Classification of Image segmentation techniques, region approach, clustering techniques. Segmentation based on thresholding, edge based segmentation. Classification of edges, edge detection, Hough transform, active contour.

v) a) TEXT BOOKS

1) Gonzalez Rafel C, *Digital Image Processing*, Pearson Education, 2009
2) S Jayaraman, S Esakkirajan, T Veerakumar, *Digital image processing*, Tata McGraw Hill, 2015

b) REFERENCES

1) Jain Anil K, *Fundamentals of digital image processing*, PHI 1988
2) Kenneth R Castleman, *Digital image processing*, 2/e, Pearson Education, 2003
3) Pratt William K, *Digital Image Processing*, 4/e, John Wiley, 2007

vi) COURSE PLAN

Module	**Contents**	**No. of hours**
I	Digital image fundamentals: Image representation, basic relationship between pixels, elements of DIP system, elements of visual perception, simple image formation model. Vidicon and Digital Camera working principles, Brightness, contrast, hue, saturation, mach band effect. Colour image fundamentals-RGB, CMY, HIS models, 2D sampling, quantization.	**9**
II	Review of matrix theory - Row and column ordering- Toeplitz, Circulant and block matrix. 2D Image transforms: DFT, its properties, Walsh transform, Hadamard transform, Haar transform, DCT, KL transform and Singular Value Decomposition. Image Compression: Need for compression, Basics of lossless compression – bit plane coding, run length encoding and predictive coding, Basics of lossy compression – uniform and non-uniform quantization techniques used in image compression, Concept of transform coding, JPEG Image compression standard	**9**
III	Image enhancement - Spatial domain methods: point processing-	**9**

	intensity transformations, histogram processing, image subtraction, image averaging. Spatial filtering- smoothing filters, sharpening filters Frequency domain methods: low pass filtering, high pass filtering, homomorphic filter	
IV	Image Restoration: Degradation model, Unconstraint restoration- Lagrange multiplier and constraint restoration Inverse filtering- removal of blur caused by uniform linear motion, Weiner filtering Geometric transformations-spatial transformations	**9**
V	Image segmentation - Classification of Image segmentation techniques, region approach, clustering techniques Segmentation based on Thresholding, edge based segmentation Classification of edges, edge detection, Hough transform, active contour	**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
EC1U31F	INTRODUCTION TO MEMS	PEC	2	1	0	3	2020

i) PREREQUISITE: ES0U10D Basics of Electrical and Electronics Engineering, ES0U10A Engineering Mechanics

ii) COURSE OVERVIEW

This course introduces students to the rapidly emerging, multi-disciplinary, and exciting field of Micro Electro Mechanical Systems.

iii) COURSE OUTCOMES

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

Course Outcomes	Description	Level
CO 1	Describe the working principles of micro sensors and actuators.	Understand
CO 2	Explain the commonly used mechanical structures in MEMS	Understand
CO 3	Explain the application of scaling laws in the design of micro systems.	Understand
CO 4	Describe the typical materials used for fabrication of micro systems.	Understand
CO 5	Explain the principles of standard micro fabrication techniques.	Understand
CO 6	Describe the challenges in the design and fabrication of Micro systems	Understand

iv) SYLLABUS

MEMS and Microsystems: Applications – multidisciplinary nature of MEMS – principles and examples of Micro sensors and micro actuators – micro accelerometer –comb drives - Micro grippers – micro motors, micro valves, micro pumps, Shape Memory Alloys.

Actuation and Sensing techniques: Thermal sensors and actuators, Electrostatic sensors and actuators, Piezoelectric sensors and actuators, magnetic actuators.

Review of Mechanical concepts: Stress, Strain, Modulus of Elasticity, yield strength, ultimate strength – General stress strain relations – compliance matrix. Overview of commonly used mechanical structures in MEMS - Beams, Cantilevers, Plates, Diaphragms – Typical applicationsFlexural beams: Types of Beams, longitudinal strain under pure bending – Deflection of beams – Spring constant of cantilever – Intrinsic stresses.
Scaling laws in miniaturization - scaling in geometry, scaling in rigid body dynamics, Trimmer force scaling vector, scaling in electrostatic and electromagnetic forces, scaling in

electricity and fluidic dynamics, scaling in heat conducting and heat convection. Materials for MEMS – Silicon – Silicon compounds – Silicon Nitride, Silicon Dioxide, Silicon carbide, Poly Silicon, GaAs , Silicon Piezo resistors. Polymers in MEMS – SU-8, PMMA, PDMS, Langmuir – Blodgett Films.

Micro System fabrication – Photolithography – Ion implantation- Diffusion – Oxidation – Chemical vapour deposition – Etching Overview of Micro manufacturing – Bulk micro manufacturing, Surface micro machining , LIGA process –Microstereo lithography

Micro system Packaging: general considerations in packaging design – Levels of Micro system packaging. Bonding techniques for MEMS: Surface bonding, Anodic bonding, Silicon - on - Insulator, wire bonding, Sealing – Assembly of micro systems. Overview of MEMS areas : RF MEMS, BioMEMS, MOEMS, NEMS.

v) a) TEXT BOOKS

1. Chang Liu, *Foundations of MEMS*, Pearson, 2012
2. Tai-Ran Hsu, *MEMS and Microsystems Design and Manufacture*, TMH, 2002

b) REFERENCES

1. Chang C Y and Sze S. M., *VLSI Technology*, McGraw-Hill, New York, 2000
2. Julian W Gardner, *Microsensors: Principles and Applications*, John Wiley & Sons, 1994
3. Mark Madou, *Fundamentals of Micro fabrication*, CRC Press, New York, 1997
4. Stephen D. Senturia, *Microsystem design*, Springer (India), 2006.
5. Thomas B. Jones, *Electromechanics and MEMS*, Cambridge University Press, 2001
6. Gregory T.A. Kovacs, *Micromachined Transducers Sourcebook*, McGraw Hill, 1998

vi) COURSE PLAN

Module	Contents	No. of hours
I	MEMS and Microsystems: Applications – multidisciplinary nature of MEMS – principles and examples of Micro sensors and micro actuators – micro accelerometer –comb drives - Micro grippers – micro motors, micro valves, micro pumps, Shape Memory Alloys. Actuation and Sensing techniques: Thermal sensors and actuators, Electrostatic sensors and actuators, Piezoelectric sensors and actuators, magnetic actuators.	10
II	Review of Mechanical concepts: Stress, Strain, Modulus of Elasticity, yield strength, ultimate strength – General stress strain relations – compliance matrix. Overview of commonly used mechanical structures in MEMS - Beams, Cantilevers, Plates, Diaphragms – Typical applications. Flexural beams: Types of Beams, longitudinal strain under pure bending – Deflection of beams – Spring constant of cantilever – Intrinsic stresses.	10

III	Scaling laws in miniaturization - scaling in geometry, scaling in rigid body dynamics, Trimmer force scaling vector, scaling in electrostatic and electromagnetic forces, scaling in electricity and fluidic dynamics, scaling in heat conducting and heat convection. Materials for MEMS – Silicon – Silicon compounds – Silicon Nitride, Silicon Dioxide, Silicon carbide, Poly Silicon, GaAs , Silicon Piezo resistors. Polymers in MEMS – SU-8, PMMA, PDMS, Langmuir – Blodgett Films.	**10**
IV	Micro System fabrication – Photolithography – Ion implantation-Diffusion – Oxidation – Chemical vapour deposition – Etching Overview of Micro manufacturing – Bulk micro manufacturing, Surface micro machining , LIGA process –Microstereo lithography	**8**
V	Micro system Packaging: general considerations in packaging design – Levels of Micro system packaging. Bonding techniques for MEMS: Surface bonding, Anodic bonding,Silicon - on - Insulator, wire bonding, Sealing – Assembly of micro systems. Overview of MEMS areas : RF MEMS, BioMEMS, MOEMS, NEMS	**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 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
EC1U31G	QUANTUM COMPUTING	PEC	2	1	0	3	2020

i) PREREQUISITE: MA0U10A - Linear Algebra and Calculus

ii) COURSE OVERVIEW

Goal of this course is to have an understanding of the fundamentals of quantum computing, working of quantum computer and algorithms, quantum error corrections, designed for bigger quantum computers which are yet to be developed.

iii) COURSE OUTCOMES

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

Course Outcomes	Description	Level
CO 1	Explain the basic constructs in linear algebra needed to build the concepts of quantum computing	Understand
CO 2	Illustrate/ demonstrate quantum measurement and quantum mechanics for computation	Understand
CO 3	Identify quantum gates and build quantum circuit model in which most of the quantum algorithms are designed	Apply
CO 4	Analyse and design quantum algorithms over classical counterparts	Analyze

iv) SYLLABUS

Basics of Linear Algebra - History and Overview of Quantum Computation and Quantum Information, Linear Algebra Basics.

Basics of Quantum Mechanics - State Space Representation - Bloch Sphere, State Evolution – Unitary transformation, Quantum measurement – Projective measurements, Composite systems - Superposition.

Quantum Gates and Circuits - Quantum gates – Hadamard gate, NOT gate, controlled-NOT gate, Toffoli gate, Realisation of classical gates with quantum gates – Z Gate

Quantum Measurement - Basic principle of quantum measurement - Principle of deferred measurement, Principle of implicit measurement

Algorithms - Quantum Fourier Transform (QFT) – Quantum circuit for QFT, Quantum phase estimation, Modular exponentiation, Order finding and factorization

v) a) TEXT BOOKS

1) M. A. Nielsen and I. L. Chuang, *Quantum Computation and Quantum Information*,
   a. 7/e, Cambridge University Press, 2010
2) J. Gruska, *Quantum Computing*,12/e, McGraw Hill, 1999
3) G. Strang, *Linear algebra and its applications*, 4/e, Thomson, 2006

b) REFERENCES

1) P. Kaye, R. Laflamme, and M. Mosca, *An Introduction to Quantum Computing*, 11/e, Oxford, 2007
2) Eleanor G. Rieffel, Wolfgang H. Polak, *Quantum Computing: A Gentle Introduction*, 3/e, MIT Press, 2011
3) NosonYanofsky and MircoMannucci, *Quantum Computing for Computer Scientists*, 4/e, Cambridge University Press, 2008
4) Abhijith, J., Adedoyin, Adetokunbo, Ambrosiano, John (and 30 others), *Quantum*
5) *Algorithm Implementations for Beginners*, 1/e, 2020

vi) COURSE PLAN

Module	Contents	No. of hours
I	**Basics of Linear Algebra** History and Overview of Quantum Computation and Quantum Information, Linear Algebra Basics, Linear Operators and matrices, The Pauli matrices, Inner Products, Eigen values and Eigen vectors, Hermitian operators and Adjoints, Spectral theorem, Tensor Products.	9
II	**Basics of Quantum Mechanics** State Space Representation - Bloch Sphere, State Evolution – Unitary transformation, Quantum measurement – Projective measurements, Composite systems - Superposition.	9
III	**Quantum Gates and Circuits** Quantum gates – Hadamard gate, NOT gate, controlled-NOT gate, Toffoli gate, Realisation of classical gates with quantum gates – Z Gate, Fredkein Gate, Pauli Matrices – Controlled Swap and Controlled U- operations, Circuit Identities	9
IV	**Quantum Measurement** Basic principle of quantum measurement - Principle of deferred measurement, Principle of implicit measurement, Gates with projective measurements, Universal quantum gates, Universality of two level unitary gates.	9

V	**Algorithms** Quantum Fourier Transform (QFT) – Quantum circuit for QFT, Quantum phase estimation, Modular exponentiation, Order finding and factorisation – Deutsch's algorithm.	**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.

MINORS

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EC0M30D	VLSI Circuits	VAC (MINOR)	3	1	0	4	2020

i) PREREQUISITE: EC0M20A Electronic Circuits

ii) COURSE OVERVIEW

Goal of this course is to impart the knowledge about the fundamentals of Digital Systems,MOSFETs, basic VLSI circuits and Application Specific Integrated Circuits.

iii) COURSE OUTCOMES

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

Course Outcomes	Description	Level
CO 1	Explain the working of various functional building blocks used in digital system design.	Understand
CO 2	Explain Structure and Working of MOSFETS and basic VLSI circuits using MOSFET.	Understand
CO 3	Explain the circuit technique used to implement dynamic logic and storage cells.	Understand
CO 4	Explain the application specific integrated circuit design flow and design approached.	Understand
CO 5	Explain the programmable logic cells, programming technologies, different type of i/o cells and different timing constraints in ASIC design.	Understand

iv) SYLLABUS

Basic logic gates, binary adder, subtractor, magnitude comparator, decoders, encoders, multiplexers, simple examples for combinational circuits (discuss with respective truth tables) Sequential circuits, Latched and flip-flops, clocked sequential circuits ,registers, shift registers, counters (analysis not required).
Structure and working principle of MOSFETS, VI characteristics, current equations(derivations not required),NMOS and CMOS inverter circuits, static characteristics and comparison, implementation of CMOS logic gates, stick diagram representation, Layout Design and Design rules- Lambda rules and micron rules (Definitions only).
Dynamic Logic Design-Pre charge- Evaluate logic, Domino Logic, NP domino logic. Read Only Memory-4x4 MOS ROM Cell Arrays (NOR) Random Access Memory –SRAM-Six transistor CMOS SRAM cell, DRAM –Three transistor and One transistor Dynamic Memory Cell.

Introduction Moores law .ASIC design, Full custom ASICs, Standard cell based ASICs, Gate array based ASICs, SoCs, FPGA devices, ASIC and FPGA Design flows Top-Down and Bottom-Up design methodologies. Logical and Physical design. Speed power and area considerations in VLSI design.
FPGA Architecture :Programmable logic cells: multiplexer based logic cells(ACT1), lookup table based logic implementation(XC3000 CLB), programmable array based logic implementation (Altera MAX).
ASIC programming technologies: antifuse, SRAM, EPROM, EEPROM Different types of I/O cells used in programmable ASICs
Timing constraints in ASIC design: setup time, hold time, propagation delay, clock to output delay, critical path (concept only).

v) a) TEXT BOOKS

1. M. Morris Mano, *Digital Design*, 3/e, Prentice Hall of India, 2002.
2. M. J. S. Smith, *Application Specific Integrated Circuits*, Pearson Education,2007.
3. Jan M. Rabaey, *Digital Integrated Circuits- A Design Perspective*, Second Edition, Prentice Hall, 2005.

b) REFERENCES

1. Thomas Floyd, *Digital Fundamentals*, 11/e, Pearson Publication, 2015.
2. Neil H.E. Weste, Kamran Eshraghian, *Principles of CMOS VLSI Design - A Systems Perspective*, Second Edition. Pearson Publication, 2005.
3. Sung –Mo Kang & Yusuf Leblebici, *CMOS Digital Integrated Circuits - Analysis & Design*, McGraw-Hill, Third Ed., 2003.

vi) COURSE PLAN

Module	Contents	No. of hours
I	Basic Building Blocks in Digital Systems: Basic logic gates, binary adder, subtractor, magnitude comparator, decoders, encoders, multiplexers, simple examples for combinational circuits (discuss with respective truth tables)Sequential circuits, Latched and flip-flops, clocked sequential circuits ,registers, shift registers, counters (analysis not required).	12
II	MOSFET Fundamentals and basic VLSI circuits: Structure and working principle of MOSFETS, VI characteristics, current equations(derivations not required),NMOS and CMOS inverter circuits, static characteristics and comparison, implementation of CMOS logic gates, stick diagram representation, Layout Design and Design rules- Lambda rules and micron rules (Definitions only).	12
III	Dynamic logic Design and Storage Cells: Dynamic Logic Design-Pre charge- Evaluate logic, Domino Logic, NP domino logic. Read Only Memory-4x4 MOS ROM Cell Arrays (NOR) Random Access Memory	12

	–SRAM-Six transistor CMOS SRAM cell, DRAM –Three transistor and One transistor Dynamic Memory Cell.	
IV	VLSI Design Methodologies: Introduction Moore s law .ASIC design, Full custom ASICs, Standard cell based ASICs, Gate array based ASICs, SoCs, FPGA devices, ASIC and FPGA Design flows Top-Down and Bottom-Up design methodologies. Logical and Physical design. Speed power and area considerations in VLSI design.	**12**
V	FPGA Architecture:Programmable logic cells: multiplexer based logic cells(ACT1), lookup table based logic implementation(XC3000 CLB), programmable array based logic implementation (Altera MAX). ASIC programming technologies: antifuse, SRAM, EPROM, EEPROM Different types of I/O cells used in programmable ASICs. Timing constraints in ASIC design: setup time, hold time, propagation delay, clock to output delay, critical path (concept only).	**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
EC0M30E	DATA NETWORKS	VAC (MINOR)	4	0	0	4	2020

i) COURSE OVERVIEW

Goal of this course is to provide an insight into the basic concepts of data communication and networking.

ii) COURSE OUTCOMES

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

Course Outcomes	Description	Level
CO 1	Explain the concepts of data communication, structure of networks and compare OSI and TCP/IP networking models.	Understand
CO 2	Explain the responsibilities of the data link layer including framing, addressing, flow control, error control and media access control.	Understand
CO 3	Illustrate the functions and protocols of network layer, transport layer and application layer in inter-networking.	Apply
CO 4	Discuss congestion control techniques and Quality of Service requirements for a network.	Understand

iii) SYLLABUS

Data Communications- Components, Network criteria, Physical Structures, Switching, Categories of Networks, Interconnection of Networks, OSI Model, TCP/IP Protocol Suite, Physical Layer, Data Link Layer – Framing, Flow and Error Control, Error Correction and Detection, Networking Devices. Multiple Access Protocols, Ethernet, Wireless LANs, IPV4, IPV6, ARP, RARP, BOOTP, DHCP, Routing protocols, Transport Layer, Congestion Control & Quality of Service, Application Layer.

iv) a) TEXT BOOKS

1) Behrouz A Forouzan, *Data Communication and Networking*, 5/e, Tata McGraw Hill, 2012

b) REFERENCES

1) Andrew S. Tanenbaum, *Computer Networks*, 4/e, PHI (Prentice Hall India), 2002
2) William Stallings, *Computer Networking with Internet Protocols and technology*, Prentice-Hall, 2004

3) Fred Halsall, *Computer Networking and the Internet*, 5/e, Pearson Education, 2005.
4) Larry L Peterson and Bruce S Davie, *Computer Networks – A Systems Approach*, 5/e, Morgan Kaufmann, 2011
5) James F. Kurose, Keith W. Ross, *Computer Networking: A Top-Down Approach*, 6/e, Pearson Education, 2013

v) COURSE PLAN

Module	Contents	No. of hours
I	Data Communications- Components, Data representation, Data flow- Simplex, Half Duplex, Full Duplex Modes, Networks- Network criteria, Physical Structures- Point to Point Connection, Multipoint Connection, Physical Topology, Switching- Circuit Switched Networks and Datagram Networks, Categories of Networks, Interconnection of Networks, Protocols, Network models – OSI Model, Layers in the OSI Model, TCP/IP Protocol Suite.	12
II	**Physical Layer and Data Link Layer:** Guided Media and Unguided Transmission Media, Data Link Layer – Framing, Flow and Error Control - Stop and Wait Protocol, Sliding Window Protocol, Error Correction and Detection - Types of Errors, Redundancy, Detection vs Correction, Forward Error Correction vs Retransmission, Check Sum, Networking Devices- Hubs, Bridges, Switches.	12
III	**Multiple Access, Ethernet, Wireless LANs**: Multiple Access Protocols – Random Access, ALOHA, CSMA, CSMA/CD, CSMA/CA, Controlled Access, Channelization -FDMA, TDMA, CDMA, Ethernet - IEEE standards, Wireless LANs- IEEE 802.11, Bluetooth.	11
IV	**Network Layer**: Internetworking- Need for Network Layer, Internet as a Datagram Network, Internet as a Connectionless Network, Network Layer Logical Addressing – IPv4 and IPv6 Addressing only, Address Mapping -ARP, RARP, BOOTP, DHCP. Delivery, Forwarding, Routing Protocols - Distance Vector routing.	12
V	**Transport Layer, Application layer**: Transport layer – UDP, TCP, Congestion, Congestion Control, Quality of Service, Techniques to Improve QoS. Application Layer- FTP, Telnet, DNS, Electronic Mail.	13
	Total hours	**60**

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
EC0M30F	TOPICS IN COMPUTER VISION	VAC (MINOR)	3	1	0	4	2020

i) COURSE OVERVIEW

This course aims to develop the knowledge of various methods, algorithms and applications of computer vision

ii) COURSE OUTCOMES

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

Course Outcomes	Description	Level
CO 1	Apply basic point operators and 2D transforms for digital filtering operations	Apply
CO 2	Apply various algorithms for morphological operations and binary shape analysis.	Apply
CO 3	Describe the theoretical aspects of image formation models, projections and transformations in a 3D vision system.	Understand
CO 4	Explain different feature detection methods and optical flow algorithms to locate objects in-vision system.	Understand
CO 5	Explain the motion analysis of objects in a given scene using appropriate computer vision algorithms for real time applications.	Understand

iii) SYLLABUS

Review of image processing techniques: Filtering, Point operators-Histogram Based operators, neighbourhood operators, Thresholding - linear filtering – development of filtering masks - 2D Fourier transforms – filtering in frequency domain, Homomorphic filtering
Mathematical Operators: Binary shape analysis: Basics of Morphological operations, structuring element, Erosion, Dilation, Opening and Closing, Hit-or-Miss Transform, Connectedness, object labelling and counting , Boundary descriptors – Chain codes.

Camera models: Monocular and binocular imaging system, Orthographic and Perspective Projection, Image formation, geometric transformations, Camera Models (Basic idea only), 3D-Imaging system-Stereo Vision.

Feature Detection: Edge detection – edges, lines, active contours, Split and merge, Mean shift and mode finding, Normalized cuts, Graph cuts, energy-based and Canny’s methods.

Corner detection, Harris corner detection algorithm, Line and curve detection, Hough transform SIFT operators, Shape from X, Shape Matching, Structure from motion.

Motion Analysis- Regularization theory, Optical Flow: brightness constancy equation, aperture problem, Horn-Shunck method, Lucas-Kanade method. (Analysis not required) Object Detection and Object classification: SVM, Linear discriminant analysis, Bayes rule, ML. Face detection, Face Recognition, Eigen faces, 3D face models Applications of Computer Vision: Context and scene understanding, Real Time applications: Locating road way and road marking, locating road signs and pedestrians.

iv) a) TEXT BOOKS

3) E. R .Davies, *Computer and Machine Vision -Theory Algorithm and Practicalities*, 4/e, Academic Press, 2012
4) Richard Szeliski, *Computer Vision: Algorithms and Applications*, ISBN 978-1- 84882-935-0, Springer 2011.
5) David Forsyth and Jean Ponce, *Computer Vision: A Modern Approach*,2/e, Pearson India, 2012

c) REFERENCES

1) Goodfellow, Bengio, and Courville, *Deep Learning*, MIT Press, 2016
2) Daniel LelisBaggio, KhvedcheniaIevgen, ShervinEmam, David MillanEscriva, NaureenMahmoo, Jason Saragi, Roy Shilkrot, *Mastering Open CV 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) Schalkoff, *Digital Image Processing and Computer Vision*, John Wiley, 2004.

v) COURSE PLAN

Module	Contents	No. of hours
1	Introduction, Review of image processing techniques: filtering, Point operators- Histogram, neighbourhood operators, thresholding– development of filtering masks, 2D Fourier transforms – filtering in frequency domain, homomorphic filtering	12
2	Mathematical Operators: Basics of Morphological operations, structuring element, Binary shape analysis: Erosion, Dilation, Opening and Closing, Hit-or-Miss Transform, Connectedness, object labelling and counting, Boundary descriptors –Chain Codes	12
3	Camera models - Monocular and binocular imaging system, Orthographic & Perspective Projection, Image formation, geometric transformations, camera Models(Basic idea only), 3D-Imaging system- Stereo Vision	10

4	Feature Detection: Edge detection – edges, lines, active contours, Split and merge, Mean shift and mode finding, Normalized cuts, Graph cuts, energy-based and Canny's methods. Corner detection, Harris corner detection algorithm, Line and curve detection, Hough transform, SIFT operators, Shape from X, Shape Matching	12
5	Motion Analysis - Motion Analysis- Regularization theory, Optical Flow: brightness constancy equation, aperture problem, Horn-Shunck method, Lucas-Kanade method (Analysis not required) Object Detection and Object classification: SVM, Linear discriminant analysis, Bayes rule, maximum likelihood, Face detection, Face Recognition, Eigen faces, 3D face models Applications of Computer Vision: Context and scene understanding, Real Time applications: Locating road way and road marking, locating road signs and pedestrians	14
	Total hours	**60**

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.

HONOURS

Course Code	Course Name	Category	L	T	P	Credit	Year of Introduction
EC1H30D	ELECTRONIC DESIGN AUTOMATION	VAC (HONOUR)	4	0	0	4	2020

i) COURSE OVERVIEW

Goal of this course is to introduce principles behind advanced methods in automation of electronic design.

ii) COURSE OUTCOMES

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

Course Outcomes	Description	Level
CO 1	Determine various graph solutions using search algorithms and shortest path algorithms.	Apply
CO 2	Describe VLSI Design Flow and Design Styles and apply partitioning algorithms on graphs representing netlist.	Understand
CO 3	Illustrate Design Layout Rules and apply different algorithms for layout compaction.	Apply
CO 4	Determine solutions for placement and floorplan problems using various algorithms.	Apply
CO 5	Explain different algorithms to solve routing problems.	Understand

iii) SYLLABUS

Graph Terminology: Basic graph theory terminology, Data structures for representation of

Graphs Search Algorithms: Breadth First Search, Depth First Search, Topological Sort.

Shortest Path Algorithms: Dijkstra's Shortest-Path Algorithm for single pair shortest path, Floyd Warshall Algorithm for all pair shortest path.

Design Automation: VLSI Design Flow, VLSI Design Styles.

Partitioning: Levels of Partitioning, Parameters for Partitioning, Classification of Partitioning Algorithms, Kernighan-Lin Algorithm, Fiduccia-Mattheyses Algorithm, Simulated Annealing.

Layout: Layout Layers and Design Rules, Physical Design Optimizations.

Compaction: Applications of Compaction, Informal Problem Formulation, Graph Theoretical Formulation, Maximum Distance Constraints, Longest Path algorithm for

DAG,Longest path in graph with cycles, Liao-Wong Algorithm, Bellman-Ford Algorithm.

Placement: Optimization Objectives, Wirelength Estimation, Weighted Wirelength, Maximum Cut Size, Wire Density.

Placement Algorithms: Quadratic Placement.

Floorplanning: Optimization Objectives, Slicing Floorplan, Non-Slicing Floorplan.

Floorplan Representations: Constraint Graph, Sequence Pair.

Floorplan Algorithms: Minimum Area Algorithm.

Global Routing: Terminology and Definitions, Optimization Goals, Representation of Routing Regions.

Maze Routing Algorithms: Lee's Algorithm, Hadlock Algorithm.

Detailed Routing: Horizontal and Vertical Constraint Graph.

Channel Routing Algorithms: Left-Edge algorithm.

iv) a) TEXT BOOKS

1. Jin Hu, Jens Lienig, Igor L. Markov, Andrew B. Kahng, *VLSI Physical Design: From Graph Partitioning to Timing Closure*, Springer, 2011
2. Gerez, Sabih H., *Algorithms for VLSI Design Automation*, John Wiley & Sons, 2006
3. Sherwani, Naveed A., *Algorithms for VLSI Physical Design Automation*, Kluwer Academic Publishers, 1999

d) REFERENCES

1. Sadiq M. Sait and H. Youssef, *VLSI Physical Design Automation: Theory and Practice*, World Scientific, 1999
2. Cormen, Thomas H., Charles E. Leiserson, and Ronald L. Rivest., *Introduction to Algorithms*, 3rd edition, The MIT Press, 2009

v) COURSE PLAN

Module	Contents	No. of hours
I	**Graph Terminology, Search Algorithms and Shortest Path Algorithms:** **Graph Terminology:** Basic graph theory terminology, Data structures for representation of Graphs. **Graphs Search Algorithms:** Breadth First Search, Depth First Search,	12

	Topological Sort **Shortest Path Algorithms:** Dijkstra's Shortest-Path Algorithm for single pair shortest path, Floyd Warshall Algorithm for all pair shortest path	
II	**Design Automation and Partitioning Algorithms:** **Design Automation:** VLSI Design Flow, VLSI Design Styles **Partitioning:** Levels of Partitioning, Parameters for Partitioning, Classification of Partitioning Algorithms, Kernighan-Lin Algorithm, Fiduccia-Mattheyses Algorithm, Simulated Annealing	**12**
III	**Layout Compaction:** **Layout:** Layout Layers and Design Rules, Physical Design Optimizations **Compaction:** Applications of Compaction, Informal Problem Formulation, Graph Theoretical Formulation, Maximum Distance Constraints, Longest Path algorithm for DAG,Longest path in graph with cycles, Liao-Wong Algorithm, Bellman-Ford Algorithm.	**12**
IV	**Placement and Floor planning:** **Placement:** Optimization Objectives, Wirelength Estimation, Weighted Wirelength, Maximum Cut Size, Wire Density **Placement Algorithms:** Quadratic Placement **Floor planning:** Optimization Objectives, Slicing Floorplan, Non-Slicing Floorplan **Floorplan Representations:** Constraint Graph, Sequence Pair **Floorplan Algorithms:** Minimum Area Algorithm	**12**
V	**Global Routing and Detailed Routing:** **Global Routing**: Terminology and Definitions, Optimization Goals, Representation of Routing Regions **Maze Routing Algorithms:** Lee's Algorithm, Hadlock Algorithm **Detailed Routing:** Horizontal and Vertical Constraint Graph **Channel Routing Algorithms:** Left-Edge algorithm	**12**
	Total hours	**60**

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
EC1H30E	MIMO & MULTIUSER COMMUNICATION SYSTEMS	VAC(HONOUR)	4	0	0	4	2020

i) **PREREQUISITE:** MA0U20C - Probability and Random Process, EC1U30C - Analog and Digital Communication.

ii) **COURSE OVERVIEW**

MIMO systems are rising attention of the academic community and industry because of their potential to increase to capacity and diversity gain proportionally with the number of antennas. OFDM is a promising solution to mitigate the effect of inter symbol interference (ISI) and multipath fading. MIMO OFDM is an attractive air interface solution for multiuser communication and effectively deployed in wireless local area networks, fifth Generation (5G) wireless cellular standards.

iii) **COURSE OUTCOMES**

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

Course Outcomes	Description	Level
CO 1	Describe digital communication over multipath channels.	Understand
CO 2	Analyse the performance of multiuser communication techniques over generalized fading channel.	Apply
CO 3	Describe the concept of MIMO systems and determine the capacity of MIMO channel	Apply
CO 4	Explain OFDM and associated timing and frequency synchronization in MIMO receiver	Understand
CO 5	Explain the theory of MIMO multiuser communication systems.	Understand

iv) **SYLLABUS**

Digital Communication over Fading Multipath Channels Characterization of fading multipath channels, Statistical model for fading channels (Rayleigh and Rice distribution), Relation between channel correlation and Power spectral density, Signal characteristics on the choice of channel model (frequency selective and frequency nonselective fading), Frequency nonselective slowly fading channel, Frequency selective slowly fading channel, Fast fading, Rake receiver.

Multiuser Communications Types of multiple access techniques, Capacity of multiple access methods (Inference only). Single user and multiuser detection, CDMA signal and channel model, CDMA optimum receiver (Synchronous transmission, Asynchronous transmission), Suboptimum detectors (Single user detector and Decorrelation receiver). Practical applications of multiple access techniques.

MIMO System Signal and channel model for SISO, SIMO, MISO and MIMO, Capacity of frequency flat deterministic MIMO channel (both channel unknown and known to the transmitter), SIMO channel capacity, MISO channel capacity, Capacity of random MIMO channels, Ergodic capacity, Outage capacity, Capacity of frequency selective MIMO channels (both channel unknown and known to the transmitter).

Diversity and Receiver Array gain, Diversity gain, Spatial multiplexing, Receive antenna diversity, Transmit antenna diversity, SISO receiver (MLSE, ZF and Decision feedback equalizer), SIMO receiver, MIMO receiver (both Optimal and suboptimal), Sphere decoding.

Review of AWGN channel and band limited ISI channel, Introduction to multicarrier systems, FFT based multicarrier system, Mitigation of subcarrier fading, SISO-OFDM, MIMO-OFDM, Coarse time synchronization, Fine time synchronization, Coarse frequency synchronization, OFDMA, Wireless standards (WiMAX, and 3GPP LTE)

v) a) TEXT BOOKS

1. John G Proakis, *Digital Communications*, 4/e, McGraw-Hill, 2014
2. David Tse and PramodViswanath, *Fundamentals of Wireless Communications*, Cambridge University Press, 2005
3. A Paulraj, Nabar and D Gore, *Introduction to Space Time Wireless Communications*, Cambridge University Press, 2003
4. Y S Cho, J Kim, Won Yong Yang, Chung G Kang, *MIMO OFDM Wireless Communications with MATLAB*, John Wiley& sons private Ltd, 2010

b) REFERENCES

1. Erik G Larsson, *Space Time Block Coding for Wireless Communications*, Cambrdige University Press, 2003
2. E Biglieri, R Calderbank, A Constantinides, A Goldsmith, A Paulraj, *MIMO Wireless Communications*, Cambridge University Press
3. Simon Haykin ,*Digital Communications*, John Wiley & Sons Pvt Ltd. 2001
4. Andrea Goldsmith ,*Wireless Communications*, Cambridge University Press, 2005

vi) COURSE PLAN

Module	Contents	No. of hours
I	Multipath fading, Coherence time, Coherence bandwidth, Doppler spread, Characterization of fading multipath channels, Statistical model for fading channels (Rayleigh and Rice distribution), Relation between channel correlation and Power spectral density, Signal characteristics on the choice of channel model (frequency selective and frequency nonselective fading), Frequency nonselective slowly fading channel, Frequency selective slowly fading channel, Fast fading, Rake receiver	**13**
II	Types of multiple access techniques (FDMA, TDMA and CDMA), Capacity of multiple access methods (without proof, Inference only), Single user detection, Multiuser detection, CDMA signal and channel model, CDMA optimum receiver (Synchronous transmission, Asynchronous transmission), Suboptimum detectors (Single user detector and Decorrelation receiver). Practical applications of multiple access techniques.	**11**
III	Signal and channel model for SISO, SIMO, MISO and MIMO, Capacity of frequency flat deterministic MIMO channel (both channel unknown and known to the transmitter), SIMO channel capacity, MISO channel capacity, Capacity of random MIMO channels, Ergodic capacity, Outage capacity, Capacity of frequency selective MIMO channels (both channel unknown and known to the transmitter)	**12**
IV	Array gain, Diversity gain, Spatial multiplexing. Receive antenna diversity, Transmit antenna diversity, SISO receiver (MLSE, ZF and Decision feedback equalizer), SIMO receiver, MIMO receiver (both Optimal and suboptimal), Sphere decoding.	**11**
V	Review of AWGN channel and band limited ISI channel, Introduction to multicarrier systems, FFT based multicarrier system, Mitigation of subcarrier fading, SISO-OFDM, MIMO-OFDM, Coarse time synchronization, Fine time synchronization, Coarse frequency synchronization, OFDMA, Wireless standards (WiMAX, and 3GPP LTE	**13**
	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
EC1H30F	DETECTION AND ESTIMATION THEORY	VAC(HONOUR)	3	1	0	4	2020

i) PREREQUISITE: MA0U10A - Linear Algebra and Calculus, MA0U20C - Probability, Random Process, and Numerical Methods, ECT 204 - Signals and Systems

i) COURSE OVERVIEW:

Goal of this course is to provide an insight into the fundamentals of detection and estimation theory in engineering applications.

ii) COURSE OUTCOMES

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

Course Outcomes	Description	Level
CO 1	Describe the fundamentals of statistical detection and estimation principles used in various engineering problems	Understand
CO 2	Apply various types of statistical decision rules in engineering applications.	Apply
CO 3	Apply different types of estimation methods in engineering applications.	Apply

iii) SYLLABUS

Fundamentals of detection and estimation theory and its applications, classical and Bayesian approach in detection and estimation theory, different types of statistical decision rules, different types of estimation algorithms and its applications.

iv) a) TEXT BOOKS

1. S.M. Kay, *Fundamentals of Statistical Signal Processing, Vol I: Estimation Theory*, 3/e, Pearson, 2010.
2. S.M. Kay, *Fundamentals of Statistical Signal Processing Vol II: Detection Theory*, 3/e, Pearson, 2010.

c) REFERENCES

1. H. L. Van Trees, *Detection, Estimation, and Modulation Theory*, Vol. I, John Wiley & Sons, 1968

2. Monson H. Hayes, *Statistical Digital Signal Processing and Modelling*, John Wiley & Sons, 2002.

v) COURSE PLAN

Module	Contents	No. of hours
I	Fundamentals of detection theory, the mathematical detection problem. Fundamentals of estimation theory, the mathematical estimation problem. Review of Gaussian distribution. Application examples.	**11**
II	Hypothesis testing, classical approach, Neyman-Pearson theorem, likelihood ratio test, receiver operating characteristics, Bayesian approach, minimum probability of error, Bayes risk, multiple hypothesis testing.	**13**
III	Detection of deterministic signals, matched filters, detection of random signals, estimator-correlator, linear model, application examples.	**11**
IV	Minimum variance unbiased estimation, basics of Cramer-Rao Lower Bound, linear models, best linear unbiased estimation, application examples.	**13**
V	Maximum likelihood estimation, least squares, Bayesian philosophy, minimum mean square error estimation, application examples.	**12**
	Total hours	**60**

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 F2 sub-divisions and carry 14 marks.