VISION OF THE INSTITUTE

- To be a university globally trusted for technical excellence where learning and research integrate to sustain society and industry.

MISSION OF THE INSTITUTE

- To offer undergraduate, postgraduate, doctoral and modular programmes in multi-disciplinary / inter-disciplinary and emerging areas.
- To create a converging learning environment to serve a dynamically evolving society.
- To promote innovation for sustainable solutions by forging global collaborations with academia and industry in cutting-edge research.
- To be an intellectual ecosystem where human capabilities can develop holistically.

VISION OF THE DEPARTMENT

- To excel in education and research in Electronics and Communication Engineering

MISSION OF THE DEPARTMENT

- To educate with the state of art technologies to meet the growing challenges of the industry.
- To carry out research through constant interaction with research organizations and industry.
- To equip the students with strong foundations to enable them for continuing Education.

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)

PEO1	Our Graduates would be successful in Technical and Professional careers
PEO2	Our Graduates would be successful in their post-undergraduate studies at leading Institutions.

PROGRAMME OUTCOMES (POs)

PO1	To apply the knowledge on Mathematics, Science, and Engineering concepts in Complex Engineering problems.
PO2	To analyze the complex engineering problems by using the first principles of Mathematics and Engineering fundamentals.
PO3	To design a component, a system or process to meet the specific needs within realistic constraints such as economics, environment, ethics, health, safety and manufacturability.
PO4	To perform investigations, design as well as conduct experiments, analyze and interpret the results to provide valid conclusions.
PO5	To select and apply appropriate techniques for the design & analysis of systems using modern CAD tools.
PO6	To offer engineering solutions to societal problems.
PO7	To understand that the solutions have to be provided taking the environmental issues and sustainability into consideration.
PO8	To understand professional responsibilities and Ethics.
PO9	To function effectively either as a member or a leader in multidisciplinary activities.
PO10	To communicate effectively to both the peers and the others and give as well receive clear instructions.
PO11	To apply engineering & management principles in their own / team projects in a multidisciplinary environment.
PO12	To realize the need for lifelong learning and engage them to adopt technological changes.

PROGRAMME SPECIFIC OUTCOMES (PSOs)

PSO1	To face the challenges in their professional career in industry and government by integrating the existing and advanced knowledge in Electronics and Communication engineering to analyze problems and provide solutions.
PSO2	To design cost-effective systems and components for engineering/social applications by applying appropriate technology in Electronics and Communication engineering domain.
PSO3	To lead research and transform innovative ideas into reality, establish themselves as successful professionals and possess technical competency to take up higher studies.

CURRICULUM FRAMEWORK AND CREDIT SYSTEM FOR THE FOUR-YEAR B.Tech. and 3 Year B.Sc. (Engineering) PROGRAMME

COURSE STRUCTURE

Course Category	Courses	No. of Credits	Weightage (%)
GIR (General Institute Requirements)	22	56	34.7
PC (Programme Core)	15	52 – 55**	33.1
Programme Elective (PE) / Open Elective (OE)	12$	36	22.3
Essential Laboratory Requirements (ELR)	8 Maximum 2 per session up to 6th semester	16	9.9
Total	**57**	**160+3**	**100**
Minor (Optional)	Courses for 15 credits	15 Additional credits	-
Honors (Optional)	Courses for 15 credits	15 Additional credits	-

1. **A minimum of seven Programme Core, each carrying 4 credits (II, III, IV, V, VI Semester).
2. $Out of the 12 elective courses (PE / OE), students must complete at least eight Programme Electives (PE).
3. For a Minor Degree (MI), students must earn 15 credits in addition to the credit specified by the departments (160 credits), with the details of the Minor only mentioned on the transcript, not the degree certificate.
4. To qualify for an Honours Degree (HO), students must: (a) register for at least 12 theory courses and 2 ELRs in their second year, (b) consistently maintain a minimum CGPA of 8.5 during the first four sessions, (c) maintain a minimum CGPA of 8.5 in all sessions excluding honours courses, (d) successfully completed additional courses totaling 15 credits (3 numbers of 4 credit course and 1 number of 3 credit course), and (e) achieve at least a B grade in Honours courses, which must be distinct and at a higher level than PC and PE courses, preferably M. Tech. courses. Honours courses cannot be treated as programme electives and grades from these courses do not factor into CGPA calculations.
5. Project work is compulsory for B. Tech. programme. However, those students wish to carry out the intern outside the institute (8th semester) can opt for two electives courses equivalent to 6 credits. But the project work is compulsory for B. Tech. (Honours) degree.

CURRICULUM FRAME WORK / FLEXIBLE CURRICULUM / NEP 2020 / NCrF / B.Tech.

Semester	GIR		PC		ELR		PE/OE		Total Credits	Credit Distribution
	Course	Credit	Course	Credit	Course	Credit	Course	Credit		
I	8	19	-	-	-	-	-	-	**19**	**40**
II	7	17	1	4	-	-	-	-	**21**	
III	1	4	4	15	2	4	1	3	**26**	**49**
IV	1	3	3	10	2	4	2	6	**23**	
V	-	-	4	14	2	4	2	6	**24**	**47**
VI	2	4	3	9	2	4	2	6	**23**	
VII	1	2	-	-	-	-	4	12	**14**	**24**
VIII	2	7	-	-	-	-	1	3	**10**	
Total	**22**	**56**	**15**	**52**	**8**	**16**	**12**	**36**	**160**	**160**

CURRICULUM FRAME WORK / FLEXIBLE CURRICULUM / NEP 2020 / NCrF / B.Sc. (Engineering) Exit and join back for B. Tech.

	Sem	GIR		PC		ELR		PE/OE		Total Credits	Credit Distri-bution
		Course	Credit	Course	Credit	Course	Credit	Course	Credit		
Same as B.Tech.	**I**	8	19	-	-	-	-	-	-	**19**	**40**
	II	7	17	1	4	-	-	-	-	**21**	
	III	1	4	4	15	2	4	1	3	**26**	**49**
	IV	1	3	3	10	2	4	2	6	**23**	
B.Sc. Exit	**V**	-	-	2	8	2	4	2	6	**18**	**34**
	VI	4@	12	-	-	2	4	-	-	**16***	
After B.Sc. exit and join back for B. Tech.	**VII**	-	-	2	6	-	-	4	12	**18**	**37**
	VIII	1	1	3	9	-	-	3	9	**19**	
	Total	**22**	**56**	**15**	**52**	**8**	**16**	**12**	**36**	**160**	**160**

@(Internship (2), Project Work (6), Professional Ethics (3), and Industrial Lecture (1))

B.Tech. Curriculum Structure for the Students admitted during the academic year 2024 – 2025: The total minimum credits for completing the B.Tech. programme in Electronics and Communication Engineering is 160+3.

Semester I (July Session)

Code	Course	Credits	Category
ENIR11	Energy and Environmental Engineering	2	GIR
MAIR12	Linear Algebra and Calculus (Mathematics I)	3	GIR
PHIR11	Physics (Circuit)	3	GIR
PHIR12	Physics Lab (Circuit)	2	GIR
CSIR11	Introduction to Computer Programming (Theory & lab) (**Circuit**)	3	GIR
MEIR11	Basics of Mechanical Engineering (For CE, EE, EC, IC & CS)	2	GIR
PRIR11	Engineering Practice	2	GIR
CEIR11	Basics of Civil Engineering (For EE, EC, IC & CS)	2	GIR
	Total	**19**	

Semester II (January Session)

Code	Course	Credits	Category
HSIR11	English for Communication (Theory and Lab)	4	GIR
MAIR21	Complex Analysis and Differential Equations (Mathematics II)	3	GIR
CHIR11	Chemistry (Circuit)	3	GIR
CHIR12	Chemistry Lab (Circuit)	2	GIR
ECIR15	Introduction to Electronics and communication Engineering	2	GIR
MEIR12	Engineering Graphics	3	GIR
ECPC11	Network Analysis and Synthesis	4	PC
SWIR11	NSS / NCC / NSO	0	GIR
	Total	**21**	

Semester III (July Session)

Code	Course	Credits	Category
MAIR33	Real Analysis and Probability Theory (Mathematics III)	4	GIR
ECPC10	Signals and Systems	4	PC
ECPC13	Semiconductor Physics and Devices	4	PC
ECPC12	Electrodynamics and Electromagnetic Waves	4	PC
ECPC14	Digital Circuits and Systems	3	PC
ECLR10	Devices and Networks Laboratory	2	ELR
ECLR11	Digital Electronics Laboratory	2	ELR
	Elective – I	3	PE
	Total	**26**	

Note: Department(s) to offer Minor (MI) Course and Online Course (OC) to those willing students in addition to 26 credits.

Semester IV (January Session)

Code	Course	Credits	Category
HSIR13	Industrial Economics and Foreign Trades	3	GIR
ECPC15	Digital Signal Processing	4	PC
ECPC16	Transmission Lines and Waveguides	3	PC
ECPC17	Electronic Circuits	3	PC
ECLR12	Electronic Circuits Laboratory	2	ELR
ECLR13	Microprocessor and Microcontroller Laboratory	2	ELR
	Elective – II	3	PE
	Elective – III	3	PE
	Total	**23**	

Note: Department to offer Minor (MI) Course, and ONLINE Course (OC) to those willing students in addition to 23 credits.

Semester V (July Session) / Continuing B.Tech.

Code	Course	Credits	Category
ECPC18	Analog Communication	3	PC
ECPC19	Digital Communication	4	PC
ECPC20	Antennas and Propagation	3	PC
ECPC21	Analog Integrated Circuits	4	PC
ECLR14	Analog VLSI & Embedded System Design Laboratory	2	ELR
ECLR15	Digital Signal Processing Laboratory	2	ELR
	Elective – IV	3	PE/OE
	Elective – V	3	PE/OE
	Total	**24**	

Semester VI (January Session)

Code	Course	Credits	Category
ECIR19	Industrial Lecture	1	GIR
ECPC22	Wireless Communication	3	PC
ECPC23	VLSI Systems	3	PC
ECPC24	RF and Microwave Engineering	3	PC
ECLR16	Communication Engineering Laboratory	2	ELR
ECLR17	Microwave & Fiber Optic Laboratory	2	ELR
HSIR14	Professional Ethics (Circuit)	3	GIR
	Elective - VI	3	PE
	Elective - VII	3	PE/OE
	Total	**23**	

Semester VII (July Session)

Code	Course	Credits	Category
ECIR16	Summer Internship*	2	GIR
ECIR18	Comprehensive Viva Voce	1	GIR
	Elective – VIII	3	PE
	Elective – IX	3	PE
	Elective – X	3	PE
	Elective – XI	3	PE/OE
	TOTAL	**15**	

*Evaluation for summer internship

Semester VIII (January Session)

Code	Course	Credits	Category
	Elective – XII	3	PE
ECIR17	Project Work/ Equivalent no. of Electives	6	GIR
	TOTAL	**9**	

Semester	I	II	III	IV	V	VI	VII	VIII	Total
B.Tech.	**19**	**21**	**26**	**23**	**24**	**23**	**15**	**9**	**160**

Note:

a) Curriculum should have 7 Programme Core courses shall be of 4 credits each.
b) Out of 12 elective courses (PE/OE), the students should study at least eight programme elective courses (PE).
c) Minor (MI): 15 credits over and above the minimum credit as specified by the departments (160). The details of MINOR will be mentioned in the transcript and not in the Degree certificate.
d) Honours (HO): 15 credits over and above the minimum credit as specified by the departments (160).

Specializations in B.Tech. Degree:

After the successful completion of IV year, and earning 160 credits, the student is eligible for the degree B.Tech. in Electronics and Communication Engineering. The specialization in the degree is given if the student completes any five program electives listed in the following table against each specialization.

S. No.	B.Tech. in ECE and Specialization in	List of Program Electives (to complete any five)
1.	Wireless Networks	ECPE10 - Networks and Protocols ECPE11 - Wireless Local Area Network ECPE29 - Broadband Access Technologies ECPE38 - Adhoc Wireless Networks ECPE39 - Wireless Sensor Networks ECPE55 - Advanced Topics in 5G/B5G Wireless Communication
2.	Signal Processing	ECPE17 - Statistical Theory of Communication ECPE18 - Digital Signal Processors and Applications ECPE20 - Digital Speech Processing ECPE21 - Digital Image Processing ECPE22 - Pattern Recognition ECPE32 - Digital Signal Processing for Wireless Communication

3.	Artificial Intelligence	ECPE49 - Foundations of Artificial Intelligence ECPE43 - Computer Vision ECPE44 - Natural Language Processing ECPE45 - Optimization Methods in Machine Learning ECPE46 - Hardware for Deep Learning ECPE47 - Image and Video Processing
4.	VLSI and Embedded Systems	ECPE13 - Computer Architecture and Organization ECPE14 - Embedded Systems ECPE16 - ARM System Architecture ECPE19 - High Speed System Design ECPE37 - Low Power VLSI Circuits ECPE41 - Electronic Design Automation Tools ECPE12 - Microprocessors and Micro Controllers
5.	Microwave and Fiber Optic Communication	ECPE31 - Fiber Optic Communication ECPE33 - Microwave Integrated Circuit Design ECPE34 - RF MEMS Circuit Design ECPE36 - Principles of Radar ECPE42 - Electromagnetic Interference and Compatibility ECPE50 - Photonic Integrated Circuits ECPE51 - Microwave Circuits
6.	Semiconductor Technology	a) ECPE41 - Electronic Design Automation Tools b) ECPE42 - Electromagnetic Interference and Compatibility c) ECPE48 - Automated Test Engineering for Electronics d) ECPE50 - Photonic Integrated Circuits e) ECPE51 - Microwave Circuits f) ECPE56 - Analog Power Integrated Circuits

B.Sc. (Engineering) Curriculum Structure for the Students admitted during the academic year 2024 – 2025: The total minimum credits for completing the B.Sc. (Engineering) programme is 120. After B.Sc. (Engineering) exit at year III, a student may join back for B.Tech.

Semester I (July Session)

Code	Course	Credits	Category
ENIR11	Energy and Environmental Engineering	2	GIR
MAIR12	Linear Algebra and Calculus (Mathematics I)	3	GIR
PHIR11	Physics (Circuit)	3	GIR
PHIR12	Physics Lab (Circuit)	2	GIR
CSIR11	Introduction to Computer Programming (Theory & lab) (**Circuit**)	3	GIR
MEIR11	Basics of Mechanical Engineering (For CE, EE, EC, IC & CS)	2	GIR
PRIR11	Engineering Practice	2	GIR
CEIR11	Basics of Civil Engineering (For EE, EC, IC & CS)	2	GIR
	Total	**19**	

Semester II (January Session)

Code	Course	Credits	Category
HSIR11	English for Communication (Theory and Lab)	4	GIR
MAIR21	Complex Analysis and Differential Equations (Mathematics II)	3	GIR
CHIR11	Chemistry (Circuit)	3	GIR
CHIR12	Chemistry Lab (Circuit)	2	GIR
ECIR15	Introduction to Electronics and communication Engineering	2	GIR
MEIR12	Engineering Graphics	3	GIR
ECPC11	Network Analysis and Synthesis	4	PC
SWIR11	NSS / NCC / NSO	0	GIR
	Total	**21**	

Semester III (July Session)

Code	Course	Credits	Category
MAIR33	Real Analysis and Probability Theory (Mathematics III)	4	GIR
ECPC10	Signals and Systems	4	PC
ECPC13	Semiconductor Physics and Devices	4	PC
ECPC12	Electrodynamics and Electromagnetic Waves	4	PC
ECPC14	Digital Circuits and Systems	3	PC
ECLR10	Devices and Networks Laboratory	2	ELR
ECLR11	Digital Electronics Laboratory	2	ELR
	Elective – I	3	PE
	Total	**26**	

Note: Department(s) to offer Minor (MI) Course and Online Course (OC) to those willing students in addition to 26 credits.

Semester IV (January Session)

Code	Course	Credits	Category
HSIR13	Industrial Economics and Foreign Trades	3	GIR
ECPC15	Digital Signal Processing	4	PC
ECPC16	Transmission Lines and Waveguides	3	PC
ECPC17	Electronic Circuits	3	PC
ECLR12	Electronic Circuits Laboratory	2	ELR
ECLR13	Microprocessor and Microcontroller Laboratory	2	ELR
	Elective – II	3	PE
	Elective – III	3	PE
	Total	**23**	

Note: Department to offer Minor (MI) Course, and ONLINE Course (OC) to those willing students in addition to 23 credits.

Semester V (July Session) / B.Sc. (Engineering) Exit

Code	Course	Credits	Category
ECPC19	Digital Communication	4	PC
ECPC21	Analog Integrated Circuits	4	PC
ECLR14	Analog VLSI & Embedded System Design Laboratory	2	ELR
ECLR15	Digital Signal Processing Laboratory	2	ELR
	Elective – IV	3	PE/OE
	Elective – V	3	PE/OE
	Total	**18**	

Semester VI (January Session)/ B.Sc. (Engineering) Exit

Code	Course	Credits	Category
ECIR17	Project Work	6	GIR
ECIR16	Winter Internship*	2	GIR
ECIR19	Industrial Lecture	1	GIR
ECLR16	Communication Engineering Laboratory	2	ELR
ECLR17	Microwave & Fiber Optic Laboratory	2	ELR
HSIR14	Professional Ethics (Circuit)	3	GIR
	Total	**16**	

*Evaluation for winter internship

Semester VII (July Session)/ Rejoins B.Tech. after B.Sc. (Engineering) exit

Code	Course	Credits	Category
ECPC18	Analog Communication	3	PC
ECPC20	Antennas and Propagation	3	PC
	Elective - VI	3	PE/OE
	Elective - VII	3	PE
	Elective – VIII	3	PE
	Elective – IX	3	PE/OE
	TOTAL	**18**	

Semester VIII (January Session)/ Rejoins B.Tech. after B.Sc. (Engineering) exit

Code	Course	Credits	Category
ECIR18	Comprehensive Viva Voce	1	GIR
ECPC22	Wireless Communication	3	PC
ECPC23	VLSI Systems	3	PC
ECPC24	RF and Microwave Engineering	3	PC
	Elective – X	3	PE
	Elective – XI	3	PE
	Elective – XII	3	PE
	TOTAL	**19**	

Credit Distribution

Semester	**I**	**II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**	**Total**
Credit (B.Sc. (Engg.) Exit)	**19**	**21**	**26**	**23**	**18**	**16**			**123**
Credit (Rejoin B.Tech. after B.Sc. (Engg.) Exit)	**19**	**21**	**26**	**23**	**18**	**16**	**18**	**19**	**160**

ELECTIVES CHOICES

Option 1 / Regular B.Tech.

To get a B.Tech. degree in Electronics and Communication Engineering, possible choices of electives in Programme Electives and Open Electives are,

Program Electives	Open Electives	Total
8	4	12
9	3	12
10	2	12
11	1	12
12	0	12

Option 2 / B.Sc. (Engineering) Exit (at end of 3rd year)

Program Electives	Open Electives	Total
3	2	5
4	1	5
5	0	5

Option 3 / B.Tech. with Minor

To get a B.Tech. degree in Electronics and Communication Engineering, and minor in other programmes, possible choices of electives in Programme Electives, Open Electives and Minor Electives are,

Program Electives	Open Electives	Minor Electives	Total
8	4	5	12 + 5
9	3	5	12 + 5
10	2	5	12 + 5
11	1	5	12 + 5
12	0	5	12 + 5

Option 4 / B.Tech. with Honours

To get a B.Tech. Honors degree in Electronics and Communication Engineering, possible choices of electives inProgramme Electives, Open Electives, and Honors electives are,

Program Electives	Open Electives	Honors Electives	Total
8	4	4	12 + 4
9	3	4	12 + 4
10	2	4	12 + 4
11	1	4	12 + 4
12	0	4	12 + 4

Option 5 / B.Tech. with Honours and Minor

To get a B.Tech. Honors degree in Electronics and Communication Engineering, and minor in other programmes possible choices of electives in Programme Electives, Open Electives, and Honors electives are,

Program Electives	Open Electives	Honors Electives	Minor Electives	Total
8	4	4	5	12 + 4 + 5
9	3	4	5	12 + 4 + 5
10	2	4	5	12 + 4 + 5
11	1	4	5	12 + 4 + 5
12	0	4	5	12 + 4 + 5

Note: No Minor or Honours will be awarded for B.Sc. But student can credit minors and honours during the 6 semesters and redeem it to obtain a minor or honours after rejoining and completing B.Tech. Also, B.Sc. students shall only do programme electives in place of their project work in 6th semester.

LIST OF COURSES

(I) GENERAL INSTITUTE REQUIREMENTS (GIR) COURSES:

Sl. No.	Course	Number of Courses	Max. Credits
1.	Mathematics	3	10
2.	Physics	1	3
	Physics Laboratory	1	2
3.	Chemistry	1	3
	Chemistry Laboratory	1	2
4.	Industrial Economics and Foreign Trade	1	3
5.	English for Communication	1	4
6.	Energy and Environmental Engineering	1	2
7.	Professional Ethics	1	3
8.	Engineering Graphics	1	3
9.	Engineering Practice	1	2
10.	Basic Engineering	2	4
11.	Introduction to computer Programming	1	3
12.	Branch Specific Course (Introduction to the Branch of study)	1	2
13.	Summer Internship (Winter internship for B.Sc. (Engg.))	1	2
14.	Project work	1	6
15.	Comprehensive viva	1	1
16.	Industrial Lecture	1	1
17.	NSS/NCC/NSO	1	Pass / Fail
Total		**22**	**56**

1. MATHEMATICS:

Sl.No.	Course Code	Course Title	Credits
1.	MAIR12	LINEAR ALGEBRA AND CALCULUS	**3**
2.	MAIR21	COMPLEX ANALYSIS AND DIFFERENTIAL EQUATIONS	**3**
3.	MAIR33	REAL ANALYSIS AND PROBABILITY THEORY	**4**
		Total	**10**

2. PHYSICS

Sl.No.	Course Code	Course Title	Credits
1.	PHIR11	PHYSICS	**3**
2.	PHIR12	PHYSICS LAB	**2**
		Total	**5**

3. CHEMISTRY

Sl.No.	Course Code	Course Title	Credits
1.	CHIR11	CHEMISTRY	**3**
2.	CHIR12	CHEMISTRY LAB	**2**
		Total	**5**

4. HUMANITIES

Sl.No.	Course Code	Course Title	Credits
1.	HSIR13	INDUSTRIAL ECONOMICS AND FOREIGN TRADE	**3**
		Total	**3**

5. COMMUNICATION

Sl.No.	Course Code	Course Title	Credits
1.	HSIR11	ENGLISH FOR COMMUNICATION	**4**
		Total	**4**

6. ENERGY AND ENVIRONMENTAL ENGINEERING

Sl.No.	Course Code	Course Title	Credits
1.	ENIR11	ENERGY AND ENVIRONMENTAL ENGINEERING	**2**
		Total	**2**

7. PROFESSIONAL ETHICS

Sl.No.	Course Code	Course Title	Credits
1.	HSIR14	PROFESSIONAL ETHICS	**3**
		Total	**3**

8. ENGINEERING GRAPHICS

Sl.No.	Course Code	Course Title	Credits
1.	MEIR12	ENGINEERING GRAPHICS	**3**
		Total	**3**

9. ENGINEERING PRACTICE

Sl.No.	Course Code	Course Title	Credits
1.	PRIR11	ENGINEERING PRACTICE	**2**
		Total	**2**

10. BASIC ENGINEERING

Sl.No.	Course Code	Course Title	Credits
1.	CEIR11	BASICS OF CIVIL ENGINEERING	**2**
2.	MEIR11	BASICS OF MECHANICAL ENGINEERING	**2**
		Total	**4**

11. INTRODUCTION TO COMPUTER PROGRAMMING

Sl.No.	Course Code	Course Title	Credits
1.	CSIR11	INTRODUCTION TO COMPUTER PROGRAMMING	**3**
		Total	**3**

12. BRANCH SPECIFIC COURSE

Sl.No.	Course Code	Course Title	Credits
1.	ECIR15	Introduction to Electronics and Communication Engineering	**2**
		Total	**2**

13. SUMMER INTERNSHIP

Sl.No.	Course Code	Course Title	Credits
1.	ECIR16	INTERNSHIP / INDUSTRIAL TRAINING / ACADEMIC ATTACHMENT (2 to 3 months duration during summer vacation) (during winter vacation for B.Sc. (Engg.))	**2**
		Total	**2**

The student should undergo industrial training/internship for a minimum period of two months during the summer vacation of 3rd year. Attachment with an academic institution within the country (IISc/IITs/NITs/IIITs and CFTIs) or university abroad is also permitted instead of industrial training.

 # To be evaluated at the beginning of VII semester by assessing the report and seminar presentations. (beginning of VI semester for B.Sc. (Engg.))

14. PROJECT WORK

Sl.No.	Course Code	Course Title	Credits
1.	ECIR17	Project work/equivalent number of electives	**6**
		Total	**6**

Compulsory for B.Tech. (Honours)

15. COMPREHENSIVE VIVA

Sl.No.	Course Code	Course Title	Credits
1.	ECIR18	COMPREHENSIVE VIVA	**1**
		Total	**1**

16. INDUSTRIAL LECTURE

Sl.No.	Course Code	Course Title	Credits
1.	ECIR19	INDUSTRIAL LECTURE	**1**
		Total	**1**

17. NSS / NCC / NSO

Sl.No.	Course Code	Course Title	Credits
1.	SWIR11	NSS / NCC / NSO	**0**
		Total	**0**

(II) PROGRAMME CORE (PC)

Sl. No.	Course Code	Course Title	Prerequisites	Credits
1.	ECPC10	SIGNALS AND SYSTEMS	NONE	4
2.	ECPC11	NETWORK ANALYSIS AND SYNTHESIS	NONE	4
3.	ECPC12	ELECTRODYNAMICS AND ELECTROMAGNETIC WAVES	NONE	4
4.	ECPC13	SEMICONDUCTOR PHYSICS AND DEVICES	NONE	4
5.	ECPC14	DIGITAL CIRCUITS AND SYSTEMS	NONE	3
6.	ECPC15	DIGITAL SIGNAL PROCESSING	ECPC10	4
7.	ECPC16	TRANSMISSION LINES AND WAVEGUIDES	ECPC12	3
8.	ECPC17	ELECTRONIC CIRCUITS	ECPC13	3
9.	ECPC18	ANALOG COMMUNICATION	ECPC10	3
10.	ECPC19	DIGITAL COMMUNICATION	ECPC10	4
11.	ECPC20	ANTENNAS AND PROPAGATION	ECPC12	3
12.	ECPC21	ANALOG INTEGRATED CIRCUITS	ECPC17	4
13.	ECPC22	WIRELESS COMMUNICAITON	ECPC19	3
14.	ECPC23	VLSI SYSTEMS	ECPC21	3
15.	ECPC24	RF AND MICROWAVE ENGINEERING	ECPC16	3
			Total:	**52**

(III) ELECTIVES

a. PROGRAMME ELECTIVES

Sl. No.	Course Code	Course Title	Prerequisites	Credits
1.	ECPE10	NETWORKS AND PROTOCOLS	NONE	3
2.	ECPE11	WIRELESS LOCAL AREA NETWORK	ECPE10	3
3.	ECPE12	MICROPROCESSORS AND MICROCONTROLLERS	ECPC14	3
4.	ECPE13	COMPUTER ARCHITECTURE AND ORGANIZATION	NONE	3
5.	ECPE14	EMBEDDED SYSTEMS	NONE	3
6.	ECPE15	OPERATING SYSTEMS	NONE	3
7.	ECPE16	ARM SYSTEM ARCHITECTURE	NONE	3
8.	ECPE17	STATISTICAL THEORY OF COMMUNICATION	NONE	3
9.	ECPE18	DIGITAL SIGNAL PROCESSORS AND APPLICATIONS	ECPC15	3
10.	ECPE19	HIGH SPEED SYSTEM DESIGN	NONE	3
11.	ECPE20	DIGITAL SPEECH PROCESSING	ECPC15	3
12.	ECPE21	DIGITAL IMAGE PROCESSING	NONE	3
13.	ECPE22	PATTERN RECOGNITION	NONE	3
14.	ECPE23	DISPLAY SYSTEMS	ECPC13	3
15.	ECPE24	INTERNET OF THINGS	CSIR11, ECPE12, C/C++ and Python Programming skills	3
16.	ECPE26	COGNITIVE RADIO	ECPC15	3
17.	ECPE27	MULTIMEDIA COMMUNICATION TECHNOLOGY	ECPC15	3
18.	ECPE28	COMMUNICATION SWITCHING SYSTEMS	ECPC18	3
19.	ECPE29	BROADBAND ACCESS TECHNOLOGIES	ECPC18 & ECPC19	3
20.	ECPE31	FIBER OPTIC COMMUNICATION	ECPC12 & ECPC18	3
21.	ECPE32	DIGITAL SIGNAL PROCESSING FOR WIRELESS COMMUNICATION	ECPC15	3
22.	ECPE33	MICROWAVE INTEGRATED CIRCUIT DESIGN	ECPC16 & ECPC24	3
23.	ECPE34	RF MEMS CIRCUIT DESIGN	ECPC16 & ECPC24	3
24.	ECPE35	SATELLITE COMMUNICATION	ECPC18	3
25.	ECPE36	PRINCIPLES OF RADAR	ECPC20	3
26.	ECPE37	LOW POWER VLSI CIRCUITS	ECPC23	3
27.	ECPE38	ADHOC WIRELESS NETWORKS	ECPE10	3
28.	ECPE39	WIRELESS SENSOR NETWORKS	ECPE10	3
29.	ECPE40	NANO ELECTRONICS	NONE	3
30.	ECPE41	ELECTRONIC DESIGN AUTOMATION	NONE	3

		TOOLS		
31.	ECPE42	ELECTROMAGNETIC INTERFERENCE AND COMPATIBILITY	NONE	3
32.	ECPE43	COMPUTER VISION	NONE	3
33.	ECPE44	NATURAL LANGUAGE PROCESSING	NONE	3
34.	ECPE45	OPTIMIZATION METHODS IN MACHINE LEARNING	NONE	3
35.	ECPE46	HARDWARE FOR DEEP LEARNING	NONE	3
36.	ECPE47	IMAGE AND VIDEO PROCESSING	NONE	3
37.	ECPE48	AUTOMATED TEST ENGINEERING FOR ELECTRONICS	NONE	3
38.	ECPE49	FOUNDATIONS OF ARTIFICIAL INTELLIGENCE	NONE	3
39.	ECPE50	PHOTONIC INTEGRATED CIRCUITS	NONE	3
40.	ECPE51	MICROWAVE CIRCUITS	NONE	3
41.	ECPE52	INTRODUCTION TO MACHINE LEARNING	NONE	3
42.	ECPE53	DEEP LEARNING	NONE	3
43.	ECPE54	CONTROL SYSTEMS	NONE	3
44.	ECPE55	ADVANCED TOPICS IN 5G/B5G WIRELESS COMMUNICATION	NONE	3
45.	ECPE56	ANALOG POWER INTEGRATED CIRCUITS	ECPC11, ECPC17, ECPC21	3
			Total:	**135**

b. OPEN ELECTIVE (OE)

The courses listed below are offered by the Department of Electronics and Communication Engineering for students of all Departments.

Sl. No.	Course Code	Course Title	Prerequisites	Credits
1.	ECOE10	MICROWAVE INTEGRATED CIRCUITS	NONE	3
2.	ECOE11	RF MEMS CIRCUIT	NONE	3
3.	ECOE12	HIGH SPEED SYSTEM DESIGN	NONE	3
4.	ECOE13	DIGITAL SPEECH PROCESSING	ECPC15	3
5.	ECOE14	DIGITAL IMAGE PROCESSING	NONE	3
6.	ECOE15	PATTERN RECOGNITION	NONE	3
7.	ECOE16	COMPUTER ARCHITECTURE AND ORGANIZATION	NONE	3
8.	ECOE17	OPERATING SYSTEMS	NONE	3
9.	ECOE18	WIRELESS SENSOR NETWORKS	ECPE10	3
10.	ECOE19	ARM SYSTEM ARCHITECTURE	NONE	3
11.	ECOE20	LOW POWER VLSI CIRCUITS	ECPC23	3
12.	ECOE21	COMPUTER VISION AND MACHINE LEARNING	NONE	3

13.	ECOE22	TEXT DATA MINING	NONE	3
14.	ECOE23	INTERNET OF THINGS	CSIR11, C/C++, Python	3
15.	ECOE51	NPTEL - Semiconductor Optical Communication Components and Devices	NONE	3
16.	ECOE52	NPTEL - Fundamentals of MIMO Wireless Communication	ECPC22	3
17.	ECOE53	NPTEL - Modern Digital Communication Techniques	ECPC19	3
18.	ECOE54	NPTEL - VLSI Design Verification and Test	ECPC23	3
19.	ECOE55	NPTEL - Digital VLSI Testing	ECPC23	3
20.	ECOE56	NPTEL - Analog Circuits and Systems through SPICE Simulation	ECPC17	3
21.	ECOE57	NPTEL - Linux Programming and Scripting	NONE	3
22.	ECOE58	NPTEL - Digital System Design with PLDs and FPGAs	ECPC14	3
23.	ECOE59	NPTEL - MEMS and Microsystems	NONE	3
24.	ECOE60	NPTEL - Neural Networks and Applications	NONE	3
25.	ECOE61	NPTEL - Biomedical Signal Processing	NONE	3
26.	ECOE62	NPTEL - Evolution of Air Interface Towards 5G	NONE	3
27.	ECOE63	NPTEL - Introduction to Machine Learning	NONE	3
28.	ECOE64	NPTEL - A Brief Introduction of Micro – Sensors	NONE	3
29.	ECOE65	NPTEL - An Introduction to Coding Theory	NONE	3
30.	ECOE66	NPTEL - Deep Learning	NONE	3
31.	ECOE67	NPTEL - Python for everybody	NONE	3
32.	ECOE68	NPTEL - Cryptography and network security	NONE	3
33.	ECOE69	NPTEL - Blockchain architecture design and use cases	NONE	3
34.	ECOE70	NPTEL - Optical sensors	NONE	3
35.	ECOE71	NPTEL - Non -linear adaptive control	NONE	3
36.	ECOE72	NPTEL - Modelling & simulation of dynamic systems	NONE	3
37.	ECOE73	NPTEL - Bio informatics: algorithm & applications	NONE	3
38.	ECOE74	NPTEL - ANALOG IC DESIGN	NONE	3
39.	ECOE75	NPTEL - PETROLEUM ECONOMICS	NONE	3

		AND MANAGEMENT		
40.	ECOE76	COMPUTER VISION	NONE	3
41.	ECOE77	NATURAL LANGUAGE PROCESSING	NONE	3
42.	ECOE78	OPTIMIZATION METHODS IN MACHINE LEARNING	NONE	3
43.	ECOE79	HARDWARE FOR DEEP LEARNING	NONE	3
44.	ECOE80	IMAGE AND VIDEO PROCESSING	NONE	3
45.	ECOE81	AUTOMATED TEST ENGINEERING FOR ELECTRONICS	NONE	3
46.	ECOE82	FOUNDATIONS OF ARTIFICIAL INTELLIGENCE	NONE	3
47.	ECOE84	MICROWAVE CIRCUITS	NONE	3
48.	ECOE85	COMPUTATIONAL NEUROSCIENCE	NONE	3
49.	ECOE86	VLSI PHYSICAL DESIGN WITH TIMING ANALYSIS	NONE	3
50.	ECOE87	AN INTRODUCTION TO ARTIFICIAL INTELLIGENCE	NONE	3
			Total:	**150**

c. MINOR (MI) (offered for the students of other departments)

Students of other departments who desire B.Tech. Minor in Electronics and Communication Engineering can opt to study any 5 of the courses listed below.

Sl. No.	Course Code	Course Title	Prerequisites	Credits
1.	ECMI10	SIGNALS AND SYSTEMS	NONE	3
2.	ECMI11	NETWORK ANALYSIS AND SYNTHESIS	NONE	3
3.	ECMI12	ELECTRODYNAMICS AND ELECTROMAGNETIC WAVES	NONE	3
4.	ECMI13	SEMICONDUCTOR PHYSICS AND DEVICES	NONE	3
5.	ECMI14	DIGITAL CIRCUITS AND SYSTEMS	NONE	3
6.	ECMI15	DIGITAL SIGNAL PROCESSING	ECMI10	3
7.	ECMI16	TRANSMISSION LINES AND WAVEGUIDES	ECMI12	3
8.	ECMI17	ELECTRONIC CIRCUITS	ECMI13	3
9.	ECMI18	MICROPROCESSORS AND MICRO CONTROLLERS	ECMI14	3
10.	ECMI19	DIGITAL SIGNAL PROCESSORS AND APPLICATIONS	ECMI15	3
11.	ECMI20	ANALOG COMMUNICATION	ECMI10	3
12.	ECMI21	ANTENNAS AND PROPAGATION	ECMI12	3
13.	ECMI22	ANALOG INTEGRATED CIRCUITS	ECMI17	3
14.	ECMI23	DIGITAL COMMUNICATION	ECMI20	3
15.	ECMI24	MICROWAVE COMPONENTS AND CIRCUITS	ECMI16	3
16.	ECMI25	VLSI SYSTEMS	ECMI14	3

17.	ECMI26	WIRELESS COMMUNICAITON	ECMI23	3
18.	ECMI27	FIBER OPTIC COMMUNICATION	ECMI12 &ECMI20	3
19.	ECMI28	MICROWAVE ELECTRONICS	ECMI24	3
			Total:	**57**

(IV) ESSENTIAL PROGRAMME LABORATORY REQUIREMENT (ELR)

Sl. No.	Course Code	Course Title	Prerequisites	Credits
1.	ECLR10	DEVICES AND NETWORKS LABORATORY	ECPC13	2
2.	ECLR11	DIGITAL ELECTRONICS LABORATORY	ECPC14	2
3.	ECLR12	ELECTRONIC CIRCUITS LABORATORY	ECPC17	2
4.	ECLR13	MICROPROCESSOR AND MICROCONTROLLER LABORATORY	ECPC14	2
5.	ECLR14	ANALOG VLSI & EMBEDDED SYSTEM DESIGN LABORATORY	ECPC21 & ECPC23	2
6.	ECLR15	DIGITAL SIGNAL PROCESSING LABORATORY	ECPC15	2
7.	ECLR16	COMMUNICATION ENGINEERING LABORATORY	ECPC18 & ECPC19	2
8.	ECLR17	MICROWAVE & FIBER OPTIC LABORATORY	ECPC24	2
			Total:	**16**

NOTE: Students can register for 2 laboratory courses during one session along with regular courses (PC / PE / OE / MI).

(V) ONLINE COURSES (OC)

Sl. No.	Course Code	Course Title	Prerequisites	Credits
		Course list shall be updated regularly at the start of each Academic Year or Semester by the department NPTEL Coordinator. The students shall be able to select an online course from then available list.		

VI. ADVANCED LEVEL COURSES FOR B.Tech. (HONOURS)

To qualify for an Honours Degree (HO), students must: (a) register for at least 12 theory courses and 2 ELRs in their second year, (b) consistently maintain a minimum CGPA of 8.5 during the first four sessions, (c) maintain a minimum CGPA of 8.5 in all sessions excluding honours courses, (d) successfully completed additional courses totaling 15 credits (3 numbers of 4 credit course and 1 number of 3 credit course), and

(e) achieve at least a B grade in Honours courses, which must be distinct and at a higher level than PC and PE courses, preferably M. Tech. courses. Honours courses cannot be treated as programme electives and grades from these courses do not factor into CGPA calculations.

Sl. No.	Course Code	Course Title	Prerequisites	Credits
1.	ECHO11	SPECTRAL ANALYSIS OF SIGNALS	ECPC15	3
2.	ECHO12	DETECTION AND ESTIMATION	MAIR45	3
3.	ECHO13	WAVELET SIGNAL PROCESSING	ECPC15	4
4.	ECHO14	RF CIRCUITS	NONE	3
5.	ECHO15	NUMERICAL TECHNIQUES FOR MIC	ECPC16	3
6.	ECHO16	APPLIED PHOTONICS	NONE	3
7.	ECHO17	ADVANCED RADIATION SYSTEMS	ECPC20	3
8.	ECHO18	BIO MEMS	NONE	3
9.	ECHO19	ANALOG IC DESIGN	ECPC21	3
10.	ECHO20	VLSI SYSTEM TESTING	ECPC23	3
11.	ECHO22	DESIGN OF ASICS	NONE	4
12.	ECHO23	DIGITAL SYSTEM DESIGN	ECPC14	3
13.	ECHO24	OPTIMIZATIONS OF DIGITAL SIGNAL PROCESSING STRUCTURES FOR VLSI	ECPC23, ECPE18, ECPC15	4
14.	ECHO26	VLSI DIGITAL SIGNAL PROCESSING SYSTEMS	ECPC15 &ECPC23	3
15.	ECHO27	ASYNCHRONOUS SYSTEM DESIGN	ECPC14	3
16.	ECHO28	PHYSICAL DESIGN AUTOMATION	NONE	3
17.	ECHO29	MIXED - SIGNAL CIRCUIT DESIGN	NONE	3
18.	ECHO30	DIGITAL SIGNAL PROCESSING FOR MEDICAL IMAGING	ECPC15	3
19.	ECHO31	Advanced Techniques for Wireless Reception	-	4
20.	ECHO32	Error Control Coding	-	3
21.	ECHO33	Digital Communication Receivers	-	3
22.	ECHO34	ADVANCED DIGITAL SIGNAL PROCESSING	ECPC15	3
			Total:	**70**

(VII) MICROCREDITS (MC) (Students can opt 3 courses of 1 credit (4 weeks) each as microcredits instead of 1 OE/OC)

Students are advised to take 4-week courses from NPTEL/SWAYAM platform

COURSE OUTCOME AND PROGRAMME OUTCOME MAPPING

PROGRAMME CORE (PC)

Course Outcomes: On successful completion of the course, students will be able to:

Course Code	Course Title	CO	Course outcomes At the end of the course student will be able	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
ECPC10	SIGNALS AND SYSTEMS	CO1	Understand the mathematical description and representation of continuous-time and discrete-time signals.	3	3	0	0	0	0	0	0	0	0	0	0
		CO2	Analyze the spectral characteristics of continuous-time periodic and aperiodic signals using Fourier analysis.	3	3	0	0	0	0	0	0	0	0	0	0
		CO3	Analyse system properties based on impulse response and Fourier analysis.	3	3	0	0	0	0	0	0	0	0	0	0
		CO4	Convert a continuous time signal into discrete time signal and reconstruct the	3	3	0	0	0	0	0	0	0	0	0	0

			continuous time signals back from its samples.												
		CO5	Apply the Laplace transform and Z-transform respectively for the analyse of continuous-time and discrete-time signals.	3	3	0	0	0	0	0	0	0	0	0	0
ECPC11	NETWORK ANALYSIS AND SYNTHESIS	CO1	Analyze the electric circuit using network theorems	2	2										1
		CO2	Evaluate Transient & Forced response for RL, RC ,RLS networks	2	2										1
		CO3	Determine Sinusoidal steady state response understand the real time applications of maximum power transfer theorem and equalizer	2	2										1
		CO4	Understand the two–port network parameters, are able to find out two-port network parameters & overall response for interconnection of	2	2										1

			two-port networks.												
		CO5	Synthesize one port network using Foster form, Cauer form.	2	2										1
ECPC12	ELECTRODYNAMICS AND ELECTROMAGNETIC WAVES	CO1	Recognize and classify the basic electrostatic theorems and laws and to derive them	3	3	2	1	1	2	3	3	1	1	2	3
		CO2	Discuss the behaviour of electric field in matter and polarization concepts.	3	3	2	1	1	2	3	3	1	1	2	3
		CO3	Classify the basic magnetostatic theorems and laws and infer the magnetic properties of matter	3	3	2	2	1	3	3	3	1	1	3	3
		CO4	Summarize the concept of electrodynamics and to derive and discuss the Maxwell's equations	3	3	2	2	1	3	3	3	1	1	3	3
		CO5	Familiarize the electromagnetic wave propagation and polarization	3	3	3	2	1	3	3	3	1	1	3	3
ECPC13	SEMICONDUCTOR PHYSICS AND DEVICES	CO1	Apply the knowledge of	3	2	2	3						3	2	3

			basic semiconductor material physics and understand fabrication processes.												
		CO2	Analyze the characteristics of various electronic devices like diode, transistor etc.,	3	2	2	3						3	2	3
		CO3	Classify and analyze the various circuit configurations of Transistor and MOSFETs.	3	2	2	3						3	2	3
		CO4	Illustrate the qualitative knowledge of Power electronic Devices.	3	2	2	3						3	2	3
		CO5	Become Aware of the latest technological changes in Display Devices.	3	2	2	3						3	2	3
ECPC14	DIGITAL CIRCUITS AND SYSTEMS	CO1	Apply the knowledge of Boolean algebra and simplification of Boolean expressions to deduce optimal digital circuits.	3	2	2	2	3	-	-	3	-	-	1	1
		CO2	Study and examine the SSI,	3	2	3	3	3	1	1	3	-	-	1	1

			MSI and Programmable combinational circuits.												
		CO3	Study and investigate the sequential networks using counters and shift registers.	3	2	3	3	3	1	1	3	-	-	1	2
		CO4	Work out SSI and MSI digital networks given a state diagram based on Mealy and Moore configurations. summarize the performance of logic families with respect to their speed, power consumption, number of ICs and cost.	1	1	3	3	3	1	1	3	2	-	1	2
		CO5	Design a combinational and sequential circuits using Verilog HDL.	1	1	2	3	3	-	-	3	-	1	1	2
ECPC15	DIGITAL SIGNAL PROCESSING	CO1	Analyze discrete-time systems in both time & transform domain and also through pole-zero placement.	3	3	0	0	0	0	0	0	0	0	0	0
		CO2	Analyze discrete-	3	3	0	0	0	0	0	0	0	0	0	0

			time signals and systems using DFT and FFT.												
		CO3	Design and implement digital finite impulse response (FIR) filters.	3	3	0	0	0	0	0	0	0	0	0	0
		CO4	Design and implement digital infinite impulse response (IIR) filters.	3	3	0	0	0	0	0	0	0	0	0	0
		CO5	Understand and develop multirate digital signal processing systems.	3	3	0	0	0	0	0	0	0	0	0	0
ECPC16	TRANSMISSION LINES AND WAVEGUIDES	CO1	Classify the Guided Wave solutions -TE, TM, and TEM.	3	3	2	3			3	3	2	2	3	3
		CO2	Analyze and design rectangular waveguides and understand the propagation of electromagnetic waves.	3	3	2	3			3	3	2	2	3	3
		CO3	Evaluate the resonance frequency of cavity Resonators and the associated modal field.	3	3	2	3			3	3	2	2	3	3

		CO4	Analyze the transmission lines and their parameters using the Smith Chart.	3	3	2	3			3	3	2	2	3	3
		CO5	Apply the knowledge to understand various planar transmission lines.	3	3	2	3			3	3	2	2	3	3
ECPC17	ELECTRONIC CIRCUITS	CO1	To illustrate the biasing methods of transistor and MOSFET amplifiers.	3	3	2	2	1	-	-	-	-	-	-	-
		CO2	To interpret the concept of single ended amplifiers.	3	3	3	2	2	-	-	-	-	-	-	-
		CO3	To illustrate differential amplifiers and their characteristics.	3	3	2	2	2	-	-	-	-	-	-	-
		CO4	To construct feedback amplifiers, oscillators and summarize its performance parameters.	3	3	3	2	2	-	-	-	-	-	-	-
		CO5	To examine the concept of biasing circuits and band gap reference circuits	3	3	2	2	2	-	-	-	-	-	-	-
ECPC18	ANALOG COMMUNICATION	CO1	To understand the basics of	3	2	2	3	2	2	0	0	0	0	0	3

			communication systems and amplitude modulation techniques												
		CO2	To apply the basic knowledge of signals and systems and understand the concept of Frequency modulation	3	3	3	3	2	2	0	0	0	0	0	3
		CO3	To apply the basic knowledge of electronic circuits and understand the effect of Noise in communication system and noise performance of AM system	3	3	3	2	2	2	2	0	0	0	0	3
		CO4	To understand the effect of noise on FM system	3	3	3	2	2	2	2	0	0	0	0	3
		CO5	To understand TDM and Pulse Modulation techniques	3	3	2	3	2	2	0	0	0	0	0	3
ECPC19	DIGITAL COMMUNICATION	CO1	Apply knowledge of signals and system and explain the conventional digital communication	3	3	0	0	0	0	0	0	0	0	0	1

			system												
		CO2	Apply the knowledge of statistical theory of communication and evaluate the performance of digital communication system in the presence of noise	3	3	0	0	0	0	0	0	0	0	0	2
		CO3	Describe and analyze the performance of digital modulation techniques	3	3	0	0	0	0	0	0	0	0	0	2
		CO4	Apply the knowledge of digital electronics and describe the error control codes like block code, cyclic code	3	3	0	0	0	0	0	0	0	0	0	3
		CO5	Describe and analyze the digital communication system with spread spectrum modulation	3	3	0	0	0	0	0	0	0	0	0	3
ECPC20	ANTENNAS AND PROPAGATION	CO1	Select the appropriate portion of electromagnetic theory and its application to antennas.	3	3	2	3	2	2	2	1	1	1	2	2
		CO2	Distinguish the	3	3	3	3	3	2	2	1	1	1	3	3

			receiving antennas from transmitting antennas, analyze and justify their characteristics.												
		CO3	Assess the need for antenna arrays and mathematically analyze the types of antenna arrays.	3	3	3	3	3	3	3	1	1	1	3	3
		CO4	Distinguish primary from secondary antennas and analyze their characteristics by applying optics and acoustics principles.	3	3	3	3	3	3	3	1	1	1	3	3
		CO5	Outline the factors involved in the propagation of radio waves using practical antennas.	3	3	3	1	1	3	3	1	1	1	2	3
ECPC21	ANALOG INTEGRATED CIRCUITS	CO1	Infer the DC and AC characteristics of operational amplifiers and their effect on output.	3	3	2	2	1	-	-	-	-	-	-	-
		CO2	Elucidate and design the linear	3	3	3	2	2	-	-	-	-	-	-	-

			and nonlinear applications of an op-amp and special application ICs.												
		CO3	Classify and identify different analog filters.	3	2	2	2	1	-	-	-	-	-	-	-
		CO4	Classify and comprehend the working principle of data converters and waveform generators.	3	3	2	2	2	-	-	-	-	-	-	-
		CO5	Illustrate the function of PLL and its application in communication and two stage op-amp compensation.	3	3	3	2	2	-	-	-	-	-	-	-
ECPC22	WIRELESS COMMUNICATION	CO1	Describe the cellular concept and analyze capacity improvement Techniques	3	2	2	0	0	0	2	0	0	0	0	3
		CO2	Mathematically analyze mobile radio propagation mechanisms. Summarize diversity reception techniques	3	3	3	0	0	0	2	0	0	0	0	3
		CO3	Design Base	3	3	3	0	0	0	2	0	0	0	0	3

			Station (BS) parameters and analyze the antenna configurations												
		CO4	Analyse and examine the multiple access techniques and its application	3	3	3	0	0	0	2	0	0	0	0	3
		CO5	Assess the latest wireless technologies	3	3	2	0	0	0	2	0	0	0	0	3
ECPC23	VLSI SYSTEMS	CO1	Describe the techniques used for VLSI fabrication, design of CMOS logic circuits, switches and memory	3	3	3	2	2	2	3			3	3	2
		CO2	Understand and explain the MOS transistor characteristics and second order effects	3	3	3	2	2	2	3			3	3	2
		CO3	Analyse and interpret delay, power estimations combinational circuit design	3	3	3	2	2	2	3			3	3	2
		CO4	Explain and compare the architectures for	3	3	3	2	2	2	3			3	3	2

			FPGA, PAL and PLDs and memory design												
		CO5	Describe the techniques for testing and understand test principles	3	3	3	2	2	2	3			3	3	2
ECPC24	RF and Microwave Engineering	CO1	Apply the basic knowledge of waveguide and microwave resonator circuits.	2	3	3	2	3		3	3	2		2	1
		CO2	Understand the methods used for generation and amplification of the microwave power.	2	3	3	2	3		3	3	2		2	1
		CO3	Distinguish between the linear and cross field electron beam microwave tubes.	2	3	3	2	3		3	3	2		2	1
		CO4	Learn the basics of S parameters and use them in describing the components	2	3	3	2	3		3	3	2		2	1
		CO5	Expose to the Microwave Measurements Principle	2	3	3	2	3		3	3	2		2	1

3 - High; 2 - Medium; 1 - Low

ESSENTIAL LABORATORY REQUIREMENT (ELR)

Course Outcomes: On successful completion of the course, students will be able to:

Course Code	Course Title	CO	Course outcomes At the end of the course student will be able	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
ECLR10	DEVICES AND NETWORKS LABORATORY	CO1	Demonstrate theoretical device/circuit operation in properly constructed analog circuits.	3	3	0	3	0	2	0	0	0	1	0	0
		CO2	Able to operate standard test equipment like multi-meters, oscilloscopes, power supplies, waveform generators, and to analyze, test, and implement circuits in breadboard.	3	3	0	3	0	2	0	0	0	1	0	0
		CO3	Able to analyze the operation of an active device and compare its performance with the expected performance given in the data sheets.	3	3	0	3	0	2	0	0	0	1	0	0
		CO4	Able to apply troubleshooting techniques to test the circuits.	3	3	0	3	0	2	0	0	0	1	0	0
		CO5	Able to analyze the circuits and concepts using the Mini project.	0	0	0	0	3	3	0	0	0	1	0	0
ECLR11	DIGITAL ELECTRONICS LABORATORY	CO1	Demonstrate theoretical device/circuit operation in properly constructed digital circuits.	3	2	0	2	0	2	0	0	0	1	0	0
		CO2	Able to correctly operate standard electronic test equipment digital multi-meters, power supplies to analyze, test, and implement digital circuits.	3	2	0	2	0	2	0	0	0	1	0	0
		CO3	Able to correctly analyze a circuit and compare its theoretical performance to	2	2	0	2	0	2	0	0	0	1	0	0

			actual performance.												
		CO4	Able to apply troubleshooting techniques to test digital circuits.	2	2	0	2	0	2	0	0	0	1	0	0
		CO5	Able to code a given digital logic design in HDL language.	0	0	1	0	2	2	0	0	0	1	0	0
ECLR12	ELECTRONIC CIRCUITS LABORATORY	CO1	Demonstrate theoretical device/circuit operation in properly constructed analog circuits	3	3	-	2	-	2	-	-	-	1	-	-
		CO2	Able to correctly operate standard electronic test equipment digital multi-meters, power supplies to analyze, test, and implement digital circuits	3	3	-	2	-	2	-	-	-	1	-	-
		CO3	Able to correctly analyze a circuit and compare its theoretical performance to actual performance	3	2	-	2	-	2	-	-	-	1	-	-
		CO4	Learn different techniques employed for the enhancement of Gain and Bandwidth	3	3	-	2	-	2	-	-	-	1	-	-
		CO5	Able to map the Circuits implemented to that of real time application	-	-	-	-	3	2	-	-	-	1	-	-
ECLR13	MICROPROCESSOR AND MICROCONTROLLER LABORATORY	CO1	Train their practical knowledge through laboratory experiments.	-	-	-	3	5	-	-	3	-	-	2	2
		CO2	Understand and write the assembly language programs to control the systems.	-	-	-	3	5	-	-	3	-	-	2	2
		CO3	Learn system-level simulator and design complete Microcontroller based modules.	-	-	-	3	5	-	-	3	-	-	2	2
		CO4	Study Code Composer Studio to develop and	-	-	-	3	5	-	-	3	-	-	2	2

			debug embedded applications												
		CO5	Do projects in IoT applications.	-	-	-	3	5	-	-	3	-	-	2	2
ECLR14	ANALOG VLSI & EMBEDDED SYSTEM DESIGN LABORATORY	CO1	Study the characteristics of negative feedback amplifier.	3	3		2		1						
		CO2	Design of an instrumentation amplifier.	3	3		2		1						
		CO3	Study the characteristics of regenerative feedback system-Schmitt trigger.	3	3		2		1						
		CO4	Design of a second order Butterworth band-pass filter for the given higher and lower cut-off frequencies	3	3		2		1						
		CO5	Design of a function generator-DSquare, Triangular wave.	3	3		2		1						
		CO6	To study, design and experimentally verify Comparators, Parity Generators and ALU using XILINX.	3	3		2		1						
		CO7	. Design of Flip-Flops, Shift-Registers & Counters Using XILINX.	3	3		2		1						
		CO8	Design and to study the DC transfer characteristics of an Inverter using Cadence.	3	3		2		1						
		CO9	Able to apply troubleshooting techniques to design, layout, simulate and test the digital circuits as blocks.	3	3		2		1						
		CO10	Able to map the Circuits implemented to that of real time application.	3	3		2		1						
ECLR15	DIGITAL SIGNAL PROCESSING LABORATORY	CO1	To write MATLAB program for signal processing functions	-	-	-	3	3	-	-	-	3	3	2	-
		CO2	To implement algorithms to realize digital filters and	-	-	-	3	3	-	-	-	3	3	2	-

			transforms												
		CO3	To write and execute application program in digital signal processors	-	-	-	3	3	-	-	-	3	3	2	-
		CO4	To implement signal processing algorithms in digital signal processors	-	-	-	3	3	-	-	-	3	3	2	-
		CO5	To learn real time interfacing and data acquisition of signals	-	-	-	3	3	-	-	-	3	3	2	-
ECLR16	COMMUNICATION ENGINEERING LABORATORY	CO1	To design analog modulation schemes such as amplitude modulation and DSBSC modulation.	3	2	0	2	0	2	0	0	0	0	0	3
		CO2	To design analog pulse modulation schemes by varying amplitude, position and width of the pulse signal.	3	3	0	2	0	2	0	0	0	0	0	3
		CO3	To perform the digital modulation by designing circuits for keying the amplitude and frequency of the carrier signal.	3	3	0	2	0	2	0	0	0	0	0	3
		CO4	To perform frequency multiplication using phase locked loop.	3	3	0	2	0	2	0	0	0	0	0	3
		CO5	To study the various modulation techniques using Circuit and System level simulators.	3	3	0	2	0	2	0	0	0	0	0	3
ECLR17	MICROWAVE & FIBER OPTIC LABORATORY	CO1	Understand the characteristics of optical sources and photodetectors in the fiber optic communication systems.	2	3	2	1	3			2	3	3	1	1
		CO2	Understand the characteristics and various propagation effects of the optical fibers.	2	3	2	1	3			2	3	3	1	1
		CO3	Construct analog and voice	2	3	2	1	3			2	3	3	1	1

			communication through optical fibers.												
		CO4	Analyze the performance parameters of the fiber optic communication systems through simulation software.	2	3	2	1	3			2	3	3	1	1
		CO5	Interpret the operating principle of wavelength division multiplexing systems.	2	3	2	1	3			2	3	3	1	1

3 - High; 2 - Medium; 1 - Low

PROGRAMME CORE (PC)

Course Code	:	ECPC10
Course Title	:	Signals and Systems
Type of Course	:	PC
Prerequisites	:	-
Contact Hours	:	4
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To make the students to understand the fundamental characteristics of signals and systems in terms of time domains.
CLO2	To make the students to understand the fundamental characteristics of signals and systems in terms of transformed domains.
CLO3	To make the students to develop the mathematical skills to solve convolution problems.
CLO4	To make the students to develop the mathematical skills to solve filtering problems.
CLO5	To make the students to develop the mathematical skills to solve modulation and sampling problems.

Course Content

Definition of Signals and Systems, Classification of Signals, Operations on signals, Singularity functions and related functions. Analogy between vectors and signals - orthogonal signal space, complete set of orthogonal functions, Parseval's relations. Fourier series representation of continuous time periodic signals -Trigonometric and Exponential Fourier series- Properties of Fourier series.

Fourier transform of aperiodic signals, standard signals and periodic signals - Properties of Fourier transforms. Hilbert transform and its properties. Laplace transforms-RoC-properties. Inverse Laplace transform.

Continuous-time Systems and its properties. Linear time invariant (LTI) system-Impulse response. Convolution. Analysis of LTI System using Laplace and Fourier transforms.

Sampling and reconstruction of band limited signals. Low pass and band pass sampling theorems. Aliasing. Anti-aliasing filter. Practical Sampling-aperture effect.

Discrete-time signals and systems. Discrete Fourier series. Z-transform and its properties. Analysis of LSI systems using Z – transform.

Text Books

1. *A.V.Oppenheim, A. Willsky, S. Hamid Nawab, "Signals and Systems (2/e)", Pearson 200.*
2. *S.Haykin and B.VanVeen "Signals and Systems, Wiley, 1998.*

References

1.	*M.Mandal and A.Asif, "Continuous and Discrete Time Signals and Systems, Cambridge, 2007.*
2.	*D.C.Lay, "Linear Algebra and its Applications (2/e)", Pearson, 200.*
3.	*S.S.Soliman & M.D.Srinath, "Continuous and Discrete Signals and Systems", Prentice- Hall, 1990*

Course Outcomes (CO)

At the end of the course student will be able

CO1	Understand the mathematical description and representation of continuous-time and discrete-time signals.
CO2	Analyze the spectral characteristics of continuous-time periodic and aperiodic signals using Fourier analysis.
CO3	Analyse system properties based on impulse response and Fourier analysis.
CO4	Convert a continuous time signal into discrete time signal and reconstruct the continuous time signals back from its samples.
CO5	Apply the Laplace transform and Z-transform respectively for the analyse of continuous-time and discrete-time signals.

Course Code	:	ECPC11
Course Title	:	Network Analysis and Synthesis
Type of Course	:	PC
Prerequisites	:	-
Contact Hours	:	4
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	**Electric circuit analysis using network theorems**
CLO2	**Find the transient and Forced response of RL ,RC and RLC networks**
CLO3	**Derive the sinusoidal response of RL, RC and RLC network**
CLO4	**Two port network parameters and interconnection of two port networks**
CLO5	**RL, RC and LC network synthesis using foster form and cauer form**

Course Content

Network concept. Elements and sources. Kirchhoff's laws. Tellegen's theorem. Network equilibrium equations. Node and Mesh method. Source superposition. Thevenin's and Norton's theorems. Network graphs.

First and second order networks. State equations. Transient response. Network functions. Determination of the natural frequencies and mode vectors from network functions.

Sinusoidal steady-state analysis. Maximum power-transfer theorem. Resonance. Equivalent and dual networks. Design of equalizers.

Two-port network parameters. Interconnection of two port networks. Barlett's bisection theorem. Image and Iterative parameters. Design of attenuators.

Two-terminal network synthesis. Properties of Hurwitz polynomial and Positive real function. Synthesis of LC, RC and RL Networks, Foster Forms and Cauer Forms.

Text Books

1. *Hayt W. H., Kemmerly J. E. and Durbin S. M., "Engineering Circuit Analysis", 6th Ed., TataMcGraw-Hill Publishing Company Ltd., 2008.*
2. *F.F. Kuo, "Network analysis and Synthesis", Wiley International Edition, 2008.*

References

1.	*Valkenberg V., "Network Analysis", 3rd Ed., Prentice Hall International Edition, 2007.*
2.	*B.S.Nair and S.R.Deepa, "Network analysis and Synthesis", Elsevier, 2012.*

Course Outcomes (CO)

At the end of the course student will be able

CO1	analyze the electric circuit using network theorems
CO2	evaluate Transient & Forced response for RL, RC ,RLC networks
CO3	determine Sinusoidal steady state response understand the real time applications of maximum power transfer theorem and equalizer
CO4	understand the two–port network parameters, are able to find out two-port network parameters & overall response for interconnection of two-port networks.
CO5	synthesize one port network using Foster form, Cauer form.

Course Code	**:**	ECPC12
Course Title	**:**	ELECTRODYNAMICS AND ELECTROMAGNETIC WAVES
Type of Course	**:**	PC
Prerequisites	**:**	NONE
Contact Hours	**:**	4
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To expose the students to the rudiments of Electromagnetic theory and wave propagation essential for subsequent courses on microwave engineering, antennas and wireless communication

Course Content

Electrostatics. Coulomb's law. Gauss's law and applications. Electric potential. Poisson's and Laplace equations. Method of images. Multipole Expansion.

Electrostatic fields in matter. Dielectrics and electric polarization. Capacitors with dielectric substrates. Linear dielectrics. Force and energy in dielectric systems.

Magneto-statics. Magnetic fields of steady currents. Biot-Savart's and Ampere's laws. Magnetic vector potential. Magnetic properties of matter.

Electrodynamics. Flux rule for motional emf. Faraday's law. Self and mutual inductances. Maxwell's Equations. Electromagnetic Boundary conditions. Poynting theorem.

Electromagnetic wave propagation. Uniform plane waves. Wave polarization. Waves in matter. Reflection and transmission at boundaries. Propagation in an ionized medium.

Text Books

1. *D.J.Griffiths, "Introduction to Electrodynamics (3/e)", PHI, 2001*
2. *E.C. Jordan & G. Balmain, "Electromagnetic Waves and Radiating Systems", PHI, 1995.*

References

1.	*W.H.Hayt, "Engineering Electromagnetics, (7/e)", McGraw Hill, 2006.*
2.	*D.K.Cheng, "Field and Wave Electromagnetics, (2/e)", Addison Wesley, 1999.*
3.	*M.N.O.Sadiku, "Principles of Electromagnetics, (4/e)", Oxford University Press, 2011.*
4.	*N.NarayanaRao, "Elements of Engineering Electromagnetics, (6/e)", Pearson, 2006.*
5.	*R.E.Collin, "Foundations for Microwave Engineering (2/e)", McGraw –Hill, 2002.*
6.	*R.E.Collin, "Antennas and Radio wave Propagation", McGraw-Hill, 1985.*

Course Outcomes (CO)

At the end of the course student will be able

CO1	recognize and classify the basic Electrostatic theorems and laws and to derive them.
CO2	discuss the behaviour of Electric fields in matter and Polarization concepts.
CO3	classify the basic Magneto static theorems and laws and infer the magnetic properties of matter.
CO4	summarize the concepts of electrodynamics &to derive and discuss the Maxwell's equations.
CO5	students are expected to be familiar with Electromagnetic wave propagation and wave polarization.

Course Code	**:**	ECPC13
Course Title	**:**	SEMICONDUCTOR PHYSICS AND DEVICES
Type of Course	**:**	PC
Prerequisites	**:**	NONE
Contact Hours	**:**	4
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To make the students understand the fundamentals of electronic devices.
CLO2	To train them to apply these devices in mostly used and important applications

Course Content

Course Content

Semiconductor materials: crystal growth, film formation, lithography, etching and doping. Formation of energy bands in solids, Concept of hole, Intrinsic and extrinsic semiconductors, conductivity, Equilibrium Carrier concentration, Density of states and Fermi level, Carrier transport – Drift and Diffusion, continuity equation, Hall effect and its applications.

P-N junction diodes, Energy band diagram, biasing, V-I characteristics, capacitances. Diode models, Break down Mechanisms, Rectifiers, Limiting and Clamping Circuits, types of diodes.

BJT Physics and Characteristics modes of operation, Ebers-Moll Model, BJT as a switch and Amplifier, breakdown mechanisms, Photo devices.

MOSFET: Ideal I-V characteristics, non-ideal I-V effects, MOS Capacitor, MOSFET as switch, CMOS Logic gate Circuits, Bi-CMOS circuits, CCDs.

State-of-the-art MOS technology: small-geometry effects, FinFETs, Ultrathin body FETs. Display devices, Operation of LCDs, Plasma, LED and HDTV

Text Books

1. *S.M.Sze, Semiconductors Devices, Physics and Technology, (2/e), Wiley, 2002*
2. *A.S.Sedra & K.C.Smith, Microelectronic Circuits (5/e), Oxford, 2004*

References

1.	*B.G.Streetman: Solid state devices, (4/e), PHI, 1995.*
2.	*Robert Pierret, "Semiconductor Device Fundamentals," Pearson Education, 2006*
3.	*J.Millman and C.C.Halkias: Electronic devices and Circuits, McGraw Hill, 1976.*
4.	*L.Macdonald & A.C.Lowe, Display Systems, Wiley, 2003*
5.	*N.H.E.Weste, D. Harris, "CMOS VLSI Design (3/e)", Pearson, 2005.*

Course Outcomes (CO)

At the end of the course student will be able

CO1	Apply the knowledge of basic semiconductor material physics and understand fabrication processes.
CO2	Analyze the characteristics of various electronic devices like diode, transistor etc.
CO3	Classify and analyze the various circuit configurations of Transistor and MOSFETs.
CO4	Illustrate the qualitative knowledge of Power electronic Devices.
CO5	Become Aware of the latest technological changes in Display Devices.

Course Code	:	ECPC14
Course Title	:	Digital Circuits and Systems
Type of Course	:	PC
Prerequisites	:	None
Contact Hours	:	3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To enable students to understand Boolean Algebra, Simplification of Boolean expressions and Logic Gates designs
CLO2	To enable students to design Combinational and Sequential logic circuits and their system level realizations.
CLO3	To understand the importance of State Machines and design of digital systems using FSM
CLO4	To enable students to write and simulate digital circuits and systems using Hardware Descriptive Language

Course Content

Review of number systems-representation-conversions, error detection and error correction. Review of Boolean algebra- theorems, sum of product and product of sum simplification, canonical forms-min term and max term, Simplification of Boolean expressions-Karnaugh map, completely and incompletely specified functions, Implementation of Boolean expressions using universal gates.

Combinational logic circuits- adders, subtractors, BCD adder, ripple carry look ahead adders, parity generator, decoders, encoders, multiplexers, de-multiplexers, Realization of Boolean expressions- using decoders-using multiplexers. Memories – ROM- organization, expansion. PROMs. Types of RAMs – Basic structure, organization, Static and dynamic RAMs, PLDs, PLAs.

Sequential circuits – latches, flip flops, edge triggering, asynchronous inputs. Shift registers, Universal shift register, applications. Binary counters – Synchronous and asynchronous up/down counters, mod-N counter, Counters for random sequence.

Synchronous circuit analysis and design: structure and operation, analysis-transition equations, state tables and state diagrams, Modelling- Moore machine and Mealy machine- serial binary adder, sequence recogniser, state table reduction, state assignment. Hazard; Overview and comparison of logic families.

Introduction to Verilog HDL, Structural, Dataflow and behavioural modelling of combinational and sequential logic circuits.

Text Books

1. *Wakerly J F, "Digital Design: Principles and Practices, Prentice-Hall", 2nd Ed., 2002.*
2. *D. D. Givone, "Digital Principles and Design", Tata Mc-Graw Hill, New Delhi, 2003.*

References

1.	*S.Brown and Z.Vranesic, "Fundamentals of Digital Logic with Verilog Design", Tata Mc-Graw Hill, 2008.*
2.	*D.P. Leach, A. P. Malvino, Goutam Guha, "Digital Principles and Applications", Tata Mc-Graw Hill, New Delhi, 2011.*
3.	*M. M. Mano, "Digital Design", 3rd ed., Pearson Education, Delhi, 2003.*
4.	*R.J.Tocci and N.S.Widner, "Digital Systems - Principles& Applications", PHI, 10th Ed., 2007.*
5.	*Roth C.H., "Fundamentals of Logic Design", Jaico Publishers. V Ed., 2009.*
6.	*T. L. Floyd and Jain,"Digital Fundamentals", 8th ed., Pearson Education, 2003.*

Course Outcomes (CO)

At the end of the course student will be able

CO1	Apply the knowledge of Boolean algebra and simplification of Boolean expressions to deduce optimal digital circuits.
CO2	Study and examine the SSI, MSI and Programmable combinational circuits.
CO3	Study and investigate the sequential networks using counters and shift registers.
CO4	Work out SSI and MSI digital networks given a state diagram based on Mealy and Moore configurations. summarize the performance of logic families with respect to their speed, power consumption, number of ICs and cost.
CO5	Design a combinational and sequential circuits using Verilog HDL.

Course Code	**:**	ECPC15
Course Title	**:**	DIGITAL SIGNAL PROCESSING
Type of Course	**:**	PC
Prerequisites	**:**	ECPC10
Contact Hours	**:**	4
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To study about discrete-time Fourier transform (DTFT), the concepts of frequency response characteristics of a discrete-time systems, DFT and its fast computation.
CLO2	To make the students able to design digital filters (FIR and IIR) and implement in various forms.
CLO3	To study and understand the concept of multirate DSP systems and its applications

Course Content

Review of LSI system, DTFT, Frequency response of discrete time systems, all pass inverse, linear phase and minimum phase systems.

DFT, Relationship of DFT to other transforms, FFT, DIT and DIF, FFT algorithm, Linear filtering using DFT and FFT.

Characteristics of FIR Digital Filters, types and frequency response - Design of FIR digital filters using window techniques and frequency sampling technique - basic structures and lattice structure for FIR systems.

Analog filter approximations – Butter worth and Chebyshev, Design of IIR Digital filters from analog filters, Analog and Digital frequency transformations - Basic structures of IIR systems, Transposed forms.

Sampling rate conversion by an integer and rational factor, Poly phase FIR structures for sampling rate conversion.

Text Books

1. *J.G.Proakis, D.G. Manolakis, "Digital Signal Processing", (4/e) Pearson, 2007.*
2. *A.V.Oppenheim & R.W.Schafer, "Discrete Time Signal processing", (2/e), Pearson Education, 2003.*

References

1.	*S.K.Mitra, "Digital Signal Processing (3/e)", Tata McGraw Hill, 2006.*
2.	*P.S.R.Diniz, E.A.B.da Silva and S.L.Netto, "Digital Signal Processing", Cambridge, 2002.*
3.	*E.C.Ifeachor & B.W.Jervis, "Digital Signal Processing", (2/e), Pearson Education, 2002.*
4.	*J.R.Jhonson, "Introduction to Digital Signal Processing", Prentice-Hall, 1989.*

Course Outcomes (CO)

At the end of the course student will be able

CO1	analyze discrete-time systems in both time & transform domain and also through pole-zero placement.
CO2	analyze discrete-time signals and systems using DFT and FFT.
CO3	design and implement digital finite impulse response (FIR) filters.
CO4	design and implement digital infinite impulse response (IIR) filters.
CO5	understand and develop multirate digital signal processing systems.

Course Code	**:**	ECPC16
Course Title	**:**	TRANSMISSION LINES AND WAVEGUIDES
Type of Course	**:**	PC
Prerequisites	**:**	ECPC12
Contact Hours	**:**	3
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To expose students to the complete fundamentals and essential feature of waveguides, resonators and microwave components and also able to give an introduction to microwave integrated circuit design.

Course Content

Classification of guided wave solutions-TE, TM and TEM waves. Field analysis transmission lines.

Rectangular and circular waveguides. Excitation of waveguides. Rectangular and circular cavity resonators.

Transmission line equations. Voltage and current waves. Solutions for different terminations. Transmission-line loading.

Impedance transformation and matching. Smith Chart, Quarter-wave and half-wave transformers. Binomial and T chebeyshev transformers. Single, double and triple stub matching.

Micro-striplines, stripline, slot lines, coplanar waveguide and fin line. Micro strip MIC design aspects. Computer- aided analysis and synthesis.

Text Books

1. *D.M.Pozar, "Microwave Engineering (3/e)" Wiley, 2004.*
2. *J.D.Ryder, "Networks, Lines and Fields", PHI, 2003.*

References

1.	*R.E.Collin, "Foundations for Microwave Engineering (2/e)", McGraw-Hill, 2002.*
2.	*S.Y.Liao, "Microwave Devices and Circuits", (3/e) PHI, 2005.*
3.	*J. A. Seeger, "Microwave Theory, Components, and Devices" Prentice-Hall-A division of Simon & Schuster Inc Englewood Cliffs, New Jersy 07632, 1986.*

Course Outcomes (CO)

At the end of the course student will be able

CO1	classify the Guided Wave solutions -TE, TM, and TEM.
CO2	analyze and design rectangular waveguides and understand the propagation of electromagnetic waves.
CO3	evaluate the resonance frequency of cavity Resonators and the associated modal field.
CO4	analyze the transmission lines and their parameters using the Smith Chart.
CO5	apply the knowledge to understand various planar transmission lines.

Course Code	**:**	ECPC17
Course Title	**:**	**ELECTRONIC CIRCUITS**
Type of Course	**:**	PC
Prerequisites	**:**	ECPC13
Contact Hours	**:**	3
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	**To make the students understand the fundamentals of electronic circuits**

Course Content

Load line, operating point, biasing methods for BJT and MOSFET. Low frequency and high frequency models of BJT and MOSFET, Small signal Analysis of CE, CS, CD and Cascode amplifier

Single-ended amplifiers: CS amplifier – with resistive load, diode connected load, current source load, triode load, source degeneration. CG and CD amplifiers, Cascode amplifier

Frequency response of amplifiers, Differential Amplifiers, CMRR, Differential amplifiers with active load, two stage amplifiers

Feedback concept, Properties, Feedback amplifiers, Stability analysis, Condition for oscillation, Sinusoidal oscillators.

Biasing circuits: Current mirrors, Basic current mirror, Cascode current mirror, constant gm circuits, Introduction to Band-Gap reference circuits.

Textbooks

1. A.S.Sedra & K.C.Smith, “Microelectronic Circuits (5/e)”, Oxford, 2004.
2. D.L.Schilling & C.Belove,” Electronic Circuits: Discrete and Integrated”, (3/e), McGraw Hill, 1989.
3. Behzad Razavi, “Design of Analog CMOS Integrated Circuits”, (2/e), McGraw Hill, 2017.

References

1.	J.Millman & Arvin Grabel, “Microelectronics”, McGraw Hill, 2007.
2.	Donald A Neamen, “Electronic Circuits Analysis and Design”, 3/e, McGraw Hill, 2007

Course Outcomes (CO)

At the end of the course student will be able

CO1	to illustrate rectifiers, transistor and FET amplifiers and their biasing. Also compare the performances of its low frequency models
CO2	to interpret and use the concepts of single ended amplifiers
CO3	to discuss the frequency response of MOSFET amplifiers and illustrate about MOS and BJT differential amplifiers and their characteristics.
CO4	to discuss feedback concepts and construct feedback amplifiers and oscillators. Also summarizes its performance parameters.
CO5	to identify the concept of biasing circuits and band gap reference circuits

Course Code	:	ECPC18
Course Title	:	**ANALOG COMMUNICATION**
Type of Course	:	PC
Prerequisites	:	ECPC10
Contact Hours	:	3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To develop a fundamental understanding of communication systems with emphasis on amplitude modulation techniques.
CLO2	To get an understanding of communication systems with frequency modulation techniques.
CLO3	To study the types of noise and its effect on communication systems.
CLO4	To learn the fundamental limitations of communication systems.
CLO5	To learn TDM and pulse analog modulation techniques.

Course Content

Basic blocks of Communication System. Amplitude (Linear) Modulation – AM, DSB-SC, SSB-SC and VSB-SC. Methods of generation and detection. FDM. Super Heterodyne Receivers.

Angle (Non-Linear) Modulation - Frequency and Phase modulation. Transmission Bandwidth of FM signals, Methods of generation and detection. FM Stereo Multiplexing.

Noise - Internal and External Noise, Noise Calculation, Noise Figure. Noise in linear and nonlinear AM receivers, Threshold effect.

Noise in FM receivers, Threshold effect, Capture effect, FM Threshold reduction, Pre-emphasis and De-emphasis.

Pulse Modulation techniques – Sampling Process, PAM, PWM and PPM concepts, Methods of generation and detection. TDM. Noise performance.

Textbooks

1. S.Haykins, Communication Systems, Wiley, (4/e), Reprint 2009.
2. Kennedy, Davis, Electronic Communication Systems (4/e), McGraw Hill, Reprint 2008.

References

1.	B.Carlson, Introduction to Communication Systems, McGraw-Hill, (4/e), 2009.
2.	J.Smith, Modern Communication Circuits (2/e), McGraw Hill, 1997.
3.	J.S.Beasley and G.M.Miler, Modern Electronic Communication (9/e), Prentice-Hall, 2008.

Course Outcomes (CO)

At the end of the course student will be able

CO1	To understand the basics of communication systems and amplitude modulation techniques.
CO2	To apply the basic knowledge of signals and systems and understand the concept of Frequency modulation.
CO3	To apply the basic knowledge of electronic circuits and understand the effect of noise in communication system and noise performance of AM system.
CO4	To understand the effect of noise on FM system.
CO5	To understand TDM and pulse modulation techniques.

Course Code	:	ECPC19
Course Title	:	**DIGITAL COMMUNICATION**
Type of Course	:	PC
Prerequisites	:	ECPC10
Contact Hours	:	4
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To help students understand the key modules of digital communication systems.
CLO2	To expose students to different digital modulation techniques.
CLO3	To get students introduced to the basics of source and channel coding/decoding
CLO4	To get students introduced to the basics of Spread Spectrum Modulation.

Course Content

Base band transmission. Sampling theorem, Pulse code modulation (PCM), DM, Destination SNR in PCM systems with noise. Matched filter. Nyquist criterion for zero ISI. Optimum transmit and receive filters. Correlative Coding, M-Ary PAM. Equalization- zero-forcing and basics of adaptive linear equalizers.

BASK, BFSK, and BPSK- Transmitter, Receiver, Signal space diagram, Error probabilities.

M-Ary PSK, M-Ary FSK, QAM, MSK and GMSK- Optimum detector, Signal constellation, error probability.

Linear block codes-Encoding and decoding. Cyclic codes – Encoder, Syndrome Calculator. Convolutional codes – encoding, Viterbi decoding. TCM.

Spread Spectrum (SS) Techniques - Direct Sequence Spread Spectrum modulation, Frequency-hop Spread Spectrum modulation - Processing gain and jamming margin.

Textbooks

1. S.Haykin, “Communication Systems”, Wiley, (4/e), 2001.
2. J.G.Proakis, “Digital Communication”, Tata McGraw – Hill, (4/e), 2001.

References

1.	B.Sklar, “Digital Communications: Fundamentals & Applications”, Pearson Education, (2/e), 2001.
2.	A.B.Carlson, “Communication Systems”, McGraw Hill, 3/e,2002.
3.	R.E.Zimer and R.L.Peterson,” Introduction to Digital Communication”, PHI,3/e, 2001.

Course Outcomes (CO)

At the end of the course student will be able

CO1	Apply the knowledge of signals and system and explain the conventional digital communication system.
CO2	Apply the knowledge of statistical theory of communication and evaluate the performance of digital communication systems in the presence of noise.
CO3	Describe and analyze the performance of digital modulation techniques.
CO4	Apply the knowledge of digital electronics and describe the error control codes like block code, cyclic code.
CO5	Describe and analyze the digital communication system with spread spectrum modulation.

Course Code	:	ECPC20
Course Title	:	**ANTENNAS AND PROPAGATION**
Type of Course	:	PC
Prerequisites	:	ECPC12
Contact Hours	:	3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To impart knowledge on basics of antenna theory and to analyze and design a start of art antenna for wireless communications.

Course Content

Radiation fundamentals. Potential theory. Helmholtz integrals. Radiation from a current element. Basic antenna parameters. Radiation field of an arbitrary current distribution. Small loop antennas.

Receiving antenna. Reciprocity relations. Receiving cross section, and its relation to gain. Reception of completely polarized waves. Linear antennas. Current distribution. Radiation field of a thin dipole. Folded dipole. Feeding methods. Baluns.

Antenna arrays. Array factorization. Array parameters. Broad side and end fire arrays. Yagi-Uda arrays Log-periodic arrays.

Aperture antennas. Fields as sources of radiation. Horn antennas. Babinet's principle. Parabolic reflector antenna. Microstrip antennas.

Wave Propagation: Propagation in free space. Propagation around the earth, surface wave propagation, structure of the ionosphere, propagation of plane waves in ionized medium, Determination of critical frequency, MUF. Fading, tropospheric propagation, Super refraction.

Textbooks

1. R.E.Collin, "Antennas and Radio Wave Propagation", McGraw – Hill, 1985.
2. W.L.Stutzman and G.A.Thiele, "Antenna Theory and Design", Wiley.

References

1.	K.F.Lee, "Principles of Antenna Theory", Wiley, 1984.
2.	F.E. Terman, "Electronic Radio Engineering (4/e)", McGraw Hill.
3.	J.R. James, P. S. Hall, and C. Wood, "Microstrip Antenna Theory and Design", IEE, 1981.
4.	C.A.Balanis, "Modern Antenna Handbook", Wiley India Pvt. Limited, 2008.

Course Outcomes (CO)

At the end of the course student will be able

CO1	Select the appropriate portion of electromagnetic theory and its application to antennas.
CO2	Distinguish the receiving antennas from transmitting antennas, analyze and justify their characteristics.
CO3	Assess the need for antenna arrays and mathematically analyze the types of antenna arrays.
CO4	Distinguish primary from secondary antennas and analyze their characteristics by applying optics and acoustics principles.
CO5	Outline the factors involved in the propagation of radio waves using practical antennas.

Course Code	:	ECPC21
Course Title	:	**ANALOG INTEGRATED CIRCUITS**
Type of Course	:	PC
Prerequisites	:	ECPC17
Contact Hours	:	4
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To introduce the theoretical & circuit aspects of analog integrated circuits.

Course Content

CMOS differential amplifiers: DC analysis and small signal analysis of differential amplifier with Restive load, current mirror load and current source load, Input common-mode range. Operational Amplifiers, DC and AC characteristics, typical op-amp parameters.

Applications of Op-amp: Summing and difference amplifier, Integrators and differentiators, Log and antilog amplifiers. Instrumentation amplifiers, voltage to current converters. Comparator, Multivibrators, Schmit trigger, 555 timer and applications.

Active filters: Second order filter transfer function (low pass, high pass, band pass and band reject), Butterworth and Chebyshev filter. Universal filter, Switched capacitor filter.

Triangular wave generator using OPAMP. RC phase shift and Wien bridge oscillator, Data converters: A/D and D/A converters: Flash, SAR, Dual-slope, Current Steering DAC, Introduction to sigma delta ADCs.

Two stage operational amplifiers, Compensation in amplifiers (Dominant pole compensation), OTAs Vs OPAMP Slew rate, CMRR, PSRR, Introduction to PLL- basic block diagram and its application.

Textbooks

1. S. Franco, Design with Operational Amplifiers and Analog Integrated Circuits (3/e) TMH, 2003.
2. Sedra and Smith, Microelectronics Circuits, Oxford Univ. Press, 2004.

References

1.	Coughlin, Driscoll, OP-AMPS and Linear Integrated Circuits, Prentice Hall, 2001.

Course Outcomes (CO)

At the end of the course student will be able

CO1	Infer the DC and AC characteristics of operational amplifiers and their effect on output.
CO2	Elucidate and design the linear and nonlinear applications of an op-amp and special application ICs.
CO3	Classify and identify different analog filters.
CO4	Classify and comprehend the working principle of data converters and waveform generators.
CO5	Illustrate the function of PLL and its application in communication and two stage op-amp compensation.

Course Code	:	ECPC22
Course Title	:	**WIRELESS COMMUNICATION**
Type of Course	:	PC
Prerequisites	:	ECPC19
Contact Hours	:	3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To get an understanding of mobile radio communication and capacity enhancement
CLO2	To learn the fundamental limitations on the performance of wireless systems
CLO3	To analyze the parameters for base station design
CLO4	To understand how access methods can accommodate large number of users
CLO5	To study the wide range of wireless systems

Course Content

Introduction to Wireless Communication. Cellular concept. System design fundamentals. Coverage and Capacity improvement in Cellular system. Technical Challenges.

Mobile Radio Propagation; Reflection, Diffraction, Fading. Multipath propagation. Statistical characterization of multipath fading. Diversity Techniques.

Path loss prediction over hilly terrain. Practical link budget design using Path loss models. Design parameters at base station. Antenna location, spacing, heights and configurations.

Multiple access techniques; FDMA, TDMA and CDMA. Spread spectrum. Power control. WCDMA.CDMA network design. OFDM and MC-CDMA.

GSM.3G, 4G (LTE), NFC systems, WLAN technology. WLL. Hyper LAN. Ad hoc networks. Bluetooth.

Textbooks

1. T.S.Rappaport, Wireless Communication Principles (2/e), Pearson, 2002.
2. A.F.Molisch, Wireless Communications, Wiley, 2005.

References

1.	P.MuthuChidambaraNathan, Wireless Communications, PHI, 2008.
2.	W.C.Y.Lee, Mobile Communication Engineering. (2/e), McGraw- Hill, 1998.
3.	A.Goldsmith, Wireless Communications, Cambridge University Press, 2005.
4.	S.G.Glisic, Adaptive CDMA, Wiley, 2003.
5.	Aditya Jagannatham, “Principles of Modern wireless Communication Systems, Theory and Practice”, McGraw Hill, 2016.

Course Outcomes (CO)

At the end of the course student will be able

CO1	Describe the cellular concept and analyze capacity improvement Techniques.
CO2	Mathematically analyze mobile radio propagation mechanisms and diversity reception techniques.
CO3	Design Base Station (BS) parameters and analyze the antenna configurations.
CO4	Analyze and examine the multiple access techniques and their application.
CO5	Assess the latest wireless technologies.

Course Code	:	ECPC23
Course Title	:	**VLSI SYSTEMS**
Type of Course	:	PC
Prerequisites	:	ECPC21
Contact Hours	:	3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To introduce various aspects of VLSI circuits and their design including testing
CLO2	To provide rigorous foundation in MOS and CMOS digital circuits
CLO3	To train the students in transistor budgets, clock speeds and the growing challenges of power consumption and productivity
CLO4	To introduce the students to memory design techniques and FPGA fundamental concepts

Course Content

VLSI design methodology, VLSI technology- NMOS, CMOS and BICMOS circuit fabrication. Layout design rules. Stick diagram. Latch up. FINFET Technologies.

Characteristics of MOS and CMOS switches. Implementation of logic circuits using MOS and CMOS technology, multiplexers and memory, MOS transistors, threshold voltage, MOS device design equations. MOS models, non-ideal I-V effects, DC transfer characteristics of CMOS inverter. Switch level RC delay models.

Circuit characterization and performance estimation: Delay estimation, Logical effort and transistor sizing, Power dissipation. Combinational circuit design: Static CMOS, Ratioed circuits, Cascode voltage switch logic, Dynamic circuits, Pass transistor circuits.

Programmable logic devices- anti fuse, EPROM and SRAM & DRAM techniques in CMOS. Programmable logic cells. Programmable inversion and expander logic. An overview of the features of advanced FPGAs, IP cores, soft core processors.

VLSI testing -need for testing, manufacturing test principles, design strategies for test, chip level and system level test techniques.

Textbooks

1. N. H. E. Weste, D.F. Harris, “CMOS VLSI design”, (3/e), Pearson, 2005.
2. J. Smith, “Application Specific Integrated Circuits, Pearson”, 1997.
3. R.Jacob Baker, Harry W.LI., David E.Boyee, “CMOS Circuit Design, Layout and Simulation”, Prentice Hall of India 2005.

References

1.	M.M.Vai, “VLSI design”, CRC Press, 2001.
2.	Pucknell & Eshraghian, “Basic VLSI Design”, PHI, (3/e), 2003.
3.	Uyemura, “Introduction to VLSI Circuits and Systems”, Wiley, 2002.

Course Outcomes (CO)

At the end of the course student will be able

CO1	Describe the techniques used for VLSI fabrication, design of CMOS logic circuits, switches and memory
CO2	Understand and explain the MOS transistor characteristics and second order effects.
CO3	Analyse and interpret delay, power estimations combinational circuit design
CO4	Explain and compare architectures for FPGA, PAL & PLDs and memory design.
CO5	Describe the techniques for testing and understand test principles.

Course Code	:	ECPC24
Course Title	:	**RF and Microwave Engineering**
Type of Course	:	PC
Prerequisites	:	ECPC16
Contact Hours	:	3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To impart knowledge on basics of microwave electron beam devices and their applications in X band frequency and introduces the essential Microwave Circuit Theory and the design aspects of Microwave Integrated Circuit components.

Course Content

Limitations of Conventional tubes, two cavity Klystron Amplifier, Velocity modulation and Bunching Process, Reflex klystron oscillator –Multi cavity Klystron-Travelling Wave Tube amplifier- Magnetron Working principle and modes of Operation

Two port Network theory- Scattering Matrix formulation- Passive microwave devices: E and H junction-hybrid junctions, terminations, bends, corners, attenuators, phase changers, directional couplers, Circulator, Isolator

Transferred Electron and Avalanche Devices: Gunn Diode, read diode, IMPATT, TRAPATT and BARIT

Design and Realization of MIC Components: Basics of Micro strip and Strip line – 3 dB Hybrid Design, Rat Race Coupler, Power Dividers

Microwave Measurements: Introduction to microwave Bench Set-up, Frequency, Wavelength, VSWR and Impedance Measurement. Network Analyzer, Spectrum analyzer.

Textbooks

1. I.J.Bahl & P.Bhartia, “Microwave Solid state Circuit Design”, Wiley, 2003.
2. S.Y.Liao, “Microwave Devices and Circuits (3/e)”, PHI, 2005.
3. D.M.Pozar, “Microwave Engineering (2/e)”, Wiley, 2004.

References

1.	A. Das, “Microwave Engineering”, Tata McGraw Hill, 2000.
2.	B.Bhat, S. K. Koul,”Stripline like transmission lines for Microwave Integrated Circuits”, New age International Pvt.Ltd. Publishers 2007.

Course Outcomes (CO)

At the end of the course student will be able

CO1	Apply the basic knowledge of waveguide and microwave resonator circuits.
CO2	Understand the methods used for generation and amplification of microwave power.
CO3	Distinguish between the linear and cross field electron beam microwave tubes.
CO4	Learn the basics of S parameters and use them in describing the components.
CO5	Expose to the Microwave Measurements Principle.

PROGRAMME ELECTIVES (PE)

Course Code	:	ECPE10
Course Title	:	**NETWORKS AND PROTOCOLS**
Type of Course	:	PE
Prerequisites	:	NONE
Contact Hours	:	3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To familiarize students with the importance of protocol stacks.
CLO2	To learn about two fundamental transports layer protocols and its purpose
CLO3	To know the implementation of host-to-host communication
CLO4	To explore several link layer technologies
CLO5	To understand the theory behind Secured Communication

Course Content

Network Components, Topologies, Network hardware and software, Network Models: OSI Model & TCP/IP Protocol stack, HTTP FTP, SMTP, POP, SNMP, DNS, Socket programming with TCP and UDP.

Transport Layer services, UDP, TCP, SCTP, Principles of reliable data transfer, Flow control, Congestion Control, Quality of Service. Simulation study on Reliable data transfer in TCP.

Network Layer services, Datagram and Virtual circuit service, DHCP, IPV4, IPV6, ICMP, Unicast routing protocols: DV, LS and Path vector routing, Multicast routing.

Data Link Layer services, Overview of Circuit and Packet switches, ARP, Data link control: HDLC & PPP, Multiple access protocols, Wireless LAN, Comparison wired and wireless LAN.

Network security threats, Cryptography, Security in the Internet: IP Security & Firewalls, Multimedia: Streaming stored video/ audio, RTP, Network Troubleshooting.

References

1.	J.F.Kurose & K.W.Ross, “Computer Networking: A Top-Down Approach featuring the Internet”, Pearson, 5th edition, 2010.
2.	B.A. Forouzan,” Data Communications & Networking”, Tata McGraw- Hill, 4th edition, 2006.
3.	W.Stallings, “Data & Computer Communications”, PHI, 9th edition, 2011.
4.	W.Stallings, “Cryptography & Network Security”, Pearson, 5th edition, 2011.
5.	A.S.Tanenbaum & D.J. Wetherall, “Computer Networks”, Pearson, 5th edition, 2014.
6.	Recent literature in Networks and Protocols.

Course Outcomes (CO)

At the end of the course student will be able

CO1	Compare and examine, OSI and TCP/IP protocol stacks Protocols.
CO2	Analyze a network under congestion and propose solutions for reliable data transfer.
CO3	Analyze the need for Internetworking and evaluate Intra and Inter Routing.
CO4	Explore various Link layer technologies.
CO5	Assess the cryptographic techniques, manage a network and propose solutions under network security threats.

Course Code	:	ECPE11
Course Title	:	**Wireless Local Area Networks (WLAN)**
Type of Course	:	PE
Prerequisites	:	ECPE10
Contact Hours	:	3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To expose students to wireless local area network standards
CLO2	To expose students to latest PHY layer principles in WLAN
CLO3	To expose students to MAC layer protocols in WLAN
CLO4	To expose students to network entry process in WLAN
CLO5	To introduce students to analyzing real life traces

Course Content

WLAN Introduction and Basics - 802.11 protocol stack basics, RF spectrum of operations, unlicensed band usage, Types of networks and their usage, Role of Wi-Fi alliance. Exercises: Survey of WLAN products in consumer appliances.

Evolution of WLAN Layer. The ISM PHYs: FH, DS and HR/DS, basics of OFDM design and parameters for WLAN, MIMO usage in WLAN, Throughput enhancements, Matlab Simulation of channel models and studying their characteristics

CSMA/CA principles used for WLAN MAC, Details of MAC protocol, medium reservation and hidden nodes, MAC Frame Aggregation and QoS in WLAN, Roaming, Throughput calculation.

Network Entry Process in WLAN, Security Evolution, Power save concepts, Throughput and performance of WLAN, Network tracking operations.

Sniffing WLAN Frames and analysis using open-source tools, inferring capabilities of APs and clients, analyzing network entry steps and debugging connection problems, Analyzing Data transmission and debugging performance issues, Analysis of Roaming performance.

References

1.	Eldad Perahia and Robert Stacey, Next Generation wireless LANS 802.11n and 802.11ac, 2nd edition, Cambridge University Press, 2013.
2.	Mathew Gast, 802.11 Wireless Networks: The Definitive Guide, 2nd Edition, OReily, 2009.
3.	Mathew Gast, 802.11n: A Survival Guide: Wi-Fi Above 100 Mbps, OReilly, 2012.
4.	Mathew Gast, 802.11ac: A Survival Guide: Wi-Fi at Gigabit and Beyond, OReilly, 2012.

Course Outcomes (CO)

At the end of the course student will be able

CO1	To understand basics of WLAN systems including standardizing bodies, unlicensed spectrum ranges, network types.
CO2	Appreciate physical layer challenges and solutions in 802.11 standards and be able to simulate channel conditions.
CO3	Be able to explain MAC layer steps in WLAN along with the motivation and impacts on throughput and coexistence
CO4	Trace the steps followed in a typical WLAN network with a clear understanding of security, power save, and network entry procedures
CO5	Analyze real-life protocol traces under various conditions and correlate with the concepts learnt in the earlier sections under network security threats.

Course Code	**:**	ECPE12
Course Title	**:**	**MICROPROCESSORS AND MICRO CONTROLLERS**
Type of Course	**:**	PE
Prerequisites	**:**	ECPC14
Contact Hours	**:**	3
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	This subject deals about the basics of 16-bit Microprocessor, 8-bit and 16-bit Micro controllers, their architectures, internal organization and their functions, peripherals, and interfacing

Course Content

Microprocessor based personal computer system. Software model of 8086. Segmented memory operation. Instruction set. Addressing modes. Assembly language programming. Interrupts. Programming with DOS and BIOS function calls.

Hardware detail of 8086. Bus timing. Minimum Vs Maximum mode of operation. Memory interface. Parallel and serial data transfer methods. 8255 PPI chip. 8259 Interrupt controller. 8237 DMA controller. Microcontroller. Von-Neumann Vs Harvard architecture. Programming model. Instruction set of 8051 Microcontroller. Addressing modes. Programming. Timer operation.

Mixed Signal Microcontroller: MSP430 series. Block diagram. Address space. On-chip peripherals -analog and digital. Register sets. Addressing Modes. Instruction set. Programming. FRAM Vs flash for low power and reliability.

Peripheral Interfacing using 8051 and Mixed signal microcontroller. Serial data transfer - UART, SPI and I2C. Interrupts. I/O ports and port expansion. DAC, ADC, PWM, DC motor, Stepper motor and LCD interfacing.

Text Book

1.	J.L.Antonakos, “An Introduction to the Intel Family of Microprocessors”, Pearson, 1999.
2.	M.A.Mazidi & J.C.Mazidi “Microcontroller and Embedded systems using Assembly & C (2/e)”, Pearson Education, 2007.

References

1.	John H. Davies, “MSP430 Microcontroller Basics”, Elsevier Ltd., 2008
2.	B.B. Brey, “The Intel Microprocessors, (7/e), Eastern Economy Edition”, 2006.
3.	K.J. Ayala, “The 8051 Microcontroller “, (3/e), Thomson Delmar Learning, 2004.
4.	I. S. MacKenzie and R.C.W.Phan., “The 8051 Microcontroller. (4/e)”, Pearson education, 2008.

Course Outcomes (CO)

At the end of the course student will be able

CO1	Recall and apply the basic concept of digital Fundamentals to Microprocessor based personal Computer system.
CO2	Illustrate how the different peripherals are interfaced with Microprocessor.
CO3	Distinguish and analyze the properties of Microprocessors & Microcontrollers.
CO4	Understand a low power and reliability concept of mixed signal Microcontrollers.
CO5	Analyze the data transfer information through serial & parallel ports.

Course Code	**:**	ECPE13
Course Title	**:**	**COMPUTER ARCHITECTURE AND ORGANIZATION**
Type of Course	**:**	PE
Prerequisites	**:**	None
Contact Hours	**:**	3
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To understand how computers are constructed out of a set of functional units and how the functional units operate, interact, and communicate.
CLO2	To make the students to understand the concept of interfacing memory and various I/O devices to a computer system using a suitable bus system.

Course Content

Introduction: Function and structure of a computer, Functional components of a Computer, Interconnection of components, Performance of a computer.

Representation of Instructions: Machine instructions, Memory locations & Addresses, Operands, addressing modes, Instruction formats, Instruction sets, Instruction set architectures - CISC and RISC architectures, Super scalar Architectures, Fixed point and floating-point operations.

Basic Processing Unit: Fundamental concepts, ALU, Control unit, Multiple bus organization, Hardwired control, Micro programmed control, Pipelining, Data hazards, Instruction hazards, Influence on instruction sets, Data path and control considerations, Performance considerations.

Memory organization: Basic concepts, Semiconductor RAM memories, ROM, Speed - Size and cost, Memory Interfacing circuits, Cache memory, improving cache performance, Memory management unit, Shared/Distributed Memory, Cache coherency in multiprocessor, Segmentation, Paging, Concept of virtual memory, Address translation, Secondary storage devices.

I/O Organization: Accessing I/O devices, Input/output programming, Interrupts, Exception Handling, DMA, Buses, I/O interfaces- Serial port, Parallel port, PCI bus, SCSI bus, USB bus, Firewall and Infinity band, I/O peripherals.

Text Book

1.	C.Hamacher Z. Vranesic S. Zaky and Manjikian, "Computer Organization and Embedded Systems", 6 th Edition, McGraw-Hill, 2012.
2.	W. Stallings, "Computer Organization and Architecture - Designing for Performance", 8Th Edition, Prentice Hall of India, 2010.

References

1.	B,Parhami, “Computer Architecture, From Microprocessors to Supercomputers,” Oxford University Press, Reprint 2014.
2.	J. L. Hennessy and D. A. Patterson, "Computer Architecture, A Quantitative Approach”, 5 th Edition, Morgan Kaufmann,2012.
3.	J .P. Hayes, "Computer Architecture and Organization", 3 rd Edition, McGraw-Hill, 1998.
4.	Recent literature in Computer Architecture and Organization.

Course Outcomes (CO)

At the end of the course student will be able

CO1	apply the basic knowledge of digital concept to the functional components of a Computer System.
CO2	analyze the addressing mode concepts and design the instruction set Architecture.
CO3	identify the functions of various processing units within the CPU of a Computer System.
CO4	analyze the function of the memory management unit and create suitable memory interface to the CPU.
CO5	recognize the need for recent Bus standards and I/O devices.

Course Code	**:**	ECPE14
Course Title	**:**	**EMBEDDED SYSTEMS**
Type of Course	**:**	PE
Prerequisites	**:**	None
Contact Hours	**:**	3
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To make the students to understand and program embedded systems using modern embedded processors.
CLO2	This course describes example embedded platforms, interfaces, peripherals, processors and operating systems associated with embedded systems, a comprehensive view of the software frame work being developed around embedded SOCs.

Course Content

Introduction to Embedded Computing: Characteristics of Embedding Computing Applications, Concept of Real time Systems, Challenges in Embedded System Design, Design Process. Embedded System Architecture: Instruction Set Architecture, CISC and RISC instruction set architecture, Basic Embedded Processor/Microcontroller Architecture (ATOM processor, Introduction to Tiva family etc.)

Designing Embedded Computing Platform: Bus Protocols, Bus Organization, Memory Devices and their Characteristics, Memory mapped I/O, I/O Devices, I/O mapped I/O, Timers and Counters, Watchdog Timers, Interrupt Controllers, Interrupt programming, GPIO control, Sensors, Actuators, A/D and D/A Converters, Need of low power for embedded systems, Mixed Signals Processing.

Programming Embedded Systems: Basic Features of an Operating System, Kernel Features, Real-time Kernels, Processes and Threads, Context Switching, Scheduling, Shared Memory Communication, Message-Based Communication, Real-time Memory Management, Dynamic Allocation, Device Drivers, Real-time Transactions and Files, Real-time OS (VxWorks, RT-Linux, Psos).

Network Based Embedded Applications: Embedded Networking Fundamentals, Layers and Protocols, Distributed Embedded Architectures, Internet-Enabled Systems, IoT overview and architecture, Interfacing Protocols (like UART, SPI, I2C, GPIB, FIREWIRE, USB,). Various wireless protocols and its applications: NFC, Zig Bee, Bluetooth, Bluetooth Low Energy, Wi-Fi. CAN. Overview of wireless sensor networks and design examples
Case studies: Programming in Embedded C, Embedded system design using Arduino, ATOM processors, Galileo and Tiva based embedded system applications.

Text Book

1.	Wayne Wolf, “Computers as Components- Principles of Embedded Computing System Design”, Morgan Kaufmann Publishers, Second edition, 2008.
2.	Barry Crowley, “Modern Embedded Computing”, Morgan Kaufmann Publishers, 2012.

References

1.	Lyla B. Das, “Embedded Systems – An Integrated Approach”, Pearson, 2013.
2.	Marwedel Peter, “Embedded System Design, Kluwer Publications, 2004.
3.	C.M. Krishna, Kang G. Shin, “Real time systems”, Mc- Graw Hill, 2010
4.	Recent literature in Embedded Systems.

Course Outcomes (CO)

At the end of the course student will be able

CO1	get an insight into the overall landscape and characteristics of embedded systems.
CO2	facilitate a comprehensive understanding of the overall platform architecture of modern embedded computing systems.
CO3	develop application software for embedded systems using the RTOS functions.
CO4	enable network connectivity of the embedded systems via a combination of wired and wireless network interfaces.
CO5	design and program embedded systems based on their applications.

Course Code	**:**	ECPE15
Course Title	**:**	**OPERATING SYSTEMS**
Type of Course	**:**	PE
Prerequisites	**:**	None
Contact Hours	**:**	3
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To expose the principles and practice of operating system design and to illustrate the current design practices using DOS and UNIX operating systems.

Course Content

Types of operating systems, Different views of the operating system, Principles of Design and Implementation. The process and threads. System programmer's view of processes, Operating system's views of processes, Operating system services for process management. Process scheduling, Schedulers, Scheduling algorithms. Overview of Linux operating system.

Inter process synchronization, Mutual exclusion algorithms, Hardware support, Semaphores, Concurrent programming using semaphores.

Conditional critical regions, Monitors, Inter process communication: Messages, Pipes. Deadlocks: Characterization. Prevention. Avoidance .Detection and recovery. Combined approach to deadlock handling.

Contiguous allocation. Static and dynamic partitioned memory allocation. Segmentation. Non-contiguous allocation. Paging, Hardware support, Virtual Memory.

Need for files. File abstraction. File naming. File system organization. File system optimization. Reliability. Security and protection. I/O management and disk scheduling. Recent trends and developments.

Text Book

1.	Gary: Operating Systems- A modern Perspective, (2/e), Addison Wesley, 2000.
2.	M. Milenkovic: Operating systems, Concepts and Design, McGraw Hill, 1992.

References

1.	C. Crowley: Operating Systems, Irwin, 1997.
2.	J.I. Peterson & A.S. Chatz: Operating System Concepts, Addison Wesley, 1985.
3.	W. Stallings: Operating Systems, (2/e), Prentice Hall, 1995.
4.	Mattuck,A., Introduction to Analysis, Prentice-Hall,1998.
5.	Recent literature in Operating Systems.

Course Outcomes (CO)

At the end of the course student will be able

CO1	Understand the different types of Operating systems and scheduling algorithms.
CO2	Understand the synchronization algorithms and semaphores.
CO3	Appreciate the inter process communication and dead lock handling.
CO4	Critically evaluate the different memory allocation techniques.
CO5	Appreciate the importance of file system organization, I/O management and disk scheduling.

Course Code	**:**	ECPE16
Course Title	**:**	**ARM SYSTEM ARCHITECTURE**
Type of Course	**:**	PE
Prerequisites	**:**	None
Contact Hours	**:**	3
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	The objective of this course is to give the students a thorough exposure to ARM architecture and make the students to learn the ARM programming & Thumb programming models.

Course Content

RISC machine. ARM programmer's model. ARM Instruction Set. Assembly level language programming. Development tools.

ARM organization. ARM instruction execution. ARM implementation. ARM coprocessor interface. Flynn's Taxonomy, SIMD and Vector Processors, Vector Floating Point Processor (VFP), VFP and ARM interactions, vector operation.

Floating point architecture. Expressions. Conditional statements. Loops. Functions and procedures. Run time environment. Interrupt response. Interrupt processing. Interrupt Handling schemes, Examples of Interrupt Handlers.

Thumb programmer's model. Thumb Instruction set. Thumb implementation. AMBA Overview, Typical AMAB Based Microcontroller, AHB bus features, AHB Bus transfers, APB bus transfers and APB Bridge.

Memory hierarchy. Architectural support for operating system. Memory size and speed. Cache memory management. Operating system. ARM processor chips. Features of Raspberry Pi and its applications.

Text Book

1.	S. Furber, "ARM System Architecture", Addison-Wesley, 1996.
2.	Sloss, D.Symes & C.Wright, "ARM system Developer's Guide-Designing and Optimizing System Software", Elsevier.2005.

References

1.	Technical reference manual for ARM processor cores, including Cortex, ARM 11, ARM 9 & ARM 7 processor families.
2.	User guides and reference manuals for ARM software development and modelling tools. David Seal, ARM Architecture Reference Manual, Addison-Wesley.
3.	The Definitive Guide to ARM® Cortex®-M3 and Cortex®-M4 Processors, Third Edition by Joseph Yiu, Elsevier 2015
4.	Recent literature in ARM System Architecture.

Course Outcomes (CO)

At the end of the course student will be able

CO1	understand the programmer's model of ARM processor and test the assembly level programming.
CO2	analyze various types of coprocessors and design suitable co-processor interface to ARM processor.
CO3	analyze floating point processor architecture and its architectural support for higher level language.
CO4	become aware of the Thumb mode of operation of ARM.
CO5	identify the architectural support of ARM for operating system and analyze the function of memory Management unit of ARM.

Course Code	:	ECPE17
Course Title	:	**STATISTICAL THEORY OF COMMUNICATION**
Type of Course	:	PE
Prerequisites	:	None
Contact Hours	:	3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	The subject aims to make the students to understand the statistical theory of telecommunication, which are the basics to learn analog and digital telecommunication.

Course Content

Information measure. Discrete entropy. Joint and conditional entropies. Uniquely decipherable and instantaneous codes. Kraft-McMillan inequality. Noiseless coding theorem. Construction of optimal codes.

DMC. Mutual information and channel capacity. Shannon's fundamental theorem. Entropy in the continuous case. Shannon-Hartley law.

Binary hypothesis testing. Baye's, mini max and Neyman-Pearson tests. Random parameter estimation-MMSE, MMAE and MAP estimates. Non-random parameters – ML estimation.

Coherent signal detection in the presence of additive white and non-white Gaussian noise. Matched filter.

Discrete optimum linear filtering. Orthogonality principle. Spectral factorization. FIR and IIR Wiener filters.

Text Book

1.	R.B.Ash," Information Theory", Wiley, 1965.
2.	M.D.Srinath, P.K.Rajasekaran & R.Viswanathan, "Statistical Signal Processing with Applications", PHI 1999.

References

1.	H.V.Poor, "An Introduction to Signal Detection and Estimation, (2/e)", Spring Verlag.1994.
2.	M. Mansuripur, "Introduction to Information Theory", Prentice Hall.1987.
3.	J.G.Proakis, D G Manolakis, "Digital Signal Processing", (4/e), Pearson Education, 2007.

Course Outcomes (CO)

At the end of the course student will be able

CO1	Show how the information is measured and able to use it for effective coding
CO2	summarize how the channel capacity is computed for various channels.
CO3	use various techniques involved in basic detection and estimation theory to solve the problem.
CO4	summarize the applications of detection theory in telecommunication.
CO5	summarize the application of estimation theory in telecommunication.

Course Code	:	ECPE18
Course Title	:	**DIGITAL SIGNAL PROCESSORS AND APPLICATIONS**
Type of Course	:	PE
Prerequisites	:	ECPC15
Contact Hours	:	3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To give an exposure to the various fixed point and floating-point DSP architectures, to understand the techniques to interface sensors and I/O circuits and to implement applications using these processors.

Course Content

Fixed-point DSP architectures. Basic Signal processing system. Need for DSPs. Difference between DSP and other processor architectures. TMS320C54X, ADSP21XX, DSP56XX architecture details. Addressing modes. Control and repeat operations. Interrupts. Pipeline operation. Memory Map and Buses.

Floating-point DSP architectures. TMS320C3X, DSP96XX architectures. Cache architecture. Floating-point Data formats. On-chip peripherals. Memory Map and Buses.

On-chip peripherals. Hardware details and its programming. Clock generator with PLL. Serial port. McBSP. Parallel port. DMA. EMIF. I2C. Real-time-clock (RTC). Watchdog timer.

Interfacing. Serial interface- Audio codec. Sensors - Humidity/temperature sensor, flow sensor, accelerometer, pulse sensor and finger print scanner. A/D and D/A interfaces. Parallel interface-Memory interface. RF transceiver interface – Wi-Fi and Zigbee modules.

DSP tools and applications. Implementation of Filters, DFT, QPSK Modem, Speech processing. Video processing, Video encoding/Decoding. Biometrics. Machine Vision. High performance computing (HPC).

Text Book

1.	B. Venkataramani & M. Bhaskar, “Digital Signal Processor, Architecture, Programming and Applications”, (2/e), McGraw- Hill,2010
2.	S. Srinivasan & Avtar Singh, “Digital Signal Processing, Implementations using DSP Microprocessors with Examples from TMS320C54X”, Brooks/Cole, 2004.

References

1.	S.M.Kuo & W.S.S.Gan,” Digital Signal Processors: Architectures, Implementations, and Applications”, Printice Hall, 2004
2.	C.Marven & G.Ewers, “A Simple approach to digital signal processing”, Wiley Inter science, 1996.
3.	R.A.Haddad & T.W.Parson, “Digital Signal Processing: Theory, Applications and Hardware”, Computer Science Press NY, 1991.

Course Outcomes (CO)

At the end of the course student will be able

CO1	learn the architecture details of fixed-point DSPs
CO2	learn the architecture details of floating-point DSPs
CO3	infer about the control instructions, interrupts, pipeline operations, memory and buses.
CO4	illustrate the features of on-chip peripheral devices and its interfacing with real time application devices.
CO5	learn to implement the signal processing algorithms and applications in DSPs

Course Code	:	ECPE19
Course Title	:	**HIGH SPEED SYSTEM DESIGN**
Type of Course	:	PE
Prerequisites	:	None
Contact Hours	:	3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To expose the students to all aspects of electronic packaging including electrical, thermal, mechanical and reliability issues.

Course Content

Functions of an Electronic Package, Packaging Hierarchy, IC packaging: MEMS packaging, consumer electronics packaging, medical electronics packaging, Trends, Challenges, Driving Forces on Packaging Technology, Materials for Microelectronic packaging, Packaging Material Properties, Ceramics, Polymers, and Metals in Packaging, Material for high density interconnect substrates

Overview of Transmission line theory, Clock Distribution, Noise Sources, power Distribution, signal distribution, EMI; crosstalk and non-ideal effects; signal integrity: impact of packages, via, traces, connectors; non-ideal return current paths, high frequency power delivery, simultaneous switching noise; system-level timing analysis and budgeting; methodologies for design of high-speed buses; radiated emissions and minimizing system noise.

Electrical Anatomy of Systems Packaging, Signal Distribution, Power Distribution, Electromagnetic Interference, Design Process Electrical Design: Interconnect Capacitance, Resistance and Inductance fundamentals; Transmission Lines, Clock Distribution, Noise Sources, power Distribution, signal distribution, EMI, Digital and RF Issues. Processing Technologies, Thin Film deposition, Patterning, Metal to metal joining.

IC Assembly – Purpose, Requirements, Technologies, Wire bonding, Tape Automated Bonding, Flip Chip, Wafer Level Packaging, reliability, wafer level burn – in and test. Single chip packaging: functions, types, materials processes, properties, characteristics, trends. Multi-chip packaging: types, design, comparison, trends. Passives: discrete, integrated, and embedded –encapsulation and sealing: fundamentals, requirements, materials, processes

Printed Circuit Board: Anatomy, CAD tools for PCB design, Standard fabrication, Micro via Boards. Board Assembly: Surface Mount Technology, Through Hole Technology, Process Control and Design challenges. Thermal Management, Heat transfer fundamentals, Thermal conductivity and resistance, Conduction, convection and radiation – Cooling requirements.

Reliability, Basic concepts, Environmental interactions. Thermal mismatch and fatigue – failures – thermo mechanically induced – electrically induced – chemically induced. Electrical Testing: System level electrical testing, Interconnection tests, Active Circuit Testing, Design for Testability.

Text Book

1.	Tummala, Rao R., Fundamentals of Microsystems Packaging, McGraw Hill, 2001
2.	Howard Johnson, Martin Graham, High Speed Digital Design: A Handbook of Black Magic, Prentice Hall, 1993

References

1.	Blackwell (Ed), The electronic packaging handbook, CRC Press, 2000.
2.	Tummala, Rao R, Microelectronics packaging handbook, McGraw Hill, 2008.
3.	Bosshart, Printed Circuit Boards Design and Technology,TataMcGraw Hill, 1988.
4.	R.G. Kaduskar and V.B.Baru, Electronic Product design, Wiley India, 2011
5.	R.S.Khandpur, Printed Circuit Board, Tata McGraw Hill, 2005
6.	Recent literature in Electronic Packaging.

Course Outcomes (CO)

At the end of the course student will be able

CO1	Design of PCBs which minimize the EMI and operate at higher frequency.
CO2	Enable design of packages which can withstand higher temperature, vibrations and shock.
CO3	Explain the basic techniques for statistical process control and failure mode and effect analysis.
CO4	Prescribe and perform parametric test and analysis and the troubleshooting of electronic circuits with the application of basic and virtual electronic instruments.
CO5	Explain contemporary pragmatic manufacturing processes, interconnects and assembly methods for electronic equipment fabrication.

Course Code	:	ECPE20
Course Title	:	**DIGITAL SPEECH PROCESSING**
Type of Course	:	PE
Prerequisites	:	ECPC15
Contact Hours	:	3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	The purpose of this course is to explain how DSP techniques could be used for solving problems in speech communication.

Course Content

Speech production model-1D sound waves-functional block of the Vocal tract model –Linear predictive co- efficient (LPC) -Auto-correlation method-Levinson-Durbin Algorithm-Auto-co-variance method-Lattice Structure-Computation of Lattice co-efficient from LPC-Phonetic Representation of speech-Perception of Loudness - Critical bands – Pitch perception – Auditory masking.

Feature extraction of the speech signal: Endpoint Detection-Dynamic time warping- Pitch frequency estimation: Autocorrelation approach- Homomorphic Approach-Formant frequency estimation using vocal tract model and Homomorphic Approach-Linear predictive co-efficient -Poles of the vocal tract-Reflection co-efficient-Log Area ratio.

Cepstrum- Line spectral frequencies- Functional blocks of the ear- Mel frequency cepstral co-efficient- Spectrogram-Time resolution versus frequency resolution-Discrete wavelet transformation.

Pattern recognition for speech detection: Back-propagation Neural Network-Support Vector Machine- Hidden Markov Model (HMM)-Gaussian Mixture Model (GMM) -Unsupervised Learning system: K-Means and Fuzzy K-means clustering - Kohonen self-organizing map-Dimensionality reduction techniques: Principle component analysis (PCA), Linear discriminate analysis (LDA), Kernel-LDA (KLDA), Independent component analysis (ICA).

Non-uniform quantization for Gaussian distributed data- Adaptive Quantization-Differential pulse code modulation- Code Exited Linear prediction (CELP)-Quality assessment of the compressed speech signal Text to Speech (TTS) analysis –Evolution of speech synthesis systems-Unit selection methods - TTS Applications.

Text Book

1.	L.R.Rabiner and R.W.Schafer,” Introduction to Digital speech processing”, now publishers USA,2007
2.	E.S.Gopi,”Digital speech processing using matlab”, Springer, 2014.

References

1.	L.R.Rabiner and R.W.Schafer,”Digital processing of speech signals”, PrenticeHall,1978
2.	T.F.Quatieri, ”Discrete-time Speech Signal Processing”, Prentice-Hall, PTR,2001
3.	L.Hanzaetal, “Voice Compression and Communications”, Wiley/ IEEE, 2001.
4.	Recent literature in Digital speech processing.

Course Outcomes (CO)

At the end of the course student will be able

CO1	illustrate how the speech production is modeled
CO2	summarize the various techniques involved in collecting the features from the speech signal in both time and frequency domain
CO3	summarize the functional blocks of the ear
CO4	compare the various pattern recognition techniques involved in speech and speaker detection
CO5	summarize the various speech compression techniques

Course Code	:	ECPE21
Course Title	:	**DIGITAL IMAGE PROCESSING**
Type of Course	:	PE
Prerequisites	:	None
Contact Hours	:	3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To treat the 2D systems as an extension of 1D system design and discuss techniques specific to 2D systems.

Course Content

Linearity and space-invariance. PSF, Discrete images and image transforms, 2-D sampling and reconstruction, Image quantization, 2-D transforms and properties.

Image enhancement- Histogram modeling, equalization and modification. Image smoothing, Image crispening. Spatial filtering, Replication and zooming, Generalized cepstrum and homomorphic filtering.

Image restoration- image observation models. Inverse and Wiener filtering. Filtering using image transforms. Constrained least-squares restoration. Generalized inverse, SVD and interactive methods. Recursive filtering. Maximum entropy restoration. Bayesian methods.

Image data compression- sub sampling, coarse quantization and frame repetition. Pixel coding - PCM, entropy coding, run length coding Bit-plane coding. Predictive coding. Transform coding of images. Hybrid coding and vector DPCM. Inter-frame hybrid coding.

Image analysis- applications, Spatial and transform features. Edge detection, boundary extraction, AR models and region representation. Moments as features. Image structure. Morphological operations and transforms. Texture. Scene matching and detection. Segmentation and classification.

Text Book

1.	A.K. Jain, “Fundamentals of Digital Image Processing”, PHI, 1995.
2.	R.C.Gonzalez & R.E. Woods,” Digital Image Processing”, (2/e), Pearson, 2002.

References

1.	J.C. Russ, “The Image Processing Handbook”, (5/e), CRC, 2006.
2.	E.S.Gopi, "Digital Image processing using Matlab", Scitech publications, 2006.
3.	Recent literature in Digital Image processing

Course Outcomes (CO)

At the end of the course student will be able

CO1	analyze the need for image transforms, types and their properties.
CO2	become skilled at different techniques employed for the enhancement of images both in spatial and frequency domain
CO3	explore causes for image degradation and to teach various restoration techniques.
CO4	evaluate the image compression techniques in spatial and frequency domain.
CO5	gain knowledge of feature extraction techniques for image analysis and recognition.

Course Code	:	ECPE22
Course Title	:	**PATTERN RECOGNITION**
Type of Course	:	PE
Prerequisites	:	None
Contact Hours	:	3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	The subject aims to make the students to understand the mathematical approach for pattern recognition.

Course Content

Polynomial curve fitting – The curse of dimensionality - Decision theory - Information theory - The beta distribution - Dirichlet distribution-Gaussian distribution-The exponent family: Maximum likelihood and sufficient statistics -non-parametric method: kernel-density estimators - Nearest Neighbour methods.

Linear models for regression and classification: Linear basis function models for regression - Bias variance decomposition-Bayesian linear regression-Discriminant functions - Fisher's linear discriminant analysis (LDA) - Principal Component Analysis (PCA) - Probabilistic generative model - Probabilistic discriminative model.

Kernel methods: Dual Representations-Constructing Kernels-Radial basis function networks-Gaussian Process-Maximum margin classifier (Support Vector Machine) –Relevance Vector Machines-Kernel-PCA, Kernel-LDA.

Mixture models: K-means clustering - Mixtures of Gaussian - Expectation-Maximization algorithm- Sequential models: Markov model, Hidden-Markov Model (HMM) - Linear Dynamical Systems (LDS).

Neural networks: Feed- forward Network functions functions-Network training - Error Back propagation - The Hessian Matrix - Regularization in Neural Network - Mixture density networks – Bayesian Neural Networks

Text Book

1.	C.M.Bishop,"Pattern recognition and machine learning", Springer,2006
2.	E.S.Gopi, "Pattern recognition and Computational intelligence using Matlab, Transactions on computational science and computational intelligence, Springer, 2019

References

1.	Sergious Thedorodis ,Konstantinos Koutroumbas, Pattern recognition, Elsevier, Fourth edition,2009
2.	Richard O.Duda, Peter.E.Hart, David G.Stork, "Pattern classification", Wiley, Second edition,2016
3.	Recent literature in the related topics

Course Outcomes (CO)

At the end of the course student will be able

CO1	summarize the various techniques involved in pattern recognition
CO2	identify the suitable pattern recognition techniques for the particular applications.
CO3	categorize the various pattern recognition techniques into supervised and unsupervised.
CO4	summarize the mixture models-based pattern recognition techniques
CO5	summarize the artificial neural network-based pattern recognition techniques

Course Code	**:**	ECPE23
Course Title	**:**	**DISPLAY SYSTEMS**
Type of Course	**:**	PE
Prerequisites	**:**	ECPC13
Contact Hours	**:**	3
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To expose the students to the basics of the display systems and to illustrate the current design practices of the display systems.

Course Content

Introduction to displays. Requirements of displays. Display technologies, CRT, Flat panel and advanced display technologies. Technical issues in displays.

Head mounted displays. Displays less than and greater than 0.5 m diagonal. Low power and light emitting displays.

Operation of TFTs and MIMS. LCDs, Brightness. Types of LCD displays.

Emissive displays, ACTFEL, Plasma display and Field emission displays, operating principle and performance.

Types of Displays: 3D, HDTV, LED, Touch screen.

Text Book

1.	L.W. Mackonald & A.C. Lowe, Display Systems, Design and Applications, Wiley, 2003.
2.	E.H. Stupp &M. S. Brennesholtz, Projection Displays, Wiley,1999

References

1.	Peter A. Keller, Electronic Display Measurement: Concepts, Techniques, and Instrumentation, Wiley-Inter science, 1997.
2.	Recent literature in Display Systems.

Course Outcomes (CO)

At the end of the course student will be able

CO1	appreciate the technical requirement of different types of displays systems
CO2	analyze the various low power lighting systems
CO3	understand the operation of TFTs and LCD displays.
CO4	analyze the various kinds of emissive displays
CO5	critically evaluate the recent advancements in the display device technology.

Course Code	:	ECPE24
Course Title	:	**INTERNET OF THINGS**
Type of Course	:	PE
Prerequisites	:	CSIR11, ECPE12, C/C++ and Python Programming skills
Contact Hours	:	3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To understand basics of an IOT System, IoT sensors, IoT hardware and communication protocols, data storage, data analysis and use them for real time IoT enabled domains.

Course Content

Introduction to IoT and IoT levels : Functional blocks of an IoT system (Sensors, Data Ingress, Data Aggregation Point Communication point back to the cloud, Analysis, Decision making, Actuation) Basic of Physical and logical design of IoT (IoT protocols, communication models) IoT enabled domains (Home automation, Smart cities, environment monitoring, renewable energy, agriculture, industry, healthcare, marketing and management) M2M, Difference between IoT, Embedded Systems and M2M, Industry 4.0 concepts.

IoT sensors and hardware : Passive and active sensors, differences, Different kinds of sensors (Temperature, humidity, pressure, obstacle, water flow, accelerometer, color, gyro, load cell, finger print, motion, ultrasonic distance, magnetic vibration, eye blink, hear beat, PPG, glucose, body position, blood pressure), Multi-sensors, Pre-processing (sampling, filtering, ADC, size of data, local memory, compression), IoT front end hardware (Raspberry Pi, Arduino, Galileo, beagle bone equivalent platforms)

Introduction to IoT protocols: Infrastructure (6LowPAN, IPv4/IPv6, RPL), Identification (EPC, uCode, IPv6, URIs), Communication/ Transport (Wi-Fi, Bluetooth, ZigBee, LPWAN), Data Protocols (MQTT, CoAP, AMQP, WebSocket, Node)

IoT Cloud and data analytics: Collecting data from sensors, Data Ingress, Cloud storage, IoT cloud platforms (Amazon AWS, Microsoft Azure, Google APIs), Data analytics for IoT, Software and management tool for IoT, Dashboard design

IoT architectures with case studies: Business models for IoT, smart cities, agriculture, healthcare, industry. Case studies/Mini projects for the real time IoT applications.

Text Book

1.	Arshdeep Bahga, Vijay Madisetti, “Internet of Things – A hands-on approach”, Universities Press, 2015.

References

1.	Raj kamal, Internet of Things, Architecture and Design Principles, McGraw-Hill, 2017
2.	Manoel Carlos Ramon, “Intel® Galileo and Intel® Galileo Gen 2: API Features and Arduino Projects for Linux Programmers”, Apress, 2014.H. Gerez, “Algorithms for VLSI Design Automation”, John Wiley, 1999.
3.	Marco Schwartz, “Internet of Things with the Arduino Yun”, Packt Publishing, 2014.

Course Outcomes (CO)

At the end of the course student will be able

CO1	understand basic premise of an IOT System
CO2	be familiar with the sensors available for IoT applications
CO3	learn the front-end hardware platforms and communication protocols for IoT.
CO4	understand cloud storage, data analysis and management
CO5	usage for real time IoT enabled domains

Course Code	:	ECPE26
Course Title	:	**COGNITIVE RADIO**
Type of Course	:	PE
Prerequisites	:	ECPC15
Contact Hours	:	3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	This subject introduces the fundamentals of multi rate signal processing and cognitive radio.

Course Content

Filter banks-uniform filter bank. Direct and DFT approaches. Introduction to ADSL Modem. Discrete multi-tone modulation and its realization using DFT.QMF. STFT. Computation of DWT using filter banks.

DDFS- ROM LUT approach. Spurious signals, jitter. Computation of special functions using CORDIC. Vector and rotation mode of CORDIC. CORDIC architectures.

Block diagram of a software radio. Digital down converters and demodulators Universal modulator and demodulator using CORDIC. Incoherent demodulation - digital approach for I and Q generation, special sampling schemes. CIC filters. Residue number system and high-speed filters using RNS. Down conversion using discrete Hilbert transform. Under sampling receivers, Coherent demodulation schemes.

Concept of Cognitive Radio, Benefits of Using SDR, Problems Faced by SDR, Cognitive Networks, Cognitive Radio Architecture. Cognitive Radio Design, Cognitive Engine Design,

A Basic OFDM System Model, OFDM based cognitive radio, Cognitive OFDM Systems, MIMO channel estimation, Multi-band OFDM, MIMO-OFDM synchronization and frequency offset estimation. Spectrum sensing to detect Specific Primary System, Spectrum Sensing for Cognitive OFDMA Systems.

Text Book

1.	J. H. Reed, “Software Radio”, Pearson, 2002.
2.	U. Meyer – Baese, “Digital Signal Processing with FPGAs”, Springer, 2004.

References

1.	H. Arslan “Cognitive Radio, Software Defined Radio and Adaptive Wireless Systems”, University of South Florida, USA, Springer, 2007.
2.	S. K. Mitra, “Digital Signal processing”, McGrawHill,1998
3.	K.C.Chen, R.Prasad, “Cognitive Radio Networks”, Wiley, 2009-06-15.
4.	T.W.Rondeau, C.W.Bostian, “Artificial Intelligence in Wireless Communications”,2009.
5.	Tusi, “Digital Techniques for Wideband receivers”, Artech House, 2001.
6.	T. DarcChiueh, P. Yun Tsai,” OFDM baseband receiver design for wireless communications”, Wiley,2007
7.	Recent literature in Cognitive Radio

Course Outcomes (CO)

At the end of the course student will be able

CO1	gain knowledge on multi-rate systems.
CO2	develop ability to analyze, design, and implement any application using FPGA.
CO3	be aware of how signal processing concepts can be used for efficient FPGA based system design.
CO4	understand the rapid advances in Cognitive radio technologies.
CO5	explore DDFS, CORDIC and its application.

Course Code	**:**	ECPE27
Course Title	**:**	**MULTIMEDIA COMMUNICATION TECHNOLOGY**
Type of Course	**:**	PE
Prerequisites	**:**	ECPC15
Contact Hours	**:**	3
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To made the students to understand various encoding and decoding techniques of audios and videos in multimedia systems

Course Content

Components of multimedia system, Desirable features, Applications of multimedia systems, Introduction to different types, Multimedia storage device.

Digital audio representation and processing-time domain and transform domain representations. Coding standards, transmission and processing of digital audio. Musical instrument synthesizers.

Still image coding-JPEG. Discrete cosine Transform. Sequential and Progressive DCT based encoding algorithms, lossless coding, and hierarchical coding. Basic concepts of discrete wavelet transform coding and embedded image coding algorithms. Introduction to JPEG2000.

Feature of MPEG 1, structure of encoding and decoding process, MPEG 2 enhancements, and different blocks of MPEG video encoder.

Content based video coding-overview of MPEG 4 video, motion estimation and compensation. Different coding techniques and verification models. Block diagram of MPEG 4 video encoder and decoder. An overview of H261 and H263 video coding techniques.

Text Book

1.	Y.Q.Shi & H.Sun, Image and Video Compression for Multimedia Engineering, CRC Press, 2000.
2.	S.V.Raghavan & S,K,Tripathi, Networked Multimedia Systems, Prentice-Hall,1998.

References

1.	J.F.K.Buford, Multimedia Systems, Pearson, 2000.
2.	Recent literature in Multimedia Communication Technology.

Course Outcomes (CO)

At the end of the course student will be able

CO1	analyze various components of the multimedia systems and its storage devices.
CO2	appreciate the different coding standards for the digital audio and musical synthesizers.
CO3	understand the various types of DCT based image encoding algorithms
CO4	understand the encoding and decoding process of the MPEG standards
CO5	analyze the different content-based video processing techniques.

Course Code	:	ECPE28
Course Title	:	**COMMUNICATION SWITCHING SYSTEMS**
Type of Course	:	PE
Prerequisites	:	ECPC18
Contact Hours	:	3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To understand the working principles of switching systems from manual and electromechanical systems to stored program control systems.

Course Content

Basic elements of communication network. Switching systems. Signaling and signaling functions.

Digital telephone network. TDM Principles. PCM primary multiplex group. Plesiochronous digital hierarchy. Synchronous digital hierarchy. Echo cancellers.

Digital transmission and multiplexing. Synchronous versus Asynchronous transmission. Line coding. Error performance. TDM. Framing, TDM loops and rings.

Space division switching. Multiple-stage switching. Design examples. Switching matrix control. Time division switching. Multiple-stage time and spaces witching.

Timing recovery. Jitter. Network synchronization. Digital subscriber access-ISDN. ADSL. HFC. Traffic analysis.

Text Book

1.	J.C. Bellamy, “Digital Telephony”, Wiley, 3rd edition, 2011.
2.	J.E. Flood, “Telecommunications Switching, Traffic and Networks” Pearson,1st edition,2012

References

1.	T.Viswanathan, “Telecommunication Switching Systems and Networks”, PHI, 2006.
2.	E.Keiser & E.Strange, “Digital Telephony and Network Integration”, Springer, 2nd edition, 1995.
3.	R. L.Freeman, “Fundamentals of Telecommunications”, John Wiley and Sons, 2ndedition, 1999.
4.	Recent literature in Communication Switching Systems.

Course Outcomes (CO)

At the end of the course student will be able

CO1	explain the working principle of switching systems involved in telecommunication switching
CO2	assess the need for voice digitization and T Carrier systems
CO3	compare and analyze Line coding techniques and examine its error performance
CO4	design multi stage switching structures involving time and space switching stages
CO5	analyze basic telecommunication traffic theory

Course Code	**:**	ECPE29
Course Title	**:**	**BROADBAND ACCESS TECHNOLOGIES**
Type of Course	**:**	PE
Prerequisites	**:**	ECPC18 & ECPC19
Contact Hours	**:**	3
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To impart fundamentals and latest technologies related to the design of broadband last mile-Access technologies for multimedia communication

Course Content

Wired access technologies using Phone line modem, ISDN modem. Comparison-Cable, DSL, fiber and wireless access technologies.

Last mile copper access, Flavors of Digital subscriber lines, DSL deployment, Common local loop impairments, discrete multi-tone modulation, VDSL deployment and frequency plans. Standards for XDSL and comparison.

Last mile HFC access, Cable modems. Modulation schemes, DOCSIS. Standards-comparison, physical and MAC layer protocols for HFC networks, ATM and IP-centric modem. Switched digital video.

Fiber access technologies and architectures. ATM passive optical networks, Upstream and downstream transport, Frame format, Ethernet passive optical network, Gigabit passive optical networks.

Survey on emerging broadband wireless access technologies. LMDS, MMDS, WIMAX and WIFI, Satellite technologies serving as last mile solutions, Wireless LAN, Wireless personal area networking, 3G and 4G wireless systems.

Text Book

1.	N.Jayant, “Broadband last mile”-Taylor and Francisgroup,2005
2.	N.Ransom & A.A. Azzam, “Broadband Access Technologies”, McGraw Hill, 1999.

References

1.	M.P. Clarke, “Wireless Access Network”, Wiley, 2000.
2.	T.Starr, M.Sorbara, J.M.Cioffi and P.J. Silverman,”DSLadvances”, PrenticeHall,2002
3.	S. Mervana & C.Le, “Design and Implementation of DSL-based Access Solutions”, Cisco Press, 2001.
4.	W. Vermillion, “End-to-End DSL Architecture”, Cisco Press, 2003.
5.	DOCSIS 2.0 “Radio frequency interface specification” www.cablemodem.com
6.	ITU-T Rec., G.983.1 “Broadband Optical Access systems based on Passive OpticalNetworks”,1998
7.	Recent literature in Broadband Access Technologies.

Course Outcomes (CO)

At the end of the course student will be able

CO1	recall and identify the basics of broadband technology systems and differentiate the differences between the various wired and wireless technology system
CO2	illustrate the aspects of last mile data transport on copper wire networks and flavors of DSL
CO3	summarize the versions of cable network standard and MAC protocols for HFC networks
CO4	distinguish the cost-effective broadband services for residential users and ATM based and Ethernet based passive optical networks
CO5	outline the types of broadband wireless access technologies and their characteristics.

Course Code	:	ECPE31
Course Title	:	**FIBER OPTIC COMMUNICATION**
Type of Course	:	PE
Prerequisites	:	ECPC12 & ECPC18
Contact Hours	:	3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To help students understand the structures of optical fiber and types
CLO2	To expose students to different types of fiber impairments like optical losses and signal dispersion in fibers.
CLO3	To get students introduced to the basics of optical sources and photodetectors.
CLO4	To get students introduced to the system design, WDM techniques, optical amplification, and non-linear effects in optical fibers.

Course Content

Optical Fibers: Structure, Wave guiding. Step-index and Graded index optical fibers. Modal analysis. Classification of modes. Single Mode Fibers.

Pulse dispersion. Material and Waveguide dispersion. Polarization Mode Dispersion. Absorption, scattering and bending losses. Dispersion Shifted Fibers, Dispersion Compensating Fibers.

Optical sources: LEDs and Laser Diodes. Optical Power Launching and Coupling. Source to Fiber coupling, Fiber to Fiber joints. Misalignments. Schemes for coupling improvement.

Optical detectors: PIN and Avalanche photodiodes, Photo detector noise, Optical receivers. Digital link design: Power budget and Rise time budget. Attenuation and Dispersion limit.

WDM Concepts. Optical Amplifiers: EDFA. Nonlinear effects: Self Phase Modulation, Nonlinear Schrodinger Equation. Optical Soliton.

Text Book

1.	G. Keiser, “Optical Fiber Communications (5/e)”, McGraw Hill, 2013.
2.	A. Ghatak & K. Thygarajan, “Introduction to Fiber Optics”, Cambridge, 1999.

References

1.	G. P. Agarwal, “Fiber Optic Communication Systems”, (4/e), Wiley, 2010.
2.	M. M. K. Liu, “Principles and Applications of Optical Communications”, Tata McGraw Hill, 2010.
3.	A. Selvarajan, S. Kar and T. Srinivas, “Optical Fiber Communication Principles and Systems”, Tata McGraw Hill, 2006.

Course Outcomes (CO)

At the end of the course student will be able

CO1	Recognize and classify the structures of Optical fiber and types.
CO2	Discuss the channel impairments like losses and dispersion.
CO3	Classify the Optical sources and calculate various coupling losses.
CO4	Classify detectors and to design a fiber optic link.
CO5	Familiar with concepts of WDM, optical amplifiers and Soliton Propagation.

Course Code	**:**	ECPE32
Course Title	**:**	**DIGITAL SIGNAL PROCESSING FOR WIRELESS COMMUNICATION**
Type of Course	**:**	PE
Prerequisites	**:**	ECPC15
Contact Hours	**:**	3
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	The subject aims to make the students to understand the usage of various signal processing techniques used for wireless communication

Course Content

Mathematical model of the Time-varying wireless channel: multi-path model, Coherence time and Doppler spread, Coherence frequency and Delay spread. Relationship between the time-varying impulse response of the Base band and Bandpass Transmission. Discrete Complex Base band time varying channel model for wireless communication. Computation of probability of error for Flat fading Rayleigh channel, Flat fading Rician model and single tap channel with known filter co-efficient.

Autocorrelation and the Spectral density computation of base band and the band pass signal. Sampling and reconstruction of W.S.S. random process. Spectral density computation for PSK, QPSK, FSK and MSK. Relationship between Base band- and band-pass random process using Hilbert transformation. Periodogram, Barlett method, Welch, Blackman and Tuckey methods of estimating spectrum of the modulated signal.

Multiple input Multiple output (MIMO) System model, Zero forcing receiver, LMMSE receiver, Matched filter receiver. Optimal precoding and combining, Spatial multiplexing using Decoupling of MIMO system. Massive MIMO, Power scaling, Orthogonality, Multi-cell Multi user MIMO, Pilot contamination and Rate scaling.

Orthogonal Frequency division Multiplexing (OFDM) Multicarrier modulation (MCM) , MCM transmission/Received signal, MCM-IFFT/FFT Processing, MCM-Cyclic prefix, Spectrum of OFDM transmission, MIMO-OFDM System model, BER of OFDM and MIMO-OFDM

5G Technology: Non-orthogonal multiple access, Spatial Modulation, Filter bank multi-carrier systems (FBMC), FBMC-OQAM System model, MIMO-FBMC Signal processing, Full Duplex Radio, Self-interference, Hybrid cancellation, mm wave MIMO Channel Modeling and Estimation.

Text Book

1.	D. Tse and P.Viswanath, “Fundamentals of Wireless Communication”, Cambridge university press, 2005
2.	A. Goldsmith, “Wireless Communications”, Cambridge University Press,2005
3.	E.S.Gopi, “Digital signal processing for wireless communication using Matlab’’, Springer, 2016

References

1.	T.S.Rappaport, “Wireless Communication Principles (2/e)”, Pearson,2002.
2.	E. Biglieri, R.Calderbank, A. Constantinides, A. Goldsmith, A.Paulraj, H.Vincent poor, “MIMO Wireless Communications”, Cambridge University Press,2007.
3.	Robert Gallager, Chapter 9: “Wireless communication”, course materials for 6.450 Principles of Digital communication I,Fall 2006.MIT Open coursewarehttp://ocw.mit.edu/.
4.	Recent literature in the related topics

Course Outcomes (CO)

At the end of the course student will be able

CO1	summarize the importance of Coherence time, Coherence frequency, Doppler spread and Delay spread in time-varying wireless channel model
CO2	derive the expression for BER for various wireless channel model.
CO3	derive the expression for the computation of spectral density of various bandpass transmission and methodology to estimate from the received signal.
CO4	summarize the mathematical models related to MIMO and OFDM technology
CO5	summarize the signal processing aspects in various 5G Technology

Course Code	**:**	ECPE33
Course Title	**:**	**MICROWAVE INTEGRATED CIRCUIT DESIGN**
Type of Course	**:**	PE
Prerequisites	**:**	ECPC16 & ECPC24
Contact Hours	**:**	3
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To impart knowledge on basics of microwave electron beam devices and their applications in X band frequency.

Course Content

Design and realization of power dividers, hybrids, directional couplers etc using strip lines and micro strip lines.

Filter design; Kuroda identities. K and J inverters. Filter transformations. Realization using strip lines and micro strip lines.

Transistor amplifiers; Power gain equations. Stability considerations. Analysis. Design using MICs.
Transistor oscillators. Active devices for microwave oscillators. Three port S parameter characterization of transistors. Oscillation and stability conditions.

Diode mixers. Mixer design. Single ended mixer. Balanced mixer. Image rejection mixer. Phase shifter design. PIN diode. Phase shifter.

Text Book

1.	I.J.Bahl & Bhartia, Microwave Solid State Circuit Design, Wiley, 1987.
2.	G.D.Vendelin, Design of Amplifiers and Oscillators by the S Parameter Method, Wiley, 1982.

References

1.	Stripline-like Transmission Lines for Microwave Integrated Circuits - Bharathi Bhat, Shiban Koul, New Age International(P) Limited, Publishers, 2007
2.	Microwave Engineering, David M Pozar, John Wiley & Sons,In International Student Edition
3.	T.C.Edwards, Foundations for Microstrip Circuit Design (2/e), Wiley, 1992.
4.	Recent literature in Microwave Integrated Circuit Design.

Course Outcomes (CO)

At the end of the course student will be able

CO1	the topics will make students design of the important and essential M.I.C components
CO2	Filter is the most needed circuit for many applications and the unit will make the student confident in filter design
CO3	All aspects and different parameters, design factors and properties will me made thorough
CO4	One will be confident to handle any oscillator design
CO5	The student will become familiar and confident in the design of Mixers, the other essential circuits.

Course Code	**:**	ECPE34
Course Title	**:**	**RF MEMS CIRCUIT DESIGN**
Type of Course	**:**	PE
Prerequisites	**:**	ECPC16 & ECPC24
Contact Hours	**:**	3
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To impart knowledge on basics of MEMS and their applications in RF circuit design.

Course Content

Introduction to Micromachining Processes. RF MEMS relays and switches. Switch parameters. Actuation mechanisms. Bi-stable relays and micro actuators. Dynamics of switching operation.

MEMS inductors and capacitors. Micro machined inductor. Effect of inductor layout. Modeling and design issues of planar inductor. Gap-tuning and area-tuning capacitors. Dielectric tunable capacitors.

MEMS phase shifters. Types. Limitations. Switched delay lines. Fundamentals of RF MEMS Filters. Micro machined transmission lines. Coplanar lines. Micro machined directional coupler and mixer.

Micro machined antennas. Micro strip antennas –design parameters. Micromachining to improve performance. Reconfigurable antennas.

Text Book

1.	Vijay.K.Varadanetal, "RF MEMS and their Applications", Wiley-India, 2011.

References

1.	H.J.D.Santos, "RF MEMS Circuit Design for Wireless Communications", Artech House, 2002.
2.	G.M.Rebeiz, "RF MEMS Theory, Design, and Technology", Wiley, 2003.
3.	Recent literature in RF MEMS Circuit Design.

Course Outcomes (CO)

At the end of the course student will be able

CO1	learn the Micromachining Processes
CO2	learn the design and applications of RF MEMS inductors and capacitors.
CO3	learn about RF MEMS Filters and RF MEMS Phase Shifters.
CO4	learn about the suitability of micro machined transmission lines for RF MEMS
CO5	learn about the Micro machined Antennas and Reconfigurable Antennas

Course Code	**:**	ECPE35
Course Title	**:**	**SATELLITE COMMUNICATION**
Type of Course	**:**	PE
Prerequisites	**:**	ECPC18
Contact Hours	**:**	3
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To introduce and to make understand the radio propagation channel for Earth station to satellite & satellite to Earth station.
CLO2	To introduce various aspects in the design of communication & multiple access systems for satellite communication.
CLO3	To introduce the concept of launchers and design of Earth station and satellite link.

Course Content

Elements of orbital mechanics. Equations of motion. Tracking and orbit determination. Orbital correction/control. Satellite launch systems. Multistage rocket launchers and their performance.

Elements of communication satellite design. Spacecraft subsystems. Reliability considerations. Spacecraft integration.

Multiple access techniques. FDMA, TDMA, CDMA. Random access techniques. Satellite on-board processing.

Satellite Link Design: Performance requirement and standards. Laser Satellite Communication: Link analysis, optical satellite link transmitter, optical satellite link receiver, satellite beam acquisition, tracking & positioning, deep space optical communication link.

Earth station design. Configurations. Antenna and tracking systems. Satellite broadcasting. GPS. VSAT.

Text Book

1.	D. Roddy, “Satellite Communication (4/e)”, McGraw-Hill, 2009.
2.	T. Pratt & C. W. Bostain, “Satellite Communication”, Wiley 2000.

References

1.	Bruce R. Elbert, ‘The Satellite Communication Applications’ Hand Book, Artech House Bostan London, 1997.
2.	B. N. Agrawal, “Design of Geo synchronous Spacecraft”, Prentice-Hall, 1986.
3.	A.K. Maini, V. Agrawal, “Satellite Communications”, Wiley India Pvt Ltd, 1999.
4.	Recent literature in Satellite Communication.

Course Outcomes (CO)

At the end of the course student will be able

CO1	learn the dynamics of the satellite.
CO2	learn the spacecraft and subsystems.
CO3	understand how analog and digital technologies are used for satellite communication networks.
CO4	understand the radio frequency channel from Earth station to Satellite.
CO5	study the design of Earth station and tracking of the satellites.

Course Code	**:**	ECPE36
Course Title	**:**	**PRINCIPLES OF RADAR**
Type of Course	**:**	PE
Prerequisites	**:**	ECPC20
Contact Hours	**:**	3
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To expose the students to the working principles of a radar from a signal processing perspective.

Course Content

Radar equation. Radar cross section. Cross section of small targets. Target scattering matrices. Area and volume targets.

Radar signals. Ambiguity function and its properties. Uncertainty principle. Pulse compression. Linear FM pulse. Pulse compression by Costas FM and binary phase coding.

Radar detection. Optimum Bayesian decision rules. Detection criteria for different target models.

Range and Doppler measurements and tracking. Range and Doppler frequency resolutions. Optimum receivers. Optimum filters for Doppler measurements. Coherent and non-coherent implementations.

Angle measurement and tracking. Angle measurement and tracking by conical scan and mono pulse. Optimum mono pulse systems.

Text Book

1.	P.Z.Peebles, Radar Principles, Wiley, 1998.
2.	Merrill I. Skolink, Introduction to Radar Systems, (3/e), Tata MG Graw Hill,2001

References

1.	N.Levanon, Radar Signals, Wiley, 2005.
2.	D.Wehnar: High Resolution Radar, Artech Hous, 1987.
3.	D.K.Barton: Radar systems Analysis, Prentice Hall, 1976.
4.	Recent literature in Principles of Radar.

Course Outcomes (CO)

At the end of the course student will be able

CO1	Understand the principle behind radar range equation and different types of targets available.
CO2	Appreciate the different compression techniques of radar pulse signals.
CO3	Distinguish between different detection methods of radar signals.
CO4	Appreciate the building blocks for optimum receiver and Doppler measurements.
CO5	Understand the tracking and scanning methods in the mono pulse systems.

Course Code	:	ECPE37
Course Title	:	**LOW POWER VLSI CIRCUITS**
Type of Course	:	PE
Prerequisites	:	ECPC23
Contact Hours	:	3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To expose the students to the low voltage device modelling, low voltage, low power VLSI CMOS circuit design.

Course Content

CMOS fabrication process, Shallow trench isolation. Lightly-doped drain. Buried channel. Fabrication process of BiCMOS and SOI CMOS technologies.

Modeling of CMOS devices parameters. Threshold voltage, Body effect, short channel and Narrow channel effects, Electron temperature, and MOS capacitance.

CMOS inverters, static logic circuits of CMOS, pass transistor, BiCMOS, SOI CMOS and low power CMOS techniques.

Basic concepts of dynamic logic circuits. Various problems associated with dynamic logic circuits. Differential, BiCMOS and low voltage dynamic logic circuits.

CMOS memory circuits, Decoders, sense amplifiers, SRAM architecture. Low voltage SRAM techniques.

Text Book

1.	Jan Rabaey,"Low Power Design Essentials (Integrated Circuits and Systems)", Springer,2009
2.	J.B.Kuo&J.H.Lou,"Low-voltage CMOS VLSI Circuits", Wiley, 1999.

References

1.	A.Bellaowar&M.I.Elmasry,"Low power Digital VLSI Design, Circuits and Systems", Kluwer, 1996.
2.	Recent literature in Low Power VLSI Circuits.

Course Outcomes (CO)

At the end of the course student will be able

CO1	acquire the knowledge about various CMOS fabrication process and its modeling.
CO2	infer about the second order effects of MOS transistor characteristics.
CO3	analyze and implement various CMOS static logic circuits.
CO4	learn the design of various CMOS dynamic logic circuits.
CO5	learn the different types of memory circuits and their design.

Course Code	:	ECPE38
Course Title	:	**ADHOC WIRELESS NETWORKS**
Type of Course	:	PE
Prerequisites	:	ECPE10
Contact Hours	:	3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To analyze the various design issues and challenges in the layered architecture of Ad hoc wireless networks

Course Content

Cellular and ad hoc wireless networks, Applications of ad hoc wireless networks. Issues in ad hoc wireless networks-medium access scheme, routing, transport layer protocols, security and energy management. Ad hoc wireless internet.

Design goals of a MAC protocol, Contention based protocols; Contention based protocols with reservation mechanisms and scheduling mechanisms, MAC protocols using directional antennas.

Table driven routing protocols, on demand routing protocols, hybrid routing protocols, Hierarchical routing protocols, Power aware routing protocols, Tree based and mesh-based multicast routing protocols

Network security requirements-Issues and challenges, network security attacks, key management, secure routing protocols

Energy management schemes-Battery management, transmission power management, system power management schemes. Quality of service solutions in ad hoc wireless networks.

Text Book

1.	C.Siva ram murthy, B.S. Manoj, “Ad hoc wireless networks-Architectures and protocols” Pearson Education, 2005
2.	S.Basagni, M.Conti, “Mobile ad hoc networking”, Wielyinterscience2004

References

1.	C. E.Perkins ,” Ad hoc networking”, AddisonWesley,2001
2.	X.Cheng, X.Huang ,D.Z. DU,” Ad hoc wireless networking”, Kluwer AcademicPublishers,2004
3.	G. Aggelou,”Mobile ad hoc networks-From wireless LANs to 4G networks”, McGraw Hill publishers,2005
4.	Recent literature in ADHOC Wireless Networks.

Course Outcomes (CO)

At the end of the course student will be able

CO1	compare the differences between cellular and ad hoc networks and the analyze the challenges at various layers and applications
CO2	summarize the protocols used at the MAC layer and scheduling mechanisms
CO3	compare and analyze types of routing protocols used for unicast and multicast routing
CO4	examine the network security solution and routing mechanism
CO5	evaluate the energy management schemes and Quality of service solution in ad hoc networks

Course Code	:	ECPE39
Course Title	:	**WIRELESS SENSOR NETWORKS**
Type of Course	:	PE
Prerequisites	:	ECPE10
Contact Hours	:	3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To overview the various design issues and challenges in the layered architecture of Wireless sensor networks

Course Content

Motivation for a network of wireless sensor nodes-Definitions and background-challenges and constraints for wireless sensor networks-Applications. Node architecture-sensing subsystems, processing Subsystems, Communication interfaces, Prototypes.

Physical layer- Introduction, wireless channel and communication fundamentals – frequency allocation, modulation and demodulation, wave propagation effects and noise, channels models, spread spectrum communication, packet transmission and synchronization, quality of wireless channels and measures for improvement, physical layer and transceiver design consideration in wireless sensor networks, Energy usage profile, choice of modulation, Power Management

Data link layer- Fundamentals of wireless MAC protocols, Characteristics of MAC protocol in wireless sensor networks contention-based protocols, Contention free MAC protocols, Hybrid MAC protocols

Network layer-routing metrics-Flooding and gossiping, Data centric routing, proactive routing on demand routing, hierarchical routing, Location based routing, QOS based routing. Data Aggregation – Various aggregation techniques.

Case study-Target detection tracking, Habitat monitoring, Environmental disaster monitoring, Practical implementation issues, IEEE 802.15.4 low rate WPAN, Operating System Design Issues. Simulation tools.

Text Book

1.	W. Dargie, C. Poellabauer, ”Fundamentals of Wireless sensor networks-Theory and Practice”, John Wiley & Sons Publication2010
2.	K. Sohraby, D.Minoli and T.Znati, “Wireless Sensor Network Technology- Protocols and Applications”, John Wiley & Sons, 2007.

References

1.	F.Zhao, L.Guibas, “Wireless Sensor Networks: an information processing approach”, Elsevier publication, 2004.
2.	C.S.Raghavendra Krishna, M.Sivalingam and Taribznati, “Wireless Sensor Networks”, Springer publication, 2004.
3.	H. Karl, A.willig, “Protocol and Architecture for Wireless Sensor Networks”, John Wiley publication, Jan2006.
4.	K.Akkaya and M.Younis, “A Survey of routing protocols in wireless sensor networks”, Elsevier Adhoc Network Journal, Vol.3, no.3, pp. 325-349, 2005.
5.	Philip Levis, “TinyOS Programming”, 2006 –www.tinyos.net.
6.	I.F. Akyildiz, W. Su, Sankarasubramanian, E. Cayirci, “Wireless sensor networks: a survey”, computer networks, Elsevier, 2002, 394 -422.
7.	Jamal N. Al-karaki, Ahmed E. Kamal, “Routing Techniques in Wireless sensor networks: A survey”, IEEE wireless communication, December 2004, 6 –28.
8.	Recent literature in Wireless Sensor Networks.

Course Outcomes (CO)

At the end of the course student will be able

CO1	analyze the challenges and constraints of wireless sensor network and its subsystems
CO2	examine the physical layer specification, modulation and transceiver design considerations
CO3	analyze the protocols used at the MAC layer and scheduling mechanisms
CO4	compare and analyse the types of routing protocols and data aggregation techniques
CO5	identify the application areas and practical implementation issues.

Course Code	:	ECPE40
Course Title	:	**Nano Electronics**
Type of Course	:	PE
Prerequisites	:	None
Contact Hours	:	3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To present the state of the art in the areas of semiconductor device physics and materials technology to enable nano-electronics
CLO2	To provide an overview of nano materials and device fabrication
CLO3	To discuss the extensive materials characterization techniques

Course Content

Overview: Nano devices, Nano materials, Nano characterization. Introduction to nano-electronics, CMOS technology scaling issues, Design techniques for nanoscale transistors

MOS Electrical characterization, non-classical MOSFETs: overview and carrier transport in Nano-MOSFETs, Silicon on Insulator (SOI) MOSFET

Metal-Semiconductor contacts and Metal-Source/Drain Junction MOSFETs, Germanium and compound semiconductor Nano MOSFETs

Introduction to Nanomaterials, Quantum Mechanics and Quantum Statistics for considering Nanomaterials.

Quantum mechanics and Quantum statistics for considering nanomaterials, synthesis/fabrication of nanomaterials, chemical vapour deposition (CVD) and atomic layer deposition (ALD). Characterization techniques for nanomaterials and nano structures – FTIR, XRD, AFM, SEM, TEM, EDAX

NPTEL Link:
https://nptel.ac.in/courses/117108047

Text Book

1.	Y. Taur and T. Ning, “Fundamentals of Modern VLSI Devices”, Cambridge University Press, 2nd Edition, 2013.

References

1.	Plummer, Deal and Griffin, “Silicon VLSI Technology”, 1st edition, Pearson education, 2000.
2.	Brundle, C. R., Evans, Charles A. jr., Wilson and Shaun, “Encyclopedia of Materials Characterization, 1992.

Course Outcomes (CO)

At the end of the course student will be able

CO1	get an insight of nano devices and nano materials
CO2	learn the nano-micro fabrication
CO3	get a foundation for the device fabrication
CO4	study vast understanding to the device electronics for integrated circuits
CO5	get an insight of nano materials and its characterization techniques.

Course Code	:	ECPE41
Course Title	:	**ELECTRONIC DESIGN AUTOMATION TOOLS**
Type of Course	:	PE
Prerequisites	:	None
Contact Hours	:	3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To make the students exposed to Front end and Back-end VLSI CAD tools.

Course Content

OS Architecture: System settings and configuration. Introduction to UNIX commands Handling directories, Filters and Piping, Wildcards and Regular expression, Power Filters and Files Redirection. Working on Vi editor, Basic Shell Programming, TCL Scripting language.

Algorithms in VLSI: Partitioning methods: K-L, FM, and Simulated annealing algorithms. Placement and Routing algorithms, Interconnects and delay estimation.

Synthesis and simulation using HDLs-Logic synthesis using Verilog. Memory and FSM synthesis. Performance driven synthesis, Simulation- Types of simulation. Static timing analysis. Formal verification. Switch level and transistor level simulation.

System Verilog- Introduction, Design hierarchy, Data types, Operators and language constructs. Functional coverage, Assertions, Interfaces and test bench structures.

Analog/Mixed Signal Modelling and Verification: Analog/ Mixed signal modelling using Verilog-A and Verilog-AMS. Event Driven Modelling: Real number modelling of Analog/Mixed blocks modelling using Verilog-RNM/System Verilog. Analog/Digital Boundary Issues: boundary issues coverage

Text Book

1.	M.J.S.Smith, “Application Specific Integrated Circuits”, Pearson, 2008.
2.	S.Sutherland, S. Davidmann, P. Flake, “System Verilog for Design”, (2/e), Springer, 2006.

References

1.	H.Gerez, “Algorithms for VLSI Design Automation”, John Wiley, 1999
2.	Z. Dr Mark, “Digital System Design with System Verilog “, Pearson, 2010.
3.	Recent literature in Electronic Design Automation Tools.

Course Outcomes (CO)

At the end of the course student will be able

CO1	execute the special features of VLSI back end and front-end CAD tools and UNIX shell script
CO2	explain the algorithms used for ASIC construction
CO3	design synthesizable Verilog and VHDL code.
CO4	explain the difference between Verilog and system Verilog and are able to write system Verilog code.
CO5	Model Analog and Mixed signal blocks using Verilog A and Verilog AMS

Course Code	:	ECPE42
Course Title	:	**Electromagnetic Interference and Compatibility**
Type of Course	:	PE
Prerequisites	:	None
Contact Hours	:	3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	Electromagnetic interference (EMI) is a potential threat to the present-day electronic systems. The main objective of the course is to provide insight into various sources of electromagnetic interferences and how to design an electronic product which is electromagnetically compatible with each other

Course Content

Introduction to EMI and EMC- Various EMC requirements and standards-Need for EMC and its importance in electronic product design - sources of EMI - few case studies on EMC.

Conducted and radiated emission -power supply line filters-common mode and differential mode current-common mode choke- switched mode power supplies. Shielding techniques- shielding effectiveness-shield behavior for electric and magnetic field -aperture-seams-conductive gaskets-conductive coatings

Grounding techniques- signal ground-single point and multi point grounding-system ground-common impedance coupling -common mode choke-Digital circuit power distribution and grounding.

Contact protection - arc and glow discharge-contact protection network for inductive loads-C, RC, RCD protection circuit- inductive kick back. RF and transient immunity-transient protection network- RFI mitigation filter-power line disturbance- ESD- human body model- ESD protection in system design.

PCB design for EMC compliance-PCB layout and stack up- multi layer PCB objectives- Return path discontinuities-mixed signal PCB layout. EMC pre compliance measurement-conducted and radiated emission test-LISN-Anechoic chamber.

Text Book

1.	H. W. Ott, Electromagnetic Compatibility Engineering, 2nd edition, John Wiley & Sons, 2011, ISBN: 9781118210659.
2.	C. R. Paul, Introduction to Electromagnetic Compatibility, 2nd edition, Wiley India, 2010, ISBN: 9788126528752

References

1.	K. L. Kaiser, Electromagnetic Compatibility Handbook, 1st edition, CRC Press, 2005. ISBN: 9780849320873

Course Outcomes (CO)

At the end of the course student will be able

CO1	Understand the various sources of Electromagnetic interference
CO2	Familiarize the fundamentals those are essential for product design with EMC compliance and various EMC standards
CO3	would gain knowledge to understand the concept of Shielding and grounding related to product design
CO4	Design PCBs which are electromagnetically compatible
CO5	understand and differentiate the various EMC pre compliance measurement

Course Code	:	ECPE43
Course Title	:	**Computer Vision**
Type of Course	:	PE
Prerequisites	:	None
Contact Hours	:	3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	The focus of this course is the understanding of algorithms and techniques used in computer vision
CLO2	Provide pointers into the literature and exercise a project based on a literature search and one or more research papers
CLO3	Practice software implementation of different concepts and techniques covered in the course
CLO4	Utilize programming and scientific tools for relevant software implementation

Course Content

Introduction: overview of computer vision, related areas, and applications; overview of software tools; overview of course objectives.; introduction to OpenCV. Image formation and representation: imaging geometry, radiometry, digitization, cameras and projections, rigid and affine transformations, Filtering: convolution, smoothing, differencing, and scale space.

Feature detection: edge detection, corner detection, line and curve detection, active contours, SIFT and HOG descriptors, shape context descriptors, Model fitting: Hough transform, line fitting, ellipse and conic sections fitting, algebraic and Euclidean distance measures.

Camera calibration: camera models; intrinsic and extrinsic parameters; radial lens distortion; direct parameter calibration; camera parameters from projection matrices; orthographic, weak perspective, affine, and perspective camera models.

Motion analysis: the motion field of rigid objects; motion parallax; optical flow, the image brightness constancy equation, affine flow; differential techniques; feature-based techniques; regularization and robust estimation; motion segmentation through EM, Motion tracking: statistical filtering; iterated estimation; observability and linear systems; the Kalman filter; the extended Kalman filter.

Object recognition and shape representation: alignment, appearance-based methods, invariants, image Eigen spaces, data-based techniques.

Text Book

1.	Computer Vision: Algorithms and Applications, R. Szeliski, Springer, 2011
2.	Computer Vision: A Modern Approach, D. Forsyth and J. Ponce, Prentice Hall, 2nd ed., 2011
3.	Introductory techniques for 3D computer vision, E. Trucco and A. Verri, Prentice Hall, 1998

Course Outcomes (CO)

At the end of the course student will be able

CO1	To understand the fundamental problems of computer vision
CO2	To learn techniques, mathematical concepts and algorithms used in computer vision to facilitate further study in this area
CO3	To get an idea regarding the camera calibration and its importance
CO4	To study different kinds of motion estimation methodologies and its applications
CO5	To understand the basic concepts of object and shape recognition techniques

Course Code	:	ECPE44
Course Title	:	**Natural Language Processing**
Type of Course	:	PE
Prerequisites	:	None
Contact Hours	:	3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	Understand NLP tasks in syntax, semantics and pragmatics
CLO2	Implement machine learning techniques used in NLP

Course Content

Introduction – Why NLP? NLP versus speech recognition- Applications-problem of ambiguity-role of machine learning in NLP- Basic neural networks for NLP

Words – Morphology and Finite State Transducers-Tokenization – Computational Phonology and Pronunciation Modelling

Probabilistic models in NLP—Role of language models- Simple N-gram model – Evaluation: Perplexity and Word Error Rate. Parts of Speech Tagging- Hidden Markov models–Viterbi algorithm, Maximum Entropy Markov model

Semantic analysis - Lexical semantics and word-sense disambiguation. Compositional semantics. Semantic Role Labeling and Semantic Parsing

Machine Translation- Statistical translation, word alignment, phrase-based translation, and synchronous grammars, evaluation.

References

1.	Natural Language Processing, by Jacob Eisenstein, MIT Press.
2.	Speech and Language Processing by Daniel Jurafsky and James H. Martin
3.	Foundations of Statistical Natural Language processing by Manning C. D. and Schutze H., First Edition, MIT Press, 1999
4.	Neural Network Methods for Natural Language Processing by Yoav Goldberg, Morgan & Claypool Publishers.

Course Outcomes (CO)

At the end of the course student will be able

CO1	Understand NLP and the role of machine learning in NLP
CO2	Describe finite state transducer operations and pronunciation modelling in NLP
CO3	Illustrate various probabilistic models in NLP.
CO4	Study semantic analysis in NLP
CO5	Learn various machine translation approaches and the different evaluation metrics.

Course Code	:	ECPE45
Course Title	:	**Optimization Methods In Machine Learning**
Type of Course	:	PE
Prerequisites	:	None
Contact Hours	:	3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	The course aims to equip students with advanced techniques and methods in optimization that are tailored to large-scale statistics and machine learning problems

Course Content

Basics of convex optimization-convex sets, convexity-preserving operations, examples of convex programs (linear programming (LP), second-order cone programming (SOCP), semidefinite programming (SDP)), convex relaxation, KKT conditions, duality

Gradient-based methods-gradient descent, sub gradient, mirror descent, Frank–Wolfe method, Nesterov's accelerated gradient method, ODE interpretations, dual methods, Nesterov's smoothing, proximal gradient methods, Moreau–Yosida regularization

Operator splitting methods-augmented Lagrangian methods, alternating direction method of multipliers (ADMM), monotone operators, Douglas–Rachford splitting, primal and dual decomposition

Stochastic and nonconvex optimization-Dual averaging, Polyak–Juditsky averaging, stochastic variance reduced gradient (SVRG), Langevin dynamics, escaping saddle points, landscape of nonconvex problems, deep learning

Applications of optimization methods in Image/Video/Multimedia Processing

Text Book

1.	Stephen Boyd and Lieven Vandenberghe's book: Convex Optimization
2.	Nesterov's old book: Introductory Lectures on Convex Optimization: A Basic Course
3.	Nesterov's new book: Lectures on Convex Optimization
4.	Neal Parikh and Stephen Boyd's monograph: Proximal Algorithms
5.	Sebastien Bubeck's monograph: Convex Optimization: Algorithms and Complexity

References

1.	Moritz Hardt's Berkeley EE 227C course note
2.	Prateek Jain and Purushottam Kar's survey on nonconvex optimization
3.	Kristin Bennett, Emilio Parrado-Hernandez. Interplay of Optimization and Machine Learning Research, Journal of Machine Learning Research, 2006.
4.	Nati Srebro, Ambuj Tewari. Stochastic Optimization for Machine Learning, Tutorial at International Conference on Machine Learning, 2010.

Course Outcomes (CO)

At the end of the course student will be able

CO1	To learn the basic concepts of convex optimization
CO2	To study gradient based optimization techniques
CO3	To understand the problem-solving using operator splitting methods
CO4	To learn stochastic and non-convex optimization Techniques,
CO5	To execute applications of optimization techniques in different domains

Course Code	:	ECPE46
Course Title	:	**Hardware for Deep Learning**
Type of Course	:	PE
Prerequisites	:	None
Contact Hours	:	3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To get an idea about deep learning and how to implement deep learning algorithms on FPGA

Course Content

Introduction to Deep Learning: From AI to DL, Neural Network: Perceptron, Back Propagation, Over-fitting, Regularization. Deep Networks: Definition, Motivation, Applications, Convolution Neural Network (CNN): Basic architecture, Activation functions, Pooling, Handling vanishing gradient problem, Dropout, Weight initialization methods, Batch Normalization. Training Neural networks, Additional CNN Components, Famous CNNs, Applications, Software libraries.

Computing Convolutions: Mapping Matrix multiplication, Computational Transforms, Accelerator Architectures, Dataflow Taxonomy

Reducing the Complexity: Light weight models, reducing precision, Aggressive Quantization, pruning & Deep compression.

The Deep Learning Acceleration Landscape: parallelism in deep learning, Traditional programmable hardware, specialized deep learning hardware platforms, deep learning software stack, Specialized research ASICs.

FPGAs for Deep Learning: Overview of hardware architectures for deep learning, Effective management of FPGA memory resources, optimizing algorithms and data representation for FPGA arithmetic resources, Integrating hardware and software.

Text Book

1.	Ian Goodfellow, Yishuv Bengio and Aaron Courville, “Deep Learning.” MIT Press. 2016. ISBN: 978-0262035613. Available online for free at: http://www.deeplearningbook.org
2.	Vivienne Sze; Yu-Hsin Chen; Tien-Ju Yang; Joel S. Emer, “Efficient Processing of Deep Neural Networks” Morgan & Claypool Publishers, 1st Edition, 2020.
3.	Tushar Krishna, Hyoukjun Kwon, Angshuman Parashar, Michael Pellauer, and Ananda Samajdar, “Data Orchestration in Deep Learning Accelerators”, Morgan & Claypool Publishers, 1st Edition, 2020.

References

1.	Piotr Antonik, “Application of FPGA to Real-Time Machine Learning”, Springer, 2018.
2.	Stanford C231n, 2017
3.	Sze, et al. https://eyeriss.mit.edu/ ISCA Tutorial 2019
4.	Sze, et al. “Efficient Processing of Deep Neural Networks: A Tutorial and Survey”, Proceedings of the IEEE, 2017
5.	Prof. Adam Teman https://www.eng.biu.ac.il/temanad/hardware-for-deep-learning/
6.	https://jameswhanlon.com/

Course Outcomes (CO)

At the end of the course student will be able

CO1	Understand the context of convolutional neural networks and deep learning algorithms.
CO2	Know how to use convolution in deep learning techniques.
CO3	Understand the necessity and importance of light weight models with low complexity through specialized hardware architecture
CO4	Know how to optimize hardware performance in deep neural network applications.
CO5	Discuss, suggest and evaluate specialized hardware architectures to implement deep learning algorithms in FPGA and utilize deep learning concepts in resource constrained reliable systems

Course Code	**:**	ECPE47
Course Title	**:**	**Image and Video Processing**
Type of Course	**:**	PE
Prerequisites	**:**	None
Contact Hours	**:**	3
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	The course aims to equip students with basic image and video processing techniques.

Course Content

Image Formation and Representation: 3D to 2D projection, photometric image formation, trichromatic colour representation, video format (SD, HD, UHD, HDR), contrast enhancement (concept of histogram, nonlinear mapping, histogram equalization)

Review of 1D Fourier transform and convolution: Concept of spatial frequency. Continuous and Discrete Space 2D Fourier transform. 2D convolution and its interpretation in frequency domain. Implementation of 2D convolution. Separable filters. Frequency response. Linear filtering (2D convolution) for noise removal, image sharpening, and edge detection. Gaussian filters, DOG and LOG filters as image.

Geometric mapping and Feature detection: Geometric mapping (affine, homography), Feature based camera motion estimation (RANSAC). Image warping. Image registration. Panoramic view stitching, Feature detection (Harris corner, scale space, SIFT), feature descriptors (SIFT). Bag of Visual Word representation for image classification.

Motion estimation: optical flow equation, optical flow estimation (Lucas-Kanade method, KLT tracker); block matching, multi-resolution estimation. Deformable registration (medical applications), Moving object detection (background/foreground separation): Robust PCA (low rank + sparse decomposition). Global camera motion estimation from optical flows. Video stabilization. Video scene change detection.

Video Coding: block-based motion compensated prediction and interpolation, adaptive spatial prediction, block-based hybrid video coding, rate-distortion optimized mode selection, rate control, Group of pictures (GoP) structure, tradeoff between coding efficiency, delay, and complexity, depth from disparity, disparity estimation, view synthesis. Multiview video compression. Depth camera (Kinect). 360 video camera and view stitching.

Text Book

1.	Richard Szeliski, Computer Vision: Algorithms and Applications. (Available online:”Link“) (Cover most of the material, except sparsity-based image processing and image and video coding)
2.	(Optional) Y. Wang, J. Ostermann, and Y.Q.Zhang, Video Processing and Communications. Prentice Hall, 2002. “Link” (Reference for image and video coding, motion estimation, and stereo)
3.	(Optional) R. C. Gonzalez and R. E. Woods, Digital Image Processing, Prentice Hall, (3rd Edition) 2008. ISBN number 9780131687288. “Link” (Good reference for basic image processing, wavelet transforms and image coding).

Course Outcomes (CO)

At the end of the course student will be able

CO1	Understand the concept of image formation and representation
CO2	Know the need of transformation and convolution
CO3	Understand the necessity and importance of feature detection and geometric mapping
CO4	Know how to do motion estimation in video
CO5	To understand the basic ideas of video coding

Course Code	:	ECPE48
Course Title	:	**Automated Test Engineering for Electronics**
Type of Course	:	PE
Prerequisites	:	None
Contact Hours	:	3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Content

Printed Circuit Boards (PCBs) – types of PCB – multilayer PCBs – Plated though Hole Technology (PTH) - Surface Mount Technology (SMT) – Ball Grid Array (BGA) Technology. Bare PCB electrical test concepts, Loaded PCB Visual inspection, Automated Optical inspection systems, X-Ray inspection systems- Measuring Passive components – 2 wires, 3 wire, 4 wire and 6 wire measurement concepts, Guarding techniques, Shorts location, Most common manufacturing defects, Automated Manufacturing defect analyzers, Nodal Impedance / analog signature analysis. Flying probe testers.

Concepts of PCB Trouble-shooting, Symptom recognition, Bracketing technique, Failure types and fault causes, Manual Trouble shooting, Use of DMM, Oscilloscope, Signal Generators, Logic Probes, Logic Pulsers, Logic Analyzers, Automated Test Techniques – CPU Emulation technique, ROM Emulation, In-Circuit Comparators, In- Circuit Emulators, Functional Testing of Digital ICs, Library models, Concepts of In-circuit Testing, - Back Driving technique – international defence standards - Auto Compensation, In-Circuit Test of Open collector / Emitter Devices, Tri-State, Bi-Directional Devices, Concepts of Digital Guarding, Analog and Mixed Signal ICs Test, advantages and limitations of in-circuit testing, AC – DC Parametric testing, –Advanced test techniques- Boundary Scan Test , Learn and compare technique – digital signatures, Bus Cycle Signature Test , Analog signatures.

ATE system components, Main Test Vector processor, Digital Subsystem, Pin Electronics, Programmable drive and threshold levels, RAM behind each pin, Controlling slew rate, Skew between channels, Data formats, Digital and analog simulation, Test Vector Generation, Fault simulation, Fault coverage, Test Languages, Verilog, VHDL, Automatic compare, Analog Sub system, Digital and analog matrix switch circuits, digital and analog highways, Integration of JTAG, Boundary Scan Test, BSDL, External Instrumentation, Functional and Timing tests.

Concepts of Test Program (T.P) Generation. Commercially available off the shelf Test Equipment's (COTS)

Board Functional Test (BFT) techniques – Go-No-go Test – Diagnostic Test, Reliability Test, Thermal Shock Test, Full functional Edge to edge test, Cluster Test – Guided Probe Backtracking Technique – Simulators – Online and Offline Simulation - Fault Simulation– Comprehensiveness of Board program – Fault Dictionary– Analysis – BS and Non-BS device testing–- Sample board programming and testing – BS interconnect and simulating faults - External Instrumentation used for board testing – PXI Instrumentation – Integration of PXI instruments for testing

Design for testability (DFT) and Design for manufacturability (DFM) - Basics of ATPG, – Fault Models –– Design considerations for edge functional test, Design considerations for Bus Cycle Signature Test, Design considerations for Boundary Scan Test, Built-in Self-Test, Modular Design– ATE for test - DFM - Manufacturing phases in industry-oriented Production process – strategies – new strategy - benefits of new strategies

References

1.	Test Engineering for Electronic Hardware – S R Sabapathi, Qmax Test Equipments P. Ltd., 2011
2.	Practical Electronic Fault Finding and Troubleshooting - Robin Pain Newnes, Reed Educational and professional publishing Ltd., 1996
3.	The Fundamentals of Digital Semiconductor Testing, Floyd, Pearson Education India, Sep-2005
4.	Building a Successful Board Test Strategy-Stephen F Scheiber-Butterworth Heinemann

Course Code	**:**	ECPE49
Course Title	**:**	**Foundations of Artificial Intelligence**
Type of Course	**:**	PE
Prerequisites	**:**	Programming
Contact Hours	**:**	3
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	Learning the principles and fundamentals of designing AI programs
CLO2	Developing insights into the suitability and applicability of different models for solving different problems
CLO3	Designing AI techniques for solving problems

Course Content

Unit 1: Introduction to Artificial Intelligence: Search and Problem Solving, Uninformed search, Informed search.

Unit 2: Local search, Adversarial Search, Constraint satisfaction, Logic in AI.

Unit 3: Reasoning under uncertainty: Probability theory, Bayesian networks, Inference, Probabilistic reasoning over time.

Unit 4: Decision making: Decision theory, Decision networks, Markov decision processes, Reinforcement learning, multi-agent systems.

Unit 5: Machine learning: Decision tree learning, Statistical learning, Neural networks, Introduction to Deep learning, Deep reinforcement learning, AI applications.

References

1.	Stuart Russell and Peter Norvig, Artificial Intelligence: A Modern Approach, 3rd Edition, PHI 2009.
2.	Patrick Henry Winston, Artificial Intelligence, Third Edition, Addison-Wesley Publishing Company, 2004.
3.	Nils J Nilsson, Principles of Artificial Intelligence, Illustrated Reprint Edition, Springer Heidelberg, 2014.
4.	Nils J. Nilsson, Quest for Artificial Intelligence, First Edition, Cambridge University Press, 2010.
5.	Ian Goodfellow, Yoshua Bengio and Aaron Courville, Deep Learning, MIT Press (2016).
6.	Richard Sutton and Andrew Barto, Reinforcement Learning (2nd Edition), MIT Press (2018).
7.	Christopher Bishop, Pattern Recognition and Machine Learning, Springer, New York, 2006.

Course Outcomes (CO)

At the end of the course student will be able

CO1	To understand the foundational concepts of artificial intelligence
CO2	To apply search and problem-solving techniques
CO3	To understand decision theory and apply reasoning mechanisms
CO4	To apply appropriate machine learning algorithms to solve problems in AI applications such as vision, speech, NLP etc.
CO5	Equipped with the expertise to research on advanced artificial intelligence topics

Course Code	:	ECPE50
Course Title	:	**Photonic Integrated Circuits**
Type of Course	:	PE
Prerequisites	:	None
Contact Hours	:	3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To introduce students to the basic structures of integrated optical waveguides and devices.
CLO2	To expose students to different types of application-specific photonic integrated circuits and devices.
CLO3	To get students introduced to the varieties of materials and fabrication technology for optical integrated circuits
CLO4	To get students introduced to the nonlinear effects in integrated optical waveguides.

Course Content

Brief history of optical communication, Advantages of integrated optics configuration, Guided TE and TM Modes of Symmetric and anti-symmetric planar waveguides: Step-index and graded- index waveguides. Strip and channel waveguides, Beam propagation method.

Directional couplers, Applications as power splitters, Y-junction, optical switch; modulators, filters, A/D converters, Mode splitters, Mach-Zehnder interferometer-based devices.

Acousto-optic waveguide devices. Arrayed waveguide devices, Nano-photonic-devices: Metal/dielectric plasmonic waveguides, Surface Plasmon modes, applications in waveguide polarizers.

Materials. Glass, lithium niobate, silicon, compound semiconductors. Fabrication of integrated optical waveguides and devices. Lithography, deposition.

Waveguide characterization, prism coupling, grating and tapered couplers, Nonlinear effects in integrated optical waveguides, Types and Applications.

References

1.	H. Nishihara, M. Haruna and T. Suhara, Optical Integrated Circuits; McGraw-Hill Book Company, New York, 1989.
2.	A. Ghatak and K. Thyagarajan, Optical Electronics, Cambridge University Press, 1989.
3.	José Capmany and Daniel Pérez, Photonic Integrated Circuits, Oxford University Press, 2020
4.	T. Tamir, Guided wave opto-electronics, Springer Verilag, 1990.
5.	K. Okamota, Fundamentals of Optical waveguides, Academic Press, 2006.
6.	T. Tamir, Integrated Optics, Springer Verlag, New York, 1982.
7.	C. R. Pollock and M Lipson, Integrated photonics, Kluwer Pub, 2003.

Course Outcomes (CO)

At the end of the course student will be able

CO1	Recognize the fundamental concept of optical waveguides
CO2	Classify the different types of optical waveguides.
CO3	Classify the couplers, modulators and devices for communication applications
CO4	Familiar with fabrication technologies for design of optical waveguides
CO5	Discuss the various nonlinear effects in integrated optical waveguides.

Course Code	:	ECPE51
Course Title	:	**Microwave Circuits**
Type of Course	:	PE
Prerequisites	:	None
Contact Hours	:	3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To make the students familiarize with ABCD parameters, S parameters, Applications of planar transmission lines in the practical microwave circuits, Design and layout of all Microwave Integrated Circuit Design components and then systems.

Course Content

Introduction and application of microwave circuits - Two-port network characterization. ABCD parameters, Conversion of S matrix in terms of ABCD matrix. Scattering matrix representation of microwave components. Review of Smith chart and its application- Impedance matching using Lumped and Distributed approach.

Microwave Passive circuit design: Characteristics, properties, design parameters and applications- Design and realization of MIC Power dividers. 3 dB hybrid design. Directional Coupler design- Hybrid ring design.

Microwave filter design- Filter design by insertion loss method –Richards and Kuroda transformation. K inverter, J inverter. Resonator filters. Realization using microstrip lines and strip lines.

Microwave amplifier design- Power gain equations -Stability considerations. Maximum gain design, Design for specific gain -Low Noise Amplifier Design. High power design.

Microwave oscillator design. One – port and two – port negative resistance oscillators and oscillator design

Text Book

1.	Reinhold Ludwig, RF circuit design, 2nd edition, Prentice Hall 2014, ISBN: 978-0131471375
2.	David. M. Pozar, Microwave engineering, 4th edition, John Wiley, 2011, ISBN: 978-0470631553.
3.	Devendra K. Misra, “Radio-Frequency and microwave communication circuits analysis and design”, 2nd edition, University of Wisconsin-Mulwaukee, A John Wiley & Sons Publication

References

1.	B. Bhat, S. K Koul, “Stripline like transmission lines for Microwave Integrated Circuits”, New Age International Pvt. Ltd Publishers, 2007.
2.	I.J.Bahl & P.Bhartia, “Microwave Solid state Circuit Design (2/e)”, Wiley, 2003.
3.	Matthew M. Radmanesh, Radio Frequency and Microwave Electronics Illustrated, Prentice Hall, 2012
4.	S.Y.Liao, “Microwave Circuit Analysis and Amplifier Design”, Prentice-Hall, 1986.
5.	G. Mathaei, L young, E.M.T. Jones, “Microwave filters, Impedance-Matching networks and Coupling structures”, Artech House Books.

Course Outcomes (CO)

At the end of the course student will be able

CO1	Understand the basics of Scattering matrix and two port characterization and importance of matching circuits.
CO2	Analyze the working principles of couplers, power dividers etc. and their design.
CO3	Design the different types of MIC filters and their implementation.
CO4	Understand the complexities of microwave amplifier design and its stability features.
CO5	Analyze and appreciate the design principles of microwave oscillators.

Course Code	**:**	ECPE52
Course Title	**:**	**Introduction to Machine Learning**
Type of Course	**:**	PE
Prerequisites	**:**	None
Contact Hours	**:**	3
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Content

Statistical Decision Theory - Regression, Classification, Bias Variance, Linear Regression, Multivariate Regression, Subset Selection, Shrinkage Methods, Principal Component Regression, Partial Least squares

Linear Classification, Logistic Regression, Linear Discriminant Analysis, Perceptron, Support Vector Machines, Neural Networks - Introduction, Early Models, Perceptron Learning, Backpropagation, Initialization, Training & Validation, Parameter Estimation - MLE, MAP, Bayesian Estimation

Decision Trees, Regression Trees, Stopping Criterion & Pruning loss functions, Categorical Attributes, Multiway Splits, Missing Values, Decision Trees - Instability Evaluation Measures, Bootstrapping & Cross Validation, Class Evaluation Measures, ROC curve, MDL, Ensemble Methods - Bagging, Committee Machines and Stacking, Boosting

Gradient Boosting, Random Forests, Multi-class Classification, Naive Bayes, Bayesian Networks, Undirected Graphical Models, HMM, Variable Elimination, Belief Propagation, Partitional Clustering, Hierarchical Clustering, Birch Algorithm, CURE Algorithm, Density-based Clustering,

Gaussian Mixture Models, Expectation Maximization, Learning Theory, Introduction to Reinforcement Learning

References

1.	The Elements of Statistical Learning, by Trevor Hastie, Robert Tibshirani, Jerome H. Friedman
2.	Pattern Recognition and Machine Learning, by Christopher Bishop
3.	Machine Learning: A Bayesian and Optimization Perspective by Sergios Theodoridis
4.	C229 Machine learning lecture notes, Stanford university by Andrew NG

Course Outcomes (CO)

At the end of the course student will be able

CO1	Understand various regression and classification algorithms
CO2	Develop machine learning algorithms for practical applications
CO3	Basic Neural networks and back propagation.
CO4	Develop an intuition about the bias variance trade-off
CO5	Introduction to reinforcement learning and Unsupervised learning

Course Code	**:**	ECPE53
Course Title	**:**	**Deep Learning**
Type of Course	**:**	PE
Prerequisites	**:**	None
Contact Hours	**:**	3
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Content

Machine learning, Introduction to Deep learning, McCulloch Pitts Neuron, Thresholding Logic, Perceptrons, Perceptron Learning Algorithm and Convergence, Multilayer Perceptrons (MLPs), Representation Power of MLPs, Sigmoid Neurons, Gradient Descent, Feedforward Neural Networks, Representation Power of Feedforward Neural Networks.

Gradient Descent (GD), Momentum Based GD, Nesterov Accelerated GD, Stochastic GD, AdaGrad, RMSProp, Adam, Regularization, Bias Variance Tradeoff, L2 regularization, Early stopping, Dataset augmentation, Parameter sharing and tying, Injecting noise at input, Ensemble methods, Dropout.

Greedy Layer wise Pre-training, activation functions, weight initialization methods, Batch Normalization, Convolutional Neural Networks, LeNet, AlexNet, ZF-Net, VGGNet, GoogLeNet, ResNet

Recurrent Neural Networks, Backpropagation Through Time (BPTT), Vanishing and Exploding Gradients, Truncated BPTT, Gated Recurrent Units (GRUs), Long Short-Term Memory (LSTM) Cells, Solving the vanishing gradient problem with LSTMs

Encoder Decoder Models, Attention Mechanism, Attention over images, Hierarchical Attention, Multi-headed Self Attention, Cross Attention, Autoencoders

References

1.	Ian Goodfellow and Yoshua Bengio and Aaron Courville. Deep Learning. An MIT Press book. 2016.
2.	Charu C. Aggarwal. Neural Networks and Deep Learning: A Textbook. Springer. 2019.
3.	Dive into Deep Learning

Course Outcomes (CO)

At the end of the course student will be able

CO1	Study the basic feedforward neural network and backpropagation algorithm
CO2	Understanding the various regularization approached used in deep learning
CO3	Understand the Convolutional neural networks
CO4	Understand the recurrent neural networks
CO5	Develop an intuition about attention and encoder decoder architecture

Course Code	:	ECPE54
Course Title	:	**CONTROL SYSTEMS**
Type of Course	:	PE
Prerequisites	:	None
Contact Hours	:	3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To introduce the components and their representation of control systems
CLO2	To learn various methods for analyzing the time response, frequency response and stability of the systems.
CLO3	To learn the various approach for the state variable analysis.

Course Content

Control System: Terminology and Basic Structure-Feed forward and Feedback control theory, Electrical and Mechanical Transfer Function Models-Block diagram Models-Signal flow graphs models-DC and AC servo Systems-Synchronous -Multivariable control system

Transient response-steady state response-Measures of performance of the standard first order and second order system-effect on an additional zero and an additional pole-steady error constant and system- type number-PID control-Analytical design for PD, PI, PID control systems

Closed loop frequency response-Performance specification in frequency domain-Frequency response of standard second order system- Bode Plot - Polar Plot- Nyquist Plots-Design of compensators using Bode Plots-Cascade lead compensation-Cascade lag compensation-Cascade lag-lead compensation

Concept of stability-Bounded - Input Bounded - Output stability-Routh stability criterion-Relative stability-Root locus concept-Guidelines for sketching root locus-Nyquist stability criterion.

State variable representation-Conversion of state variable models to transfer functions-Conversion of transfer functions to state variable models-Solution of state equations-Concepts of Controllability and Observability-Stability of linear systems-Equivalence between transfer function and state variable representations-State variable analysis of digital control system-Digital control design using state feedback.

Text Book

1.	M. Gopal, “Control System – Principles and Design”, Tata McGraw Hill, 4th Edition, 2012.

References

1.	J.Nagrath and M.Gopal, “Control System Engineering”, New Age International Publishers, 5th Edition, 2007.
2.	K.Ogata, “Modern Control Engineering”, PHI, 5th Edition, 2012.
3.	S.K.Bhattacharya, “Control System Engineering”, Pearson, 3rd Edition, 2013.
4.	Benjamin.C.Kuo, “Automatic Control Systems”, Prentice Hall of India, 7th Edition,1995.

Course Outcomes (CO)

At the end of the course student will be able

CO1	Compute the transfer function of different physical systems.
CO2	Analyse the time domain specification and calculate the steady state error.
CO3	Illustrate the frequency response characteristics of open loop and closed loop system response.
CO4	Analyse the stability using Routh and root locus techniques.
CO5	Illustrate the state space model of a physical system and discuss the concepts of sampled data control system.

Course Code	**:**	ECPE55
Course Title	**:**	**ADVANCED TOPICS IN 5G/B5G WIRELESS COMMUNICATION**
Type of Course	**:**	PE
Prerequisites	**:**	ECPC22 - Wireless Communication
Contact Hours	**:**	3
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	Objective of this course is to help students get familiarized with the latest advancements in 5G and B5G Wireless Communications.

Course Content

I. Introduction: 5G New radio frame structure, Numerology, Standardization, Review of orthogonal frequency division multiplexing, Review of multiple input multiple output systems.

II. Waveforms: Orthogonal time frequency space, non-orthogonal multiple access, Index modulation, Spatial modulation, intelligent reflecting surface, full duplex, physical layer security.

III. mmWAVE and massive MIMO: Spectrum, Beamforming, Angle of arrival, Angle of departure, Channel model, Precoding, Massive MIMO with imperfect CSI, Multi cell massive MIMO, Imperfect CSI, Pilot Contamination, Channel Estimation

IV. Ultra Dense Networks: Poisson point Process, Device-to-Device Networks, Femtocells, Macro cells, Heterogeneous networks, Coverage, Rate of cellular networks.

V. Coding: Low density parity check code, Log likelihood ratio, soft input soft output decoder, Rate matching, Puncturing, Polar code, successive cancellation decoding of polar codes.

Text Book

1.	“5G NR: The Next Generation Wireless Access Technology”, Erik Dahlman, Stefan Parkvall, Johan Skold, Elsevier, 2E, 2020
2.	“5G Physical Layer: Principals, Models and Technology Components”, Ali Zaidi, et al., Academic Press, 2018.
3.	“Large MIMO Systems”, A Chockalingam, B Sundar Rajan, Cambridge University Press, 2014.

References

1.	“Delay Doppler Communications -Principles and Applications”, Yi Hong et al., Elsevier, 2022.
2.	“OTFS - Orthogonal Time Frequency Space Modulation-A waveform for 6G”, Surva Sekhar Das, Ramjee Prasad, River Publishers Series in Communication, 2021.
3.	“LDPC Coded Modulations”, M. Franceschini et al., Springer, 2009
4.	Massive MIMO Networks-Spectral, Energy and Hardware Efficiency”, E.Bjornson et al., NOW Publishers, 2017
5.	“Millimetre Wave Communications”, M.G. Sache, MDPI Publishers, 2020
6.	“Stochastic Geometry Analysis of Cellular Networks”, B Blaszczyszyn et al., Cambridge University

Course Outcomes (CO)

At the end of the course student will be able

CO1	Students will learn about the different 5G Modulation Waveforms.
CO2	Students will learn about 5G Numerology, Frame structure.
CO3	Students will learn about mmwave, beamforming and massive MIMO systems.
CO4	Students will learn to analyze ultra dense networks, derive coverage, rate of heterogeneous networks.
CO5	Students will learn about LDPC and polar codes.

Course Code	:	ECPE56
Course Title	:	**Analog Power Integrated Circuits**
Type of Course	:	PE
Prerequisites	:	ECPC11 Network Analysis and Synthesis ECPC17 Electronic Circuits ECPC21 Analog Integrated Circuits
Contact Hours	:	3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To understand and design power management integrated circuits such as voltage & current references, low-dropout regulators, and DC-DC converters.
CLO2	To understand the design challenges of state-of-the-art power management unit (PMU) designed for IoT and RF applications.

Course Content

Introduction to switching and linear regulators, energy sources and load circuits, package thermal constraints, regulator performance parameters, on-chip device process variations and mismatch.

Current and voltage reference circuits: Beta multiplier current reference operating in saturation and sub-threshold region, power supply rejection ratio (PSRR) of current reference, complementary to absolute temperature (CTAT) current reference, peaking current source, temperature independent (I) reference. Bandgap voltage reference (BGR), voltage trimming, curvature correction, and PSRR improvement techniques, MOSFET only sub-threshold region-based voltage reference circuits (CVR), analysis and simulation methods.

Low drop-out voltage regulators (LDO): Linear regulator, NMOS & PMOS pass-FET LDO circuits, DC and AC analysis, small signal model and stability analysis, internally and externally compensated LDOs, PSRR analysis, load and line transient analysis.

Inductive DC-DC/Switching converters: Power stage and fundamental concepts, steady state operation, volt-second balance principle, ripple current and voltage magnitude, CCM Vs DCM operation, line and load transient response, small signal model, loop gain and stability analysis, dominant pole (type-I), type-II, and type-III compensation, power-FET loss components and optimal sizing methodology, DC-DC converter loss components and efficiency calculation.

Course project: Design to GDS analog tape out flow, design project involving specification to design, schematic, layout, and post-layout extraction of voltage and current reference circuits, LDO, power-FET and DC-DC converters in a 65nm CMOS process.

Text Book

1.	Bernhard Wicht, "Design of Power Management Integrated Circuits", Wiley-IEEE Press, 2024.
2.	Ke-Horng Chen, "Power Management Techniques for Integrated Circuit Design", Wiley-IEEE Press, 2016.

References

1.	Mona M. Hella, Patrick Mercier, "Power Management Integrated Circuits", CRC Press, 2016.
2.	"Power Topologies Handbook", Texas Instruments.
3.	Selected papers from IEEExplore (https://ieeexplore.ieee.org/Xplore/home.jsp).

Course Outcomes (CO)

At the end of the course student will be able

CO1	understand the power management unit specifications for given target applications.
CO2	understand and analyze the performance of power management integrated circuits.
CO3	appreciate the challenges involved in the design of a high-performance PMU design.
CO4	design various types of voltage & current references, LDO's, and DC-DC converters.
CO5	design high efficiency on-chip power management circuits.

OPEN ELECTIVES (PE)

Course Code	**:**	ECOE10
Course Title	**:**	**MICROWAVE INTEGRATED CIRCUITS**
Type of Course	**:**	OE
Prerequisites	**:**	None
Contact Hours	**:**	3
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To impart knowledge on basics of microwave electron beam devices and their applications in X band frequency.

Course Content

Design and realization of power dividers, hybrids, directional couplers etc using strip lines and micro strip lines.

Filter design; Kuroda identities. K and J inverters. Filter transformations. Realization using strip lines and micro strip lines.

Transistor amplifiers; Power gain equations. Stability considerations. Analysis. Design using MICs.

Transistor oscillators. Active devices for microwave oscillators. Three port S parameter characterization of transistors. Oscillation and stability conditions.

Diode mixers. Mixer design. Single ended mixer. Balanced mixer. Image rejection mixer. Phase shifter design. PIN diode. Phase shifter.

Text Book

1.	I.J.Bahl & Bhartia, Microwave Solid State Circuit Design, Wiley, 1987.
2.	G.D.Vendelin, Design of Amplifiers and Oscillators by the S Parameter Method, Wiley, 1982.

References

1.	Stripline-like Transmission Lines for Microwave Integrated Circuits - Bharathi Bhat, Shiban Koul, New Age International(P) Limited, Publishers, 2007
2.	Microwave Engineering, David M Pozar, John Wiley & Sons,In International Student Edition
3.	T.C.Edwards, Foundations for Microstrip Circuit Design (2/e), Wiley, 1992.
4.	Recent literature in Microwave Integrated Circuit Design.

Course Outcomes (CO)

At the end of the course student will be able

CO1	the topics will make students design of the important and essential M.I.C components
CO2	Filter is the most needed circuit for many applications and the unit will make the student confident in filter design
CO3	All aspects and different parameters, design factors and properties will me made thorough
CO4	One will be confident to handle any oscillator design
CO5	The student will become familiar and confident in the design of Mixers, the other essential circuits.

Course Code	:	ECOE11
Course Title	:	**RF MEMS CIRCUIT**
Type of Course	:	OE
Prerequisites	:	None
Contact Hours	:	3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To impart knowledge on basics of MEMS and their applications in RF circuit design.

Course Content

Introduction to Micromachining Processes. RF MEMS relays and switches. Switch parameters. Actuation mechanisms. Bi-stable relays and micro actuators. Dynamics of switching operation.

MEMS inductors and capacitors. Micro machined inductor. Effect of inductor layout. Modeling and design issues of planar inductor. Gap-tuning and area-tuning capacitors. Dielectric tunable capacitors.

MEMS phase shifters. Types. Limitations. Switched delay lines. Fundamentals of RF MEMS Filters. Micro machined transmission lines. Coplanar lines. Micro machined directional coupler and mixer.

Micro machined antennas. Micro strip antennas –design parameters. Micromachining to improve performance. Reconfigurable antennas.

Text Book

1.	Vijay.K.Varadanetal, "RF MEMS and their Applications", Wiley-India, 2011.

References

1.	H.J.D.Santos, "RF MEMS Circuit Design for Wireless Communications", Artech House, 2002.
2.	G.M.Rebeiz, "RF MEMS Theory, Design, and Technology", Wiley, 2003.
3.	Recent literature in RF MEMS Circuit Design.

Course Outcomes (CO)

At the end of the course student will be able

CO1	learn the Micromachining Processes
CO2	learn the design and applications of RF MEMS inductors and capacitors.
CO3	learn about RF MEMS Filters and RF MEMS Phase Shifters.
CO4	learn about the suitability of micro machined transmission lines for RF MEMS
CO5	learn about the Micro machined Antennas and Reconfigurable Antennas

Course Code	**:**	ECOE12
Course Title	**:**	**HIGH SPEED SYSTEM DESIGN**
Type of Course	**:**	OE
Prerequisites	**:**	None
Contact Hours	**:**	3
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To expose the students to all aspects of electronic packaging including electrical, thermal, mechanical and reliability issues.

Course Content

Functions of an Electronic Package, Packaging Hierarchy, IC packaging: MEMS packaging, consumer electronics packaging, medical electronics packaging, Trends, Challenges, Driving Forces on Packaging Technology, Materials for Microelectronic packaging, Packaging Material Properties, Ceramics, Polymers, and Metals in Packaging, Material for high density interconnect substrates

Overview of Transmission line theory, Clock Distribution, Noise Sources, power Distribution, signal distribution, EMI; crosstalk and non-ideal effects; signal integrity: impact of packages, via, traces, connectors; non-ideal return current paths, high frequency power delivery, simultaneous switching noise; system-level timing analysis and budgeting; methodologies for design of high-speed buses; radiated emissions and minimizing system noise.

Electrical Anatomy of Systems Packaging, Signal Distribution, Power Distribution, Electromagnetic Interference, Design Process Electrical Design: Interconnect Capacitance, Resistance and Inductance fundamentals; Transmission Lines, Clock Distribution, Noise Sources, power Distribution, signal distribution, EMI, Digital and RF Issues. Processing Technologies, Thin Film deposition, Patterning, Metal to metal joining.

IC Assembly – Purpose, Requirements, Technologies, Wire bonding, Tape Automated Bonding, Flip Chip, Wafer Level Packaging, reliability, wafer level burn – in and test. Single chip packaging: functions, types, materials processes, properties, characteristics, trends. Multi-chip packaging: types, design, comparison, trends. Passives: discrete, integrated, and embedded –encapsulation and sealing: fundamentals, requirements, materials, processes

Printed Circuit Board: Anatomy, CAD tools for PCB design, Standard fabrication, Micro via Boards. Board Assembly: Surface Mount Technology, Through Hole Technology, Process Control and Design challenges. Thermal Management, Heat transfer fundamentals, Thermal conductivity and resistance, Conduction, convection and radiation – Cooling requirements.

Reliability, Basic concepts, Environmental interactions. Thermal mismatch and fatigue – failures – thermo mechanically induced – electrically induced – chemically induced. Electrical Testing: System level electrical testing, Interconnection tests, Active Circuit Testing, Design for Testability.

Text Book

1.	Tummala, Rao R., Fundamentals of Microsystems Packaging, McGraw Hill, 2001
2.	Howard Johnson, Martin Graham, High Speed Digital Design: A Handbook of Black Magic, Prentice Hall, 1993

References

1.	Blackwell (Ed), The electronic packaging handbook, CRC Press, 2000.
2.	Tummala, Rao R, Microelectronics packaging handbook, McGraw Hill, 2008.
3.	Bosshart, Printed Circuit Boards Design and Technology,TataMcGraw Hill, 1988.
4.	R.G. Kaduskar and V.B.Baru, Electronic Product design, Wiley India, 2011
5.	R.S.Khandpur, Printed Circuit Board, Tata McGraw Hill, 2005
6.	Recent literature in Electronic Packaging.

Course Outcomes (CO)

At the end of the course student will be able

CO1	Design of PCBs which minimize the EMI and operate at higher frequency.
CO2	Enable design of packages which can withstand higher temperature, vibrations and shock.
CO3	Explain the basic techniques for statistical process control and failure mode and effect analysis.
CO4	Prescribe and perform parametric test and analysis and the troubleshooting of electronic circuits with the application of basic and virtual electronic instruments.
CO5	Explain contemporary pragmatic manufacturing processes, interconnects and assembly methods for electronic equipment fabrication.

Course Code	**:**	ECOE13
Course Title	**:**	**DIGITAL SPEECH PROCESSING**
Type of Course	**:**	OE
Prerequisites	**:**	ECPC15
Contact Hours	**:**	3
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	The purpose of this course is to explain how DSP techniques could be used for solving problems in speech communication.

Course Content

Speech production model-1D sound waves-functional block of the Vocal tract model –Linear predictive co- efficient (LPC) -Auto-correlation method-Levinson-Durbin Algorithm-Auto-co-variance method-Lattice Structure-Computation of Lattice co-efficient from LPC-Phonetic Representation of speech-Perception of Loudness - Critical bands – Pitch perception – Auditory masking.

Feature extraction of the speech signal: Endpoint Detection-Dynamic time warping- Pitch frequency estimation: Autocorrelation approach- Homomorphic Approach-Formant frequency estimation using vocal tract model and Homomorphic Approach-Linear predictive co-efficient -Poles of the vocal tract-Reflection co-efficient-Log Area ratio.

Cepstrum- Line spectral frequencies- Functional blocks of the ear- Mel frequency cepstral co-efficient- Spectrogram-Time resolution versus frequency resolution-Discrete wavelet transformation.

Pattern recognition for speech detection: Back-propagation Neural Network-Support Vector Machine- Hidden Markov Model (HMM)-Gaussian Mixture Model (GMM) -Unsupervised Learning system: K-Means and Fuzzy K-means clustering - Kohonen self-organizing map-Dimensionality reduction techniques: Principle component analysis (PCA), Linear discriminate analysis (LDA), Kernel-LDA (KLDA), Independent component analysis (ICA).

Non-uniform quantization for Gaussian distributed data- Adaptive Quantization-Differential pulse code modulation- Code Exited Linear prediction (CELP)-Quality assessment of the compressed speech signal Text to Speech (TTS) analysis –Evolution of speech synthesis systems-Unit selection methods - TTS Applications.

Text Book

1.	L.R.Rabiner and R.W.Schafer,” Introduction to Digital speech processing”, now publishers USA,2007
2.	E.S.Gopi,”Digital speech processing using matlab”, Springer, 2014.

References

1.	L.R.Rabiner and R.W.Schafer,”Digital processing of speech signals”, PrenticeHall,1978
2.	T.F.Quatieri, ”Discrete-time Speech Signal Processing”, Prentice-Hall, PTR,2001
3.	L.Hanzaetal, “Voice Compression and Communications”, Wiley/ IEEE, 2001.
4.	Recent literature in Digital speech processing.

Course Outcomes (CO)

At the end of the course student will be able

CO1	illustrate how the speech production is modeled
CO2	summarize the various techniques involved in collecting the features from the speech signal in both time and frequency domain
CO3	summarize the functional blocks of the ear
CO4	compare the various pattern recognition techniques involved in speech and speaker detection
CO5	summarize the various speech compression techniques

Course Code	:	ECOE14
Course Title	:	**DIGITAL IMAGE PROCESSING**
Type of Course	:	OE
Prerequisites	:	None
Contact Hours	:	3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To treat the 2D systems as an extension of 1D system design and discuss techniques specific to 2D systems.

Course Content

Linearity and space-invariance. PSF, Discrete images and image transforms, 2-D sampling and reconstruction, Image quantization, 2-D transforms and properties.

Image enhancement- Histogram modeling, equalization and modification. Image smoothing, Image crispening. Spatial filtering, Replication and zooming, Generalized cepstrum and homomorphic filtering.

Image restoration- image observation models. Inverse and Wiener filtering. Filtering using image transforms. Constrained least-squares restoration. Generalized inverse, SVD and interactive methods. Recursive filtering. Maximum entropy restoration. Bayesian methods.

Image data compression- sub sampling, coarse quantization and frame repetition. Pixel coding - PCM, entropy coding, run length coding Bit-plane coding. Predictive coding. Transform coding of images. Hybrid coding and vector DPCM. Inter-frame hybrid coding.

Image analysis- applications, Spatial and transform features. Edge detection, boundary extraction, AR models and region representation. Moments as features. Image structure. Morphological operations and transforms. Texture. Scene matching and detection. Segmentation and classification.

Text Book

1.	A.K. Jain, “Fundamentals of Digital Image Processing”, PHI, 1995.
2.	R.C.Gonzalez & R.E. Woods,” Digital Image Processing”, (2/e), Pearson, 2002.

References

1.	J.C. Russ, “The Image Processing Handbook”, (5/e), CRC, 2006.
2.	E.S.Gopi, "Digital Image processing using Matlab", Scitech publications, 2006.
3.	Recent literature in Digital Image processing

Course Outcomes (CO)

At the end of the course student will be able

CO1	analyze the need for image transforms, types and their properties.
CO2	become skilled at different techniques employed for the enhancement of images both in spatial and frequency domain
CO3	explore causes for image degradation and to teach various restoration techniques.
CO4	evaluate the image compression techniques in spatial and frequency domain.
CO5	gain knowledge of feature extraction techniques for image analysis and recognition.

Course Code	:	ECOE15
Course Title	:	**PATTERN RECOGNITION**
Type of Course	:	OE
Prerequisites	:	None
Contact Hours	:	3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	The subject aims to make the students to understand the mathematical approach for pattern recognition.

Course Content

Polynomial curve fitting – The curse of dimensionality - Decision theory - Information theory - The beta distribution - Dirichlet distribution-Gaussian distribution-The exponent family: Maximum likelihood and sufficient statistics -non-parametric method: kernel-density estimators - Nearest Neighbour methods.

Linear models for regression and classification: Linear basis function models for regression - Bias variance decomposition-Bayesian linear regression-Discriminant functions - Fisher's linear discriminant analysis (LDA) - Principal Component Analysis (PCA) - Probabilistic generative model - Probabilistic discriminative model.

Kernel methods: Dual Representations-Constructing Kernels-Radial basis function networks-Gaussian Process-Maximum margin classifier (Support Vector Machine) –Relevance Vector Machines-Kernel-PCA, Kernel-LDA.

Mixture models: K-means clustering - Mixtures of Gaussian - Expectation-Maximization algorithm- Sequential models: Markov model, Hidden-Markov Model (HMM) - Linear Dynamical Systems (LDS).

Neural networks: Feed- forward Network functions functions-Network training - Error Back propagation - The Hessian Matrix - Regularization in Neural Network - Mixture density networks – Bayesian Neural Networks

Text Book

1.	C.M.Bishop,"Pattern recognition and machine learning", Springer,2006
2.	E.S.Gopi, "Pattern recognition and Computational intelligence using Matlab, Transactions on computational science and computational intelligence, Springer, 2019

References

1.	Sergious Thedorodis ,Konstantinos Koutroumbas, Pattern recognition, Elsevier, Fourth edition,2009
2.	Richard O.Duda, Peter.E.Hart, David G.Stork, "Pattern classification", Wiley, Second edition,2016
3.	Recent literature in the related topics

Course Outcomes (CO)

At the end of the course student will be able

CO1	summarize the various techniques involved in pattern recognition
CO2	identify the suitable pattern recognition techniques for the particular applications.
CO3	categorize the various pattern recognition techniques into supervised and unsupervised.
CO4	summarize the mixture models-based pattern recognition techniques
CO5	summarize the artificial neural network-based pattern recognition techniques

Course Code	:	ECOE16
Course Title	:	**COMPUTER ARCHITECTURE AND ORGANIZATION**
Type of Course	:	OE
Prerequisites	:	None
Contact Hours	:	3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To understand how computers are constructed out of a set of functional units and how the functional units operate, interact, and communicate.
CLO2	To make the students to understand the concept of interfacing memory and various I/O devices to a computer system using a suitable bus system.

Course Content

Introduction: Function and structure of a computer, Functional components of a Computer, Interconnection of components, Performance of a computer.

Representation of Instructions: Machine instructions, Memory locations & Addresses, Operands, addressing modes, Instruction formats, Instruction sets, Instruction set architectures - CISC and RISC architectures, Super scalar Architectures, Fixed point and floating-point operations.

Basic Processing Unit: Fundamental concepts, ALU, Control unit, Multiple bus organization, Hardwired control, Micro programmed control, Pipelining, Data hazards, Instruction hazards, Influence on instruction sets, Data path and control considerations, Performance considerations.

Memory organization: Basic concepts, Semiconductor RAM memories, ROM, Speed - Size and cost, Memory Interfacing circuits, Cache memory, improving cache performance, Memory management unit, Shared/Distributed Memory, Cache coherency in multiprocessor, Segmentation, Paging, Concept of virtual memory, Address translation, Secondary storage devices.

I/O Organization: Accessing I/O devices, Input/output programming, Interrupts, Exception Handling, DMA, Buses, I/O interfaces- Serial port, Parallel port, PCI bus, SCSI bus, USB bus, Firewall and Infinity band, I/O peripherals.

Text Book

1.	C.Hamacher Z. Vranesic S. Zaky and Manjikian, "Computer Organization and Embedded Systems", 6 th Edition, McGraw-Hill, 2012.
2.	W. Stallings, "Computer Organization and Architecture - Designing for Performance", 8Th Edition, Prentice Hall of India, 2010.

References

1.	B,Parhami, “Computer Architecture, From Microprocessors to Supercomputers,” Oxford University Press, Reprint 2014.
2.	J. L. Hennessy and D. A. Patterson, "Computer Architecture, A Quantitative Approach”, 5 th Edition, Morgan Kaufmann,2012.
3.	J.P. Hayes, "Computer Architecture and Organization", 3 rd Edition, McGraw-Hill, 1998.
4.	Recent literature in Computer Architecture and Organization.

Course Outcomes (CO)

At the end of the course student will be able

CO1	apply the basic knowledge of digital concept to the functional components of a Computer System.
CO2	analyze the addressing mode concepts and design the instruction set Architecture.
CO3	identify the functions of various processing units within the CPU of a Computer System.
CO4	analyze the function of the memory management unit and create suitable memory interface to the CPU.
CO5	recognize the need for recent Bus standards and I/O devices.

Course Code	:	ECOE17
Course Title	:	**OPERATING SYSTEMS**
Type of Course	:	OE
Prerequisites	:	None
Contact Hours	:	3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To expose the principles and practice of operating system design and to illustrate the current design practices using DOS and UNIX operating systems.

Course Content

Types of operating systems, Different views of the operating system, Principles of Design and Implementation. The process and threads. System programmer's view of processes, Operating system's views of processes, Operating system services for process management. Process scheduling, Schedulers, Scheduling algorithms. Overview of Linux operating system.

Inter process synchronization, Mutual exclusion algorithms, Hardware support, Semaphores, Concurrent programming using semaphores.

Conditional critical regions, Monitors, Inter process communication: Messages, Pipes. Deadlocks: Characterization. Prevention. Avoidance. Detection and recovery. Combined approach to deadlock handling.

Contiguous allocation. Static and dynamic partitioned memory allocation. Segmentation. Non-contiguous allocation. Paging, Hardware support, Virtual Memory.

Need for files. File abstraction. File naming. File system organization. File system optimization. Reliability. Security and protection. I/O management and disk scheduling. Recent trends and developments.

Text Book

1.	Gary: Operating Systems- A modern Perspective, (2/e), Addison Wesley, 2000.
2.	M. Milenkovic: Operating systems, Concepts and Design, McGraw Hill, 1992.

References

1.	C. Crowley: Operating Systems, Irwin, 1997.
2.	J.I. Peterson & A.S. Chatz: Operating System Concepts, Addison Wesley, 1985.
3.	W. Stallings: Operating Systems, (2/e), Prentice Hall, 1995.
4.	Mattuck,A., Introduction to Analysis, Prentice-Hall,1998.
5.	Recent literature in Operating Systems.

Course Outcomes (CO)

At the end of the course student will be able

CO1	Understand the different types of Operating systems and scheduling algorithms.
CO2	Understand the synchronization algorithms and semaphores.
CO3	Appreciate the inter process communication and dead lock handling.
CO4	Critically evaluate the different memory allocation techniques.
CO5	Appreciate the importance of file system organization, I/O management and disk scheduling.

Course Code	**:**	ECOE18
Course Title	**:**	**WIRELESS SENSOR NETWORKS**
Type of Course	**:**	OE
Prerequisites	**:**	ECPE10
Contact Hours	**:**	3
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To overview the various design issues and challenges in the layered architecture of Wireless sensor networks

Course Content

Motivation for a network of wireless sensor nodes-Definitions and background-challenges and constraints for wireless sensor networks-Applications. Node architecture-sensing subsystems, processing Subsystems, Communication interfaces, Prototypes.

Physical layer- Introduction, wireless channel and communication fundamentals – frequency allocation, modulation and demodulation, wave propagation effects and noise, channels models, spread spectrum communication, packet transmission and synchronization, quality of wireless channels and measures for improvement, physical layer and transceiver design consideration in wireless sensor networks, Energy usage profile, choice of modulation, Power Management

Data link layer- Fundamentals of wireless MAC protocols, Characteristics of MAC protocol in wireless sensor networks contention-based protocols, Contention free MAC protocols, Hybrid MAC protocols

Network layer-routing metrics-Flooding and gossiping, Data centric routing, proactive routing on demand routing, hierarchical routing, Location based routing, QOS based routing. Data Aggregation – Various aggregation techniques.

Case study-Target detection tracking, Habitat monitoring, Environmental disaster monitoring, Practical implementation issues, IEEE 802.15.4 low rate WPAN, Operating System Design Issues. Simulation tools.

Text Book

1.	W. Dargie, C. Poellabauer, ”Fundamentals of Wireless sensor networks-Theory and Practice”, John Wiley & Sons Publication2010
2.	K. Sohraby, D.Minoli and T.Znati, “Wireless Sensor Network Technology- Protocols and Applications”, John Wiley & Sons, 2007.

References

1.	F.Zhao, L.Guibas, “Wireless Sensor Networks: an information processing approach”, Elsevier publication, 2004.
2.	C.S.Raghavendra Krishna, M.Sivalingam and Taribznati, “Wireless Sensor Networks”, Springer publication, 2004.
3.	H. Karl, A.willig, “Protocol and Architecture for Wireless Sensor Networks”, John Wiley publication, Jan2006.
4.	K.Akkaya and M.Younis, “A Survey of routing protocols in wireless sensor networks”, Elsevier Adhoc Network Journal, Vol.3, no.3, pp. 325-349, 2005.
5.	Philip Levis, “TinyOS Programming”, 2006 –www.tinyos.net.
6.	I.F. Akyildiz, W. Su, Sankarasubramanian, E. Cayirci, “Wireless sensor networks: a survey”, computer networks, Elsevier, 2002, 394 -422.
7.	Jamal N. Al-karaki, Ahmed E. Kamal, “Routing Techniques in Wireless sensor networks: A survey”, IEEE wireless communication, December 2004, 6 –28.
8.	Recent literature in Wireless Sensor Networks.

Course Outcomes (CO)

At the end of the course student will be able

CO1	analyze the challenges and constraints of wireless sensor network and its subsystems
CO2	examine the physical layer specification, modulation and transceiver design considerations
CO3	analyze the protocols used at the MAC layer and scheduling mechanisms
CO4	compare and analyse the types of routing protocols and data aggregation techniques
CO5	identify the application areas and practical implementation issues.

Course Code	**:**	ECOE19
Course Title	**:**	**ARM SYSTEM ARCHITECTURE**
Type of Course	**:**	OE
Prerequisites	**:**	None
Contact Hours	**:**	3
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	The objective of this course is to give the students a thorough exposure to ARM architecture and make the students to learn the ARM programming & Thumb programming models.

Course Content

RISC machine. ARM programmer's model. ARM Instruction Set. Assembly level language programming. Development tools.

ARM organization. ARM instruction execution. ARM implementation. ARM coprocessor interface. Flynn's Taxonomy, SIMD and Vector Processors, Vector Floating Point Processor (VFP), VFP and ARM interactions, vector operation.

Floating point architecture. Expressions. Conditional statements. Loops. Functions and procedures. Run time environment. Interrupt response. Interrupt processing. Interrupt Handling schemes, Examples of Interrupt Handlers.

Thumb programmer's model. Thumb Instruction set. Thumb implementation. AMBA Overview, Typical AMAB Based Microcontroller, AHB bus features, AHB Bus transfers, APB bus transfers and APB Bridge.

Memory hierarchy. Architectural support for operating system. Memory size and speed. Cache memory management. Operating system. ARM processor chips. Features of Raspberry Pi and its applications.

Text Book

1.	S. Furber, "ARM System Architecture", Addison-Wesley, 1996.
2.	Sloss, D.Symes & C.Wright, "ARM system Developer's Guide-Designing and Optimizing System Software", Elsevier.2005.

References

1.	Technical reference manual for ARM processor cores, including Cortex, ARM 11, ARM 9 & ARM 7 processor families.
2.	User guides and reference manuals for ARM software development and modelling tools. David Seal, ARM Architecture Reference Manual, Addison-Wesley.
3.	The Definitive Guide to ARM® Cortex®-M3 and Cortex®-M4 Processors, Third Edition by Joseph Yiu, Elsevier 2015
4.	Recent literature in ARM System Architecture.

Course Outcomes (CO)

At the end of the course student will be able

CO1	understand the programmer's model of ARM processor and test the assembly level programming.
CO2	analyze various types of coprocessors and design suitable co-processor interface to ARM processor.
CO3	analyze floating point processor architecture and its architectural support for higher level language.
CO4	become aware of the Thumb mode of operation of ARM.
CO5	identify the architectural support of ARM for operating system and analyze the function of memory Management unit of ARM.

Course Code	**:**	ECOE20
Course Title	**:**	**LOW POWER VLSI CIRCUITS**
Type of Course	**:**	OE
Prerequisites	**:**	ECPC23
Contact Hours	**:**	3
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To expose the students to the low voltage device modelling, low voltage, low power VLSI CMOS circuit design.

Course Content

CMOS fabrication process, Shallow trench isolation. Lightly-doped drain. Buried channel. Fabrication process of BiCMOS and SOI CMOS technologies.

Modeling of CMOS devices parameters. Threshold voltage, Body effect, short channel and Narrow channel effects, Electron temperature, and MOS capacitance.

CMOS inverters, static logic circuits of CMOS, pass transistor, BiCMOS, SOI CMOS and low power CMOS techniques.

Basic concepts of dynamic logic circuits. Various problems associated with dynamic logic circuits. Differential, BiCMOS and low voltage dynamic logic circuits.

CMOS memory circuits, Decoders, sense amplifiers, SRAM architecture. Low voltage SRAM techniques.

Text Book

1.	Jan Rabaey,"Low Power Design Essentials (Integrated Circuits and Systems)", Springer,2009
2.	J.B.Kuo&J.H.Lou,"Low-voltage CMOS VLSI Circuits", Wiley, 1999.

References

1.	A. Bellaowar & M.I.Elmasry,"Low power Digital VLSI Design, Circuits and Systems", Kluwer, 1996.
2.	Recent literature in Low Power VLSI Circuits.

Course Outcomes (CO)

At the end of the course student will be able

CO1	acquire the knowledge about various CMOS fabrication process and its modeling.
CO2	infer about the second order effects of MOS transistor characteristics.
CO3	analyze and implement various CMOS static logic circuits.
CO4	learn the design of various CMOS dynamic logic circuits.
CO5	learn the different types of memory circuits and their design.

Course Code	:	ECOE21
Course Title	:	**COMPUTER VISION AND MACHINE LEARNING**
Type of Course	:	OE
Prerequisites	:	None
Contact Hours	:	3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	Be familiar with the theoretical aspects of computing with images;
CLO2	Describe the foundation of image formation, measurement, and analysis;

Course Content

Computer Vision and Computer Graphics, Computer Vision - Low-level, Mid-level, High-level, Diverse Computer Vision Applications: Document Image Analysis, Biometrics, Object Recognition, Tracking, Medical Image Analysis, Content-Based Image Retrieval, Video Data Processing.

Segmentation -Object Recognition, Activity Recognition, and Gesture Recognition - Image features: Color, Shape, Texture Shape orientation descriptors – SIFT, SURF, Viola Jones Feature detectors, Harris. Integral Histogram.

Adaboost: concept of ensemble of classifiers; basic algorithm; case study- Face detection Artificial Immune Systems Fuzzy belief networks, Evolving belief networks Bayesian belief networks Evolutionary and swarm-based neural networks.

Machine learning: classification, Machine learning: clustering, Machine learning: classification. Logistic regression Bayesian logistic regression Non-linear logistic regression Dual logistic regression Kernel logistic regression, Incremental fitting and boosting.

Reinforcement learning - Classification trees- multi-class logistic regression Random trees, Random forests, Applications. Introduction to Deep Learning.

Text Book

1.	Richard Szeliski, “Computer Vision: Algorithms and Applications”, Springer, 2010.
2.	D. Forsyth and J. Ponce, "Computer Vision - A modern approach”, Prentice Hall, 2002.

References

1.	Richard Hartley and Andrew Zisser man, Multiple view geometry in computer vision 2nd edition, Cambridge University press, 2004.
2.	E Davies, “Computer and Machine Vision, Algorithms, Practicalities”, 4th Edition, Elsevier, 2012.

Course Outcomes (CO)

At the end of the course student will be able

CO1	learn the basics of computer vision.
CO2	learn the vision features.
CO3	understand issue of segmentation in computer vision algorithms.
CO4	study the basics of Machine learning.
CO5	know the design of Deep learning architectures.

Course Code	**:**	ECOE22
Course Title	**:**	**TEXT DATA MINING**
Type of Course	**:**	OE
Prerequisites	**:**	None
Contact Hours	**:**	3
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To understand the role played by text mining in Information retrieval and extraction.

Course Content

Data, information and knowledge, Models of knowledge representation information retrieval and data mining -relevance, association rules, and knowledge discovery. Conceptual models of an information retrieval and knowledge discovery system.

Information extraction- prediction and evaluation-Textual information to numerical vectors - Types and tokens, Document similarity Vector space models, TF-IDF weighting Indexing, Boolean search Evaluation of IR systems Ranked retrieval Relevance feedback.

Text Categorization – Definition – Document Representation –Feature Selection - Decision Tree Classifiers - Rule-based Classifiers - Probabilistic and Naive Bayes Classifiers - Linear Classifiers- Clustering –Definition- Distance-based Algorithms- Word and Phrase-based Clustering -Semi-Supervised Clustering - Transfer Learning. Naive Bayes - k Nearest Neigh bor (kNN) - Logistic Regression-Decision Trees. Connectivity-based clustering and centroid-based clustering.

Probabilistic Models for Text Mining -Mixture Models - Stochastic Processes in Bayesian Nonparametric Models - Graphical Models - Relationship Between Clustering, Dimension Reduction and Topic Modelling - Latent Semantic Indexing - Probabilistic Latent Semantic Indexing -Latent Dirichlet Allocation- Probabilistic Document Clustering and Topic Models - Probabilistic Models for Information Extraction - Hidden Markov Models- Maximal Entropy Modelling - Maximal Entropy Markov Models -Conditional Random Fields.

Visualization Approaches - Architectural Considerations - Visualization Techniques in Link Analysis - Example- Mining Text Streams - Text Mining in Multimedia - Text Analytics in social media - Opinion Mining and Sentiment Analysis - Document Sentiment Classification Aspect-Based Sentiment Analysis - Opinion Spam Detection – Text Mining Applications and Case studies.

Text Book

1.	Sholom Weiss, Nitin Indurkhya, Tong Zhang, Fred Damerau "The Text Mining Handbook: Advanced Approaches in Analyzing Unstructured Data", Springer, paperback 2010.
2.	Ronen Feldman, James Sanger - "The Text Mining Handbook: Advanced Approaches in Analyzing Unstructured Data"-Cambridge University press, 2006.

References

1.	Charu C. Aggarwal, Cheng Xiang Zhai, Mining Text Data, Springer; 2012.

Course Outcomes (CO)

At the end of the course student will be able

CO1	know about the basics of text mining.
CO2	Identify the different features that can be mined from text and web documents.
CO3	learn about text classification.
CO4	learn to improve the efficiency of features and reduce the dimensionality.
CO5	understand the basics of recent advances in text classification.

Course Code	:	ECOE23
Course Title	:	**INTERNET OF THINGS**
Type of Course	:	OE
Prerequisites	:	CSIR11, ECPE12, C/C++ and Python Programming skills
Contact Hours	:	3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To understand basics of an IOT System, IoT sensors, IoT hardware and communication protocols, data storage, data analysis and use them for real time IoT enabled domains.

Course Content

Introduction to IoT and IoT levels : Functional blocks of an IoT system (Sensors, Data Ingress, Data Aggregation Point Communication point back to the cloud, Analysis, Decision making, Actuation) Basic of Physical and logical design of IoT (IoT protocols, communication models) IoT enabled domains (Home automation, Smart cities, environment monitoring, renewable energy, agriculture, industry, healthcare, marketing and management) M2M, Difference between IoT, Embedded Systems and M2M, Industry 4.0 concepts.

IoT sensors and hardware : Passive and active sensors, differences, Different kinds of sensors (Temperature, humidity, pressure, obstacle, water flow, accelerometer, color, gyro, load cell, finger print, motion, ultrasonic distance, magnetic vibration, eye blink, hear beat, PPG, glucose, body position, blood pressure), Multi-sensors, Pre-processing (sampling, filtering, ADC, size of data, local memory, compression), IoT front end hardware (Raspberry Pi, Arduino, Galileo, beagle bone equivalent platforms)

Introduction to IoT protocols: Infrastructure (6LowPAN, IPv4/IPv6, RPL), Identification (EPC, uCode, IPv6, URIs), Communication/ Transport (Wi-Fi, Bluetooth, ZigBee, LPWAN), Data Protocols (MQTT, CoAP, AMQP, WebSocket, Node)

IoT Cloud and data analytics: Collecting data from sensors, Data Ingress, Cloud storage, IoT cloud platforms (Amazon AWS, Microsoft Azure, Google APIs), Data analytics for IoT, Software and management tool for IoT, Dashboard design

IoT architectures with case studies: Business models for IoT, smart cities, agriculture, healthcare, industry. Case studies/Mini projects for the real time IoT applications.

Text Book

1.	Arshdeep Bahga, Vijay Madisetti, “Internet of Things – A hands-on approach”, Universities Press, 2015.

References

1.	Raj kamal, Internet of Things, Architecture and Design Principles, McGraw-Hill, 2017
2.	Manoel Carlos Ramon, “Intel® Galileo and Intel® Galileo Gen 2: API Features and Arduino Projects for Linux Programmers”, Apress, 2014.H. Gerez, “Algorithms for VLSI Design Automation”, John Wiley, 1999.
3.	Marco Schwartz, “Internet of Things with the Arduino Yun”, Packt Publishing, 2014.

Course Outcomes (CO)

At the end of the course student will be able

CO1	understand basic premise of an IOT System
CO2	be familiar with the sensors available for IoT applications
CO3	learn the front-end hardware platforms and communication protocols for IoT.
CO4	understand cloud storage, data analysis and management
CO5	usage for real time IoT enabled domains

Course Code	**:**	**ECOE76**
Course Title	**:**	**Computer Vision**
Type of Course	**:**	OE
Prerequisites	**:**	NONE
Contact Hours	**:**	3
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	The focus of this course is the understanding of algorithms and techniques used in computer vision.
CLO2	Provide pointers into the literature and exercise a project based on a literature search and one or more research papers.
CLO3	Practice software implementation of different concepts and techniques covered in the course.
CLO4	Utilize programming and scientific tools for relevant software implementation.

Course Content

Introduction: overview of computer vision, related areas, and applications; overview of software tools; overview of course objectives.; introduction to OpenCV. Image formation and representation: imaging geometry, radiometry, digitization, cameras and projections, rigid and affine transformations, Filtering: convolution, smoothing, differencing, and scale space

Feature detection: edge detection, corner detection, line and curve detection, active contours, SIFT and HOG descriptors, shape context descriptors, Model fitting: Hough transform, line fitting, ellipse and conic sections fitting, algebraic and Euclidean distance measures.

Camera calibration: camera models; intrinsic and extrinsic parameters; radial lens distortion; direct parameter calibration; camera parameters from projection matrices; orthographic, weak perspective, affine, and perspective camera models.

Motion analysis: the motion field of rigid objects; motion parallax; optical flow, the image brightness constancy equation, affine flow; differential techniques; feature-based techniques; regularization and robust estimation; motion segmentation through EM, Motion tracking: statistical filtering; iterated estimation; observability and linear systems; the Kalman filter; the extended Kalman filter

Object recognition and shape representation: alignment, appearance-based methods, invariants, image Eigen spaces, data-based techniques.

References

1.	Computer Vision: Algorithms and Applications, R. Szeliski, Springer, 2011.
2.	Computer Vision: A Modern Approach, D. Forsyth and J. Ponce, Prentice Hall, 2nd ed., 2011.
3.	Introductory techniques for 3D computer vision, E. Trucco and A. Verri, Prentice Hall, 1998.

Course Outcomes (CO)

At the end of the course student will be able

CO1	To understand the fundamental problems of computer vision.
CO2	To learn techniques, mathematical concepts and algorithms used in computer vision to facilitate further study in this area.
CO3	To get an idea regarding the camera calibration and its importance.
CO4	To study different kinds of motion estimation methodologies and its applications.
CO5	To understand the basic concepts of object and shape recognition techniques

Course Code	**:**	**ECOE77**
Course Title	**:**	**Natural Language Processing**
Type of Course	**:**	OE
Prerequisites	**:**	NONE
Contact Hours	**:**	3
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	Understand NLP tasks in syntax, semantics and pragmatics
CLO2	Implement machine learning techniques used in NLP

Course Content

Introduction – Why NLP? NLP versus speech recognition- Applications-problem of ambiguity-role of machine learning in NLP- Basic neural networks for NLP

Words – Morphology and Finite State transducers-Tokenization – Computational Phonology and Pronunciation Modelling

Probabilistic models in NLP—Role of language models- Simple N-gram model – Evaluation: Perplexity and Word Error Rate. Parts of Speech Tagging- Hidden markov models–Viterbi algorithm, Maximum Entropy Markov model

Semantic analysis - Lexical semantics and word-sense disambiguation. Compositional semantics. Semantic Role Labeling and Semantic Parsing

Machine Translation- Statistical translation, word alignment, phrase-based translation, and synchronous grammars, evaluation.

References

1.	Natural Language Processing, by Jacob Eisenstein, MIT Press.
2.	Speech and Language Processing by Daniel Jurafsky and James H. Martin
3.	Foundations of Statistical Natural Language processing by Manning C. D. and Schutze H., First Edition, MIT Press, 1999
4.	Neural Network Methods for Natural Language Processing by Yoav Goldberg, Morgan & Claypool Publishers.

Course Outcomes (CO)

At the end of the course student will be able

CO1	Understand NLP and the role of machine learning in NLP
CO2	Describe finite state transducer operations and pronunciation modelling in NLP
CO3	Illustrate various probabilistic models in NLP.
CO4	Study semantic analysis in NLP
CO5	Learn various machine translation approaches and the different evaluation metrics.

Course Code	:	**ECOE78**
Course Title	:	**Optimization Methods In Machine Learning**
Type of Course	:	OE
Prerequisites	:	NONE
Contact Hours	:	3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	The course aims to equip students with advanced techniques and methods in optimization that are tailored to large-scale statistics and machine learning problems

Course Content

Basics of convex optimization-convex sets, convexity-preserving operations, examples of convex programs (linear programming (LP), second-order cone programming (SOCP), semidefinite programming (SDP)), convex relaxation, KKT conditions, duality

Gradient-based methods-gradient descent, subgradient, mirror descent, Frank–Wolfe method, Nesterov's accelerated gradient method, ODE interpretations, dual methods, Nesterov's smoothing, proximal gradient methods, Moreau–Yosida regularization

Operator splitting methods-augmented Lagrangian methods, alternating direction method of multipliers (ADMM), monotone operators, Douglas–Rachford splitting, primal and dual decomposition

Stochastic and nonconvex optimization-dualaveraging, Polyak–Juditsky averaging, stochastic variance reduced gradient (SVRG), Langevin dynamics, escaping saddle points, landscape of nonconvex problems, deep learning

Applications of optimization methods in Image/Video/Multimedia Processing

References

1.	Stephen Boyd and Lieven Vandenberghe's book: Convex Optimization
2.	Nesterov's old book: Introductory Lectures on Convex Optimization: A Basic Course
3.	Nesterov's new book: Lectures on Convex Optimization
4.	Neal Parikh and Stephen Boyd's monograph: Proximal Algorithms
5.	Sebastien Bubeck's monograph: Convex Optimization: Algorithms and Complexity
6.	Moritz Hardt's Berkeley EE 227C course note
7.	Prateek Jain and Purushottam Kar's survey on nonconvex optimization
8.	Kristin Bennett, Emilio Parrado-Hernandez. Interplay of Optimization and Machine Learning Research, Journal of Machine Learning Research, 2006.
9.	Nati Srebro, Ambuj Tewari. Stochastic Optimization for Machine Learning, Tutorial at International Conference on Machine Learning, 2010.

Course Outcomes (CO)

At the end of the course student will be able

CO1	To learn the basic concepts of convex optimization
CO2	To study gradient based optimization techniques
CO3	To understand the problem solving using operator splitting methods
CO4	To learn stochastic and non-convex optimization Techniques,
CO5	To execute applications of optimization techniques in different domains

Course Code	**:**	**ECOE79**
Course Title	**:**	**Hardware for Deep Learning**
Type of Course	**:**	OE
Prerequisites	**:**	NONE
Contact Hours	**:**	3
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To get an idea about deep learning and how to implement deep learning algorithms on FPGA

Course Content

Introduction to Deep Learning: From AI to DL, Neural Network: Perceptrons, Back Propagation, Over-fitting, Regularization. Deep Networks: Definition, Motivation, Applications, Convolution Neural Network (CNN): Basic architecture, Activation functions, Pooling, Handling vanishing gradient problem, Dropout, Weight initialization methods, Batch Normalization. Training Neural networks, Additional CNN Components, Famous CNNs, Applications, Software libraries.

Computing Convolutions: Mapping Matrix multiplication, Computational Transforms, Accelerator Architectures, Dataflow Taxonomy

Reducing the Complexity: Light weight models, reducing precision, Aggressive Quantization, pruning & Deep compression.

The Deep Learning Acceleration Landscape: parallelism in deep learning, Traditional programmable hardware, specialized deep learning hardware platforms, deep learning software stack, Specialized research ASICs.

FPGAs for Deep Learning: Overview of hardware architectures for deep learning, Effective management of FPGA memory resources, optimizing algorithms and data representation for FPGA arithmetic resources, Integrating hardware and software.

References

1.	Ian Goodfellow, Yishuv Bengio and Aaron Courville, “Deep Learning.” MIT Press. 2016. ISBN: 978-0262035613. Available online for free at: http://www.deeplearningbook.org
2.	Vivienne Sze; Yu-Hsin Chen; Tien-Ju Yang; Joel S. Emer, “Efficient Processing of Deep Neural Networks” Morgan & Claypool Publishers, 1st Edition, 2020.
3.	Tushar Krishna, Hyoukjun Kwon, Angshuman Parashar, Michael Pellauer, and Ananda Samajdar, “Data Orchestration in Deep Learning Accelerators”, Morgan & Claypool Publishers, 1st Edition, 2020.
4.	Piotr Antonik, “Application of FPGA to Real-Time Machine Learning”, Springer, 2018.
5.	Stanford C231n, 2017
6.	Sze, et al. https://eyeriss.mit.edu/ ISCA Tutorial 2019
7.	Sze, et al. “Efficient Processing of Deep Neural Networks: A Tutorial and Survey”, Proceedings of the IEEE, 2017
8.	Prof. Adam Teman https://www.eng.biu.ac.il/temanad/hardware-for-deep-learning/
9.	https://jameswhanlon.com/

Course Outcomes (CO)

At the end of the course student will be able

CO1	Understand the context of convolutional neural networks and deep learning algorithms.
CO2	Know how to use convolution in deep learning techniques.
CO3	Understand the necessity and importance of light weight models with low complexity through specialized hardware architecture
CO4	Know how to optimize hardware performance in deep neural network applications.
CO5	Discuss, suggest and evaluate specialised hardware architectures to implement deep learning algorithms in FPGA and utilise deep learning concepts in resource constrained reliable systems.

Course Code	**:**	**ECOE80**
Course Title	**:**	**Image and Video Processing**
Type of Course	**:**	OE
Prerequisites	**:**	NONE
Contact Hours	**:**	3
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	The course aims to equip students with basic image and video processing techniques.

Course Content

Image Formation and Representation: 3D to 2D projection, photometric image formation, trichromatic colour representation, video format (SD, HD, UHD, HDR), contrast enhancement (concept of histogram, nonlinear mapping, histogram equalization)
Review of 1D Fourier transform and convolution: Concept of spatial frequency. Continuous and Discrete Space 2D Fourier transform. 2D convolution and its interpretation in frequency domain. Implementation of 2D convolution. Separable filters. Frequency response. Linear filtering (2D convolution) for noise removal, image sharpening, and edge detection. Gaussian filters, DOG and LOG filters as image.
Geometric mapping and Feature detection: Geometric mapping (affine, homography), Feature based camera motion estimation (RANSAC). Image warping. Image registration. Panoramic view stitching, Feature detection (Harris corner, scale space, SIFT), feature descriptors (SIFT). Bag of Visual Word representation for image classification.
Motion estimation: optical flow equation, optical flow estimation (Lucas-Kanade method, KLT tracker); block matching, multi-resolution estimation. Deformable registration (medical applications), Moving object detection (background/foreground separation): Robust PCA (low rank + sparse decomposition). Global camera motion estimation from optical flows. Video stabilization. Video scene change detection.
Video Coding: block-based motion compensated prediction and interpolation, adaptive spatial prediction, block-based hybrid video coding, rate-distortion optimized mode selection, rate control, Group of pictures (GoP) structure, tradeoff between coding efficiency, delay, and complexity, depth from disparity, disparity estimation, view synthesis. Multiview video compression. Depth camera (Kinect). 360 video camera and view stitching.

References

1.	Richard Szeliski, Computer Vision: Algorithms and Applications. (Available online:"Link") (Cover most of the material, except sparsity-based image processing and image and video coding)
2.	(Optional) Y. Wang, J. Ostermann, and Y.Q.Zhang, Video Processing and Communications. Prentice Hall, 2002. "Link" (Reference for image and video coding, motion estimation, and stereo)
3.	(Optional) R. C. Gonzalez and R. E. Woods, Digital Image Processing, Prentice Hall, (3rd Edition) 2008. ISBN number 9780131687288. "Link" (Good reference for basic image processing, wavelet transforms and image coding).

Course Outcomes (CO)

At the end of the course student will be able

CO1	Understand the concept of image formation and representation
CO2	Know the need of transformation and convolution
CO3	Understand the necessity and importance of feature detection and geometric mapping
CO4	Know how to do motion estimation in video
CO5	To understand the basic ideas of video coding

Course Code	**:**	**ECOE81**
Course Title	**:**	**Automated Test Engineering for Electronics**
Type of Course	**:**	OE
Prerequisites	**:**	NONE
Contact Hours	**:**	3
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Content

Printed Circuit Boards (PCBs) – types of PCB – multilayer PCBs – Plated though Hole Technology (PTH) - Surface Mount Technology (SMT) – Ball Grid Array (BGA) Technology. Bare PCB electrical test concepts, Loaded PCB Visual inspection, Automated Optical inspection systems, X-Ray inspection systems- Measuring Passive components – 2 wire, 3 wire, 4 wire and 6 wire measurement concepts, Guarding techniques, Shorts location, Most common manufacturing defects, Automated Manufacturing defect analyzers, Nodal Impedance / analog signature analysis. Flying probe testers.

Concepts of PCB Trouble-shooting, Symptom recognition, Bracketing technique, Failure types and fault causes, Manual Trouble shooting, Use of DMM, Oscilloscope, Signal Generators, Logic Probes, Logic Pulsers, Logic Analyzers, Automated Test Techniques – CPU Emulation technique, ROM Emulation, In-Circuit Comparators, In-Circuit Emulators, Functional Testing of Digital ICs, Library models, Concepts of In-circuit Testing, - Back Driving technique – international defence standards - Auto Compensation, In-Circuit Test of Open collector / Emitter Devices, Tri-State, Bi-Directional Devices, Concepts of Digital Guarding, Analog and Mixed Signal ICs Test, advantages and limitations of in-circuit testing, AC – DC Parametric testing, –Advanced test techniques- Boundary Scan Test , Learn and compare technique – digital signatures, Bus Cycle Signature Test , Analog signatures.

ATE system components, Main Test Vector processor, Digital Subsystem, Pin Electronics, Programmable drive and threshold levels, RAM behind each pin, Controlling slew rate, Skew between channels, Data formats, Digital and analog simulation, Test Vector Generation, Fault simulation, Fault coverage, Test Languages, Verilog, VHDL, Automatic compare, Analog Sub system, Digital and analog matrix switch circuits, digital and analog highways, Integration of JTAG, Boundary Scan Test, BSDL, External Instrumentation, Functional and Timing tests.

Concepts of Test Program (T.P) Generation. Commercially available off the shelf Test Equipment's (COTS)

Board Functional Test (BFT) techniques – Go-No-go Test – Diagnostic Test, Reliability Test, Thermal Shock Test, Full functional Edge to edge test, Cluster Test – Guided Probe Backtracking Technique – Simulators – Online and Offline Simulation - Fault Simulation– Comprehensiveness of Board program – Fault Dictionary– Analysis – BS and Non-BS device testing–- Sample board programming and testing – BS interconnect and simulating faults - External Instrumentation used for board testing – PXI Instrumentation – Integration of PXI instruments for testing

Design for testability (DFT) and Design for manufacturability (DFM) - Basics of ATPG, – Fault Models –– Design considerations for edge functional test, Design considerations for Bus Cycle Signature Test, Design considerations for Boundary Scan Test, Built-in Self Test, Modular Design,– ATE for test - DFM - Manufacturing phases in industry oriented Production process – strategies – new strategy - benefits of new strategies

References

1.	Test Engineering for Electronic Hardware – S R Sabapathi, Qmax Test Equipments P Ltd., 2011
2.	Practical Electronic Fault Finding and Trouble shooting - Robin Pain Newnes, Reed Educational and professional publishing Ltd., 1996
3.	The Fundamentals of Digital Semiconductor Testing, Floyd, Pearson Education India, Sep-2005
4.	Building a Successful Board Test Strategy-Stephen F Scheiber-Butterworth Heinemann

Course Code	**:**	**ECOE82**
Course Title	**:**	**Foundations of Artificial Intelligence**
Type of Course	**:**	OE
Prerequisites	**:**	NONE
Contact Hours	**:**	3
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	Approaches to produce "intelligent" systems, Knowledge representation (both symbolic and neural network), search and machine learning.
CLO2	To learn the principles and fundamentals of designing AI programs.

Course Content

Introduction to AI-Problem Solving as State Space Search, Uniformed Search, Heuristic Search, Informed Search, Constraint Satisfaction Problems, Searching AND/OR Graphs.

Knowledge representation and Reasoning-Introduction to Knowledge Representation, Propositional Logic, First Order Logic –I, First Order Logic –II, Inference in First Order Logic-I, Inference in First Order Logic – II, Answer Extraction, Procedural Control of Reasoning, Reasoning under Uncertainty, Bayesian Network, Decision Network.

Planning and decision Making-Introduction to Planning, Plan Space Planning, Planning Graph and Graph Plan, Practical Planning and Acting, Sequential Decision Problems, Making Complex Decisions.

Machine Learning-Introduction to Machine Learning, Learning Decision Trees, Linear Regression, Support Vector Machines, Unsupervised Learning, Reinforcement Learning, **Introduction to deep learning, neural network learning**

References

1.	Patrick Henry Winston, Artificial Intelligence, Third Edition, Addison-Wesley Publishing Company, 2004.
2.	Stuart Russell and Peter Norvig, Artificial Intelligence: A Modern Approach, 3rd Edition, PHI 2009.
3.	Nils J Nilsson, Principles of Artificial Intelligence, Illustrated Reprint Edition, Springer Heidelberg, 2014.
4.	Nils J. Nilsson, Quest for Artificial Intelligence, First Edition, Cambridge University Press, 2010.

Course Outcomes (CO)

At the end of the course student will be able

CO1	To learn the concepts of artificial intelligence
CO2	To study problem solving techniques
CO3	To understand the representation of knowledge and reasoning mechanism
CO4	To learn to panning and decision making
CO5	To study network models used for learning

Course Code	:	**ECOE84**
Course Title	:	**Microwave Circuits**
Type of Course	:	OE
Prerequisites	:	NONE
Contact Hours	:	3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To make the students familiarize with ABCD parameters, S parameters, Applications of planar transmission lines in the practical microwave circuits, Design and layout of all Microwave Integrated Circuit Design components and then systems.

Course Content

Introduction and application of microwave circuits - Two-port network characterization. ABCD parameters, Conversion of S matrix in terms of ABCD matrix. Scattering matrix representation of microwave components. Review of Smith chart and its application- Impedance matching using Lumped and Distributed approach.

Microwave Passive circuit design: Characteristics, properties, design parameters and applications- Design and realization of MIC Power dividers. 3 dB hybrid design. Directional Coupler design- Hybrid ring design.

Microwave filter design- Filter design by insertion loss method –Richards and Kuroda transformation. K inverter, J inverter. Resonator filters. Realization using microstrip lines and strip lines.

Microwave amplifier design- Power gain equations -Stability considerations. Maximum gain design, Design for specific gain -Low Noise Amplifier Design. High power design.

Microwave oscillator design. One – port and two – port negative resistance oscillators and oscillator design

References

1.	Reinhold Ludwig, RF circuit design, 2nd edition, Prentice Hall 2014, ISBN: 978-0131471375
2.	David. M. Pozar, Microwave engineering, 4th edition, John Wiley, 2011, ISBN: 978-0470631553.
3.	Devendra K. Misra, "Radio-Frequency and microwave communication circuits analysis and design", 2nd edition, University of Wisconsin-Mulwaukee, A John Wiley & Sons Publication
4.	B. Bhat, S. K Koul, "Stripline like transmission lines for Microwave Integrated Circuits", New Age International Pvt. Ltd Publishers, 2007.
5.	I.J.Bahl & P.Bhartia, "Microwave Solid state Circuit Design (2/e)", Wiley, 2003.
6.	Matthew M. Radmanesh, Radio Frequency and Microwave Electronics Illustrated, Prentice Hall, 2012
7.	S.Y.Liao, "Microwave Circuit Analysis and Amplifier Design", Prentice-Hall, 1986.
8.	G. Mathaei, L young, E.M.T. Jones, "Microwave filters, Impedance-Matching networks and Coupling structures", Artech House Books.

Course Outcomes (CO)

At the end of the course student will be able

CO1	Understand the basics of Scattering matrix and two port characterization and importance of matching circuits.
CO2	Analyze the working principles of couplers, power dividers etc. and their design.
CO3	Design the different types of MIC filters and their implementation.
CO4	Understand the complexities of microwave amplifier design and its stability features.
CO5	Analyze and appreciate the design principles of microwave oscillators.

Course Code	:	**ECOE85**
Course Title	:	**Computational Neuroscience**
Type of Course	:	OE
Prerequisites	:	NONE
Contact Hours	:	3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To provide students a quantitative understanding of information processing by neurons in the brain.
CLO2	To review the state-of-the-art in applying computational approaches to address cognitive neuroscience research problems.

Course Content

Introduction to Neurons: Neuron structure, Networks of Neurons and Synapses, System of neural processing, Basic structures in the brain, Sensory - Executive - Behavior systems, Excitable Membranes and Neural Activity- Membrane Potential and All or None Spike, Patch Clamp Techniques, Membrane Potential, Ion Channels, Current Injection – Synapses, Single neuron activity,

Point models: Hodgkin Huxley Equations (HHE), Point and Compartmental Models of Neurons, Hodgkin Huxley Equations – I & II, Hodgkin Huxley Equations – II, Reducing the HHE and Moris-Lecar Equations (MLE) 5) Properties of MLE, Analysis of Neural Models, Phase Plane Analysis – I & II, Analyzing HHE, Bifurcations, Other Point Models

Spike Trains: Encoding and Decoding – I, II, & III: Random Variables and Random Processes, Spike Train Statistics and Response Measure, Receptive fields and Models of Receptive Fields, The Spike Triggered Average (Coding), Stimulus Reconstruction (Decoding), Nonlinear approaches: Basics of Information Theory, Maximally Informative Dimensions, Discrimination based approaches, Measuring Spike Train Distances, Statistical Methods in Discrimination, Examples-I & II: Encoding/Decoding in Neural Systems, Neural Population Based Encoding/Decoding – I & II, Population Based Encoding/Decoding

Plasticity – I, II, III, & IV: Synaptic Transmission and Synaptic Strength, Ways of Modification of Synaptic Strength, Types of Plasticity, Short Term Plasticity – I & II, Implications of Short Term Plasticity, Long Term Plasticity – I & II, Modeling Long Term Plasticity, Computational Implications, Adaptation, Attention, Learning and Memory – I & II, Developmental Changes, Modeling Phenomena with Plasticity, Conditioning and Reinforcement Learning, Reward Prediction (Error), Decision Problems, Learning and Memory – II, Developmental Changes

Theoretical Approaches and Current Research: Optimal Coding Principles – I, Optimal Coding Principles – II, Theoretical Approaches to Understanding Plasticity, Current Topics – I, Current Topics - II

References

1.	"Theoretical Neuroscience: Computational and Mathematical Modeling of Neural Systems", P. Dayan and L. F. Abbott, The MIT Press, London, England, 2005
2.	Principles of Neural Science, E. R. Kandel, J. D. Koester, S. H. Mack, and S. A. Siegelbaum, Mc Graw Hill, USA, 2012.
3.	"Nonlinear Dynamics and Chaos", S. H. Strogatz, CRC Press, New York, 2018
4.	"Elements of Information Theory and Coding", T. M. Cover and J. A. Thomas, Wiley & Sons, 2005
5.	"Methods in Neuronal Modeling", C. Koch and I. Segev, The MIT Press, 2003

Course Outcomes (CO)

At the end of the course student will be able

CO1	To understand how humans learn efficiently, create, and recall memories, make decisions among many others.
CO2	To analyze different point models.
CO3	To understand representation of information by neurons and how such information may be readout for practical applications.
CO4	To analyze computational modeling of implementing plasticity, the most important aspect of the brain, aiding in learning, memory and cognition.
CO5	To verify the optimal coding principles in various real-time applications.

MINORS (MI)

Course Code	:	**ECMI10**
Course Title	:	SIGNALS AND SYSTEMS
Type of Course	:	MI
Prerequisites	:	NA
Contact Hours	:	3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To make the students to understand the fundamental characteristics of signals and systems in terms of both the time and transform domains
CLO2	Development of the mathematical skills to solve problems involving convolution, filtering, modulation and sampling.

Course Content

Definition of Signals and Systems, Classification of Signals, Operations on signals, Singularity functions and related functions. Analogy between vectors and signals - orthogonal signal space, complete set of orthogonal functions, Parseval's relations. Fourier series representation of continuous time periodic signals -Trigonometric and Exponential Fourier series- Properties of Fourier series.

Fourier transform of aperiodic signals, standard signals and periodic signals - Properties of Fourier transforms. Hilbert transform and its properties. Laplace transforms-RoC-properties. Inverse Laplace transform.

Continuous-time Systems and its properties. Linear time invariant (LTI) system-Impulse response. Convolution. Analysis of LTI System using Laplace and Fourier transforms.

Sampling and reconstruction of band limited signals. Low pass and band pass sampling theorems. Aliasing. Anti-aliasing filter. Practical Sampling-aperture effect.

Discrete-time signals and systems. Discrete Fourier series. Z-transform and its properties. Analysis of LSI systems using Z – transform.

Text Books

1. *A.V.Oppenheim, A. Willsky, S. Hamid Nawab, "Signals and Systems (2/e)", Pearson 200.*
2. *S.Haykin and B.VanVeen "Signals and Systems, Wiley, 1998.*

References

1.	*M.Mandal and A.Asif, "Continuous and Discrete Time Signals and Systems, Cambridge, 2007.*
2.	*D.C.Lay, "Linear Algebra and its Applications (2/e)", Pearson, 200.*
3.	*S.S.Soliman & M.D.Srinath, "Continuous and Discrete Signals and Systems", Prentice- Hall, 1990.*

Course Outcomes (CO)

At the end of the course student will be able

CO1	Understand the mathematical description and representation of continuous-time and discrete-time signals.
CO2	Analyze the spectral characteristics of continuous-time periodic and aperiodic signals using Fourier analysis.
CO3	Analyse system properties based on impulse response and Fourier analysis
CO4	Convert a continuous time signal into discrete time signal and reconstruct the continuous time signals back from its samples
CO5	Apply the Laplace transform and Z- transform respectively for the analyse of continuous-time and discrete-time signals.

Course Code	**:**	**ECMI11**
Course Title	**:**	NETWORK ANALYSIS AND SYNTHESIS
Type of Course	**:**	MI
Prerequisites	**:**	NA
Contact Hours	**:**	3
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To make the students capable of analysing any given electrical network.
CLO2	To make the students to learn synthesis of an electrical network for a given impedance/ admittance function.

Course Content

Network concept. Elements and sources. Kirchhoff's laws. Tellegen's theorem. Network equilibrium equations. Node and Mesh method. Source superposition. Thevenin's and Norton's theorems. Network graphs.

First and second order networks. State equations. Transient response. Network functions. Determination of the natural frequencies and mode vectors from network functions.

Sinusoidal steady-state analysis. Maximum power-transfer theorem. Resonance. Equivalent and dual networks. Design of equalizers.

Two-port network parameters. Interconnection of two port networks. Barlett's bisection theorem. Image and
Iterative parameters. Design of attenuators.

Two-terminal network synthesis. Properties of Hurwitz polynomial and Positive real function. Synthesis of LC, RC and RL Networks, Foster Forms and Cauer Forms.

Text Books

1. *Hayt W. H., Kemmerly J. E. and Durbin S. M., "Engineering Circuit Analysis", 6th Ed., Tata McGraw-Hill Publishing Company Ltd., 2008.*
2. *F.F. Kuo, "Network analysis and Synthesis", Wiley International Edition, 2008.*

References

1.	*Valkenberg V., "Network Analysis", 3rd Ed., Prentice Hall International Edition, 2007.*
2.	*B.S.Nair and S.R.Deepa, "Network analysis and Synthesis", Elsevier, 2012.*

Course Outcomes (CO)

At the end of the course student will be able

CO1	analyze the electric circuit using network theorems
CO2	understand and Obtain Transient & Forced response
CO3	determine Sinusoidal steady state response; understand the real time applications of maximum power transfer theorem and equalizer
CO4	understand the two–port network parameters, are able to find out two-port network parameters & overall response for interconnection of two-port networks.
CO5	synthesize one port network using Foster form, Cauer form.

Course Code	:	**ECMI12**
Course Title	:	ELECTRODYNAMICS AND ELECTROMAGNETIC WAVES
Type of Course	:	MI
Prerequisites	:	NA
Contact Hours	:	3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To expose the students to the rudiments of Electromagnetic theory and wave propagation essential for subsequent courses on microwave engineering, antennas and wireless communication

Course Content

Electrostatics. Coulomb's law. Gauss's law and applications. Electric potential. Poisson's and Laplace equations. Method of images. Multipole Expansion.

Electrostatic fields in matter. Dielectrics and electric polarization. Capacitors with dielectric substrates. Linear dielectrics. Force and energy in dielectric systems.

Magneto statics. Magnetic fields of steady currents. Biot-Savart's and Ampere's laws. Magnetic vector potential. Magnetic properties of matter.

Electrodynamics. Flux rule for motional emf. Faraday's law. Self and mutual inductances. Maxwell's Equations. Electromagnetic Boundary conditions. Poynting theorem.

Electromagnetic wave propagation. Uniform plane waves. Wave polarization. Waves in matter. Reflection and transmission at boundaries. Propagation in an ionized medium.

Text Books

1. *D.J.Griffiths, "Introduction to Electrodynamics (3/e)", PHI, 2001*
2. *E.C. Jordan & G. Balmain, "Electromagnetic Waves and Radiating Systems", PHI, 1995.*

References

1.	*W.H.Hayt, "Engineering Electromagnetics, (7/e)", McGraw Hill, 2006.*
2.	*D.K.Cheng, "Field and Wave Electromagnetics, (2/e)", Addison Wesley, 1999.*
3.	*M.N.O.Sadiku, "Principles of Electromagnetics, (4/e)", Oxford University Press, 2011.*
4.	*N.Narayana Rao, "Elements of Engineering Electromagnetics, (6/e)", Pearson, 2006.*
5.	*R.E.Collin, "Foundations for Microwave Engineering (2/e)", McGraw –Hill, 2002.*
6.	*R.E.Collin, "Antennas and Radiowave Propagation", McGraw-Hill, 1985.*

Course Outcomes (CO)

At the end of the course student will be able

CO1	recognize and classify the basic Electrostatic theorems and laws and to derive them.
CO2	discuss the behaviour of Electric fields in matter and Polarization concepts.
CO3	classify the basic Magneto static theorems and laws and infer the magnetic properties of matter.
CO4	summarize the concepts of electrodynamics &to derive and discuss the Maxwell's equations.
CO5	students are expected to be familiar with Electromagnetic wave propagation and wave polarization.

Course Code	**:**	**ECMI13**
Course Title	**:**	SEMICONDUCTOR PHYSICS AND DEVICES
Type of Course	**:**	MI
Prerequisites	**:**	NA
Contact Hours	**:**	3
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To make the students understand the fundamentals of electronic devices.
CLO2	To train them to apply these devices in mostly used and important applications.

Course Content

Semiconductor materials: crystal growth, film formation, lithography, etching and doping. Formation of energy bands in solids, Concept of hole, Intrinsic and extrinsic semiconductors, conductivity, Equilibrium Carrier concentration, Density of states and Fermi level, Carrier transport – Drift and Diffusion, continuity equation, Hall effect and its applications.

P-N junction diodes, Energy band diagram, biasing, V-I characteristics, capacitances. Diode models, Break down Mechanisms, Rectifiers, Limiting and Clamping Circuits, types of diodes.

BJT Physics and Characteristics modes of operation, Ebers-Moll Model, BJT as a switch and Amplifier, breakdown mechanisms, Photo devices.

MOSFET: Ideal I-V characteristics, non-ideal I-V effects, MOS Capacitor, MOSFET as switch, CMOS Logic gate Circuits, Bi-CMOS circuits, CCDs.

State-of-the-art MOS technology: small-geometry effects, FinFETs, Ultrathin body FETs. Display devices, Operation of LCDs, Plasma, LED and HDTV

Text Books

1. *S.M.Sze, Semiconductors Devices, Physics and Technology, (2/e), Wiley, 2002*
2. *A.S.Sedra & K.C.Smith, Microelectronic Circuits (5/e), Oxford, 2004*

References

1.	*L.Macdonald & A.C.Lowe, Display Systems, Wiley, 2003Robert Pierret, "Semiconductor Device Fundamentals," Pearson Education, 2006*
2.	*J.Millman and C.C.Halkias: Electronic devices and Circuits, McGraw Hill, 1976.*
3.	*B.G.Streetman: Solid state devices, (4/e), PHI, 1995.*
4.	*N.H.E.Weste, D. Harris, "CMOS VLSI Design (3/e)", Pearson, 2005.*

Course Outcomes (CO)

At the end of the course student will be able

CO1	Apply the knowledge of basic semiconductor material physics and understand fabrication processes.
CO2	Analyze the characteristics of various electronic devices like diode, transistor etc.,
CO3	Classify and analyze the various circuit configurations of Transistor and MOSFETs.
CO4	Illustrate the qualitative knowledge of Power electronic Devices.
CO5	Become Aware of the latest technological changes in Display Devices.

Course Code	**:**	**ECMI14**
Course Title	**:**	DIGITAL CIRCUITS AND SYSTEMS
Type of Course	**:**	MI
Prerequisites	**:**	NA
Contact Hours	**:**	3
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To enable students to understand Boolean Algebra, Simplification of Boolean expressions and Logic Gates designs
CLO2	To enable students to design Combinational and Sequential logic circuits and their system level realizations.
CLO3	To understand the importance of Finite State Machines and design of digital systems using FSM
CLO4	To enable students to write and simulate digital circuits and systems using Hardware Descriptive Language

Course Content

Review of number systems-representation-conversions, error detection and error correction. Review of Boolean algebra- theorems, sum of product and product of sum simplification, canonical forms-minterm and maxterm, Simplification of Boolean expressions-Karnaugh map, completely and incompletely specified functions, Implementation of Boolean expressions using universal gates.

Combinational logic circuits- adders, subtractors, BCD adder, ripple carry look ahead adders, parity generator, decoders, encoders, multiplexers, DE multiplexers, Realization of Boolean expressions-using decoders-using multiplexers. Memories – ROM- organization, expansion. PROMs. Types of RAMs – Basic structure, organization, Static and dynamic RAMs, PLDs, PLAs.

Sequential circuits – latches, flip flops, edge triggering, asynchronous inputs. Shift registers, Universal shift register, applications. Binary counters – Synchronous and asynchronous up/down counters, mod-N counter, Counters for random sequence.

Synchronous circuit analysis and design: structure and operation, analysis-transition equations, state tables and state diagrams, Modelling- Moore machine and Mealy machine- serial binary adder, sequence recogniser, state table reduction, state assignment. Hazard; Overview and comparison of logic families.

Introduction to Verilog HDL, Structural, Dataflow and behavioural modelling of combinational and sequential logic circuits.

Text Books

1. *Wakerly J F, "Digital Design: Principles and Practices, Prentice-Hall", 2nd Ed., 2002.*
2. *D. D. Givone, "Digital Principles and Design", Tata Mc-Graw Hill, New Delhi, 2003.*

References

1.	*S.Brown and Z.Vranesic, "Fundamentals of Digital Logic with Verilog Design", Tata Mc-Graw Hill, 2008.*
2.	*D.P. Leach, A. P. Malvino, GoutamGuha, "Digital Principles and Applications", Tata Mc-Graw Hill, New Delhi, 2011.*
3.	*M. M. Mano, "Digital Design", 3rd ed., Pearson Education, Delhi, 2003.*
4.	*R.J.Tocci and N.S.Widner, "Digital Systems - Principles& Applications", PHI, 10th Ed., 2007.*
5.	*Roth C.H., "Fundamentals of Logic Design", Jaico Publishers. V Ed., 2009.*
6.	*T. L. Floyd and Jain,"Digital Fundamentals", 8th ed., Pearson Education, 2003.*

Course Outcomes (CO)

At the end of the course student will be able

CO1	Apply the knowledge of Boolean Algebra and simplification of Boolean expressions to deduce optimal digital networks.
CO2	Study and examine the SSI, MSI and Programmable combinational networks.
CO3	Study and investigate the sequential networks suing counters and shift registers; summarize the performance of logic families with respect to their speed, power consumption, number of ICs and cost.
CO4	Work out SSI and MSI digital networks given a state diagram based on Mealy and Moore configurations.
CO5	Code combinational and sequential networks using Verilog HDL.

Course Code	**:**	**ECMI15**
Course Title	**:**	DIGITAL SIGNAL PROCESSING
Type of Course	**:**	MI
Prerequisites	**:**	NA
Contact Hours	**:**	3
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To study about discrete-time Fourier transform (DTFT), the concepts of frequency response characteristics of a discrete-time systems, DFT and its fast computation.
CLO2	To make the students able to design digital filters (FIR and IIR) and implement in various forms.
CLO3	To study and understand the concept of multirate DSP systems and its applications

Course Content

Review of LSI system, DTFT, Frequency response of discrete time systems, all pass inverse, linear phase and minimum phase systems.

DFT, Relationship of DFT to other transforms, FFT, DIT and DIF, FFT algorithm, Linear filtering using DFT and FFT.

Characteristics of FIR Digital Filters, types and frequency response - Design of FIR digital filters using window techniques and frequency sampling technique - basic structures and lattice structure for FIR systems.

Analog filter approximations – Butter worth and Chebyshev, Design of IIR Digital filters from analog filters, Analog and Digital frequency transformations - Basic structures of IIR systems, Transposed forms.

Sampling rate conversion by an integer and rational factor, Poly phase FIR structures for sampling rate conversion.

Text Books

1. *J.G.Proakis, D.G. Manolakis, "Digital Signal Processing", (4/e) Pearson, 2007.*
2. *A.V.Oppenheim & R.W.Schafer, "Discrete Time Signal processing", (2/e), Pearson Education, 2003.*

References

1.	*S.K.Mitra, "Digital Signal Processing (3/e)", Tata McGraw Hill, 2006.*
2.	*P.S.R.Diniz, E.A.B.da Silva and S.L.Netto, "Digital Signal Processing", Cambridge, 2002.*
3.	*E.C.Ifeachor & B.W.Jervis, "Digital Signal Processing", (2/e), Pearson Education, 2002.*
4.	*J.R.Jhonson, "Introduction to Digital Signal Processing", Prentice-Hall, 1989.*

Course Outcomes (CO)

At the end of the course student will be able

CO1	analyze discrete-time systems in both time & transform domain and also through pole-zero placement.
CO2	analyze discrete-time signals and systems using DFT and FFT.
CO3	design and implement digital finite impulse response (FIR) filters.
CO4	design and implement digital infinite impulse response (IIR) filters.
CO5	understand and develop multirate digital signal processing systems.

Course Code	:	**ECMI16**
Course Title	:	TRANSMISSION LINES AND WAVEGUIDES
Type of Course	:	MI
Prerequisites	:	**ECMI12**
Contact Hours	:	3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To expose students to the complete fundamentals and essential feature of waveguides, resonators and microwave components and also able to give an introduction to microwave integrated circuit design.

Course Content

Classification of guided wave solutions-TE, TM and TEM waves. Field analysis transmission lines.

Rectangular and circular waveguides. Excitation of waveguides. Rectangular and circular cavity resonators.

Transmission line equations. Voltage and current waves. Solutions for different terminations. Transmission-line loading.

Impedance transformation and matching. Smith Chart, Quarter-wave and half-wave transformers. Binomial and T-chebeyshev transformers. Single, double and triple stub matching.

Microstriplines, stripline, slot lines, coplanar waveguide and fin line. Micro strip MIC design aspects. Computer- aided analysis and synthesis.

Text Books

1. *D.M.Pozar, "Microwave Engineering (3/e)" Wiley, 2004.*
2. *J.D.Ryder, "Networks, Lines and Fields", PHI, 2003.*

References

1.	*R.E.Collin, "Foundations for Microwave Engineering (2/e)", McGraw-Hill, 2002.*
2.	*S.Y.Liao, "Microwave Devices and Circuits", (3/e) PHI, 2005.*
3.	*J. A. Seeger, "Microwave Theory, Components, and Devices" Prentice-Hall-A division of Simon & Schuster Inc Englewood Cliffs, New Jersy 07632, 1986.*

Course Outcomes (CO)

At the end of the course student will be able

CO1	classify the Guided Wave solutions -TE, TM, and TEM.
CO2	analyze and design rectangular waveguides and understand the propagation of electromagnetic waves.
CO3	evaluate the resonance frequency of cavity Resonators and the associated modal field.
CO4	analyze the transmission lines and their parameters using the Smith Chart.
CO5	apply the knowledge to understand various planar transmission lines.

Course Code	**:**	**ECMI17**
Course Title	**:**	ELECTRONIC CIRCUITS
Type of Course	**:**	MI
Prerequisites	**:**	**ECMI13**
Contact Hours	**:**	3
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To make the students understand the fundamentals of electronic circuits.

Course Content

Load line, operating point, biasing methods for BJT and MOSFET. Low frequency and high models of BJT and MOSFET, Small signal Analysis of CE, CS, CD and Cascade amplifier

MOSFET amplifiers: Current mirrors: Basic current mirror, Cascade current mirror, Single-ended amplifiers: CS amplifier – with resistive load, diode connected load, current source load, triode load, source degeneration. CG and CD amplifiers, Cascade amplifier,

Frequency response of amplifiers, Differential Amplifiers, CMRR, Differential amplifiers with active load, two stage amplifiers

Feedback concept, Properties, Feedback amplifiers, Stability analysis, Condition for oscillation, Sinusoidal oscillators.

Power amplifiers- class A, class B, class AB, Biasing circuits, class C and class D

Text Books

1. *A.S.Sedra & K.C.Smith, "Microelectronic Circuits (5/e)", Oxford, 2004.*
2. *D.L.Schilling & C.Belove, "Electronic Circuits: Discrete and Integrated", (3/e), McGraw Hill, 1989.*

References

1.	*Behzad Razavi, "Design of Analog CMOS Integrated Circuits", (2/e), McGraw Hill, 2017.*
2.	*Millman&A., "Microelectronics", McGraw Hill, 1987.*
3.	*K.V.Ramanan, "Functional Electronics", Tata McGraw Hill, 1984.*

Course Outcomes (CO)

At the end of the course student will be able

CO1	illustrate about rectifiers, transistor and FET amplifiers and its biasing. Also compare the performances of its low frequency models.
CO2	discuss about the frequency response of MOSFET and BJT amplifiers.
CO3	illustrate about MOS and BJT differential amplifiers and its characteristics.
CO4	discuss about the feedback concepts and construct feedback amplifiers and oscillators. Also summarizes its performance parameters.
CO5	explain about power amplifiers and its types and also analyze its characteristics

Course Code	:	**ECMI18**
Course Title	:	MICROPROCESSORS AND MICRO CONTROLLERS
Type of Course	:	MI
Prerequisites	:	**ECMI14**
Contact Hours	:	3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	This subject deals about the basics of 16-bit Microprocessor, 8-bit and 16-bit Micro controllers, their architectures, internal organization and their functions, peripherals, and interfacing.

Course Content

Microprocessor based personal computer system. Software model of 8086. Segmented memory operation. Instruction set. Addressing modes. Assembly language programming. Interrupts. Programming with DOS and BIOS function calls.

Hardware detail of 8086. . Bus timing. Minimum Vs Maximum mode of operation. Memory interface. Parallel and serial data transfer methods. 8255 PPI chip. 8259 Interrupt controller. 8237 DMA controller.

Microcontroller. Von-Neumann Vs Harvard architecture. Programming model. Instruction set of 8051 Microcontroller. Addressing modes. Programming. Timer operation.

Mixed Signal Microcontroller: MSP430 series. Block diagram. Address space. On-chip peripherals -analog and digital. Register sets. Addressing Modes. Instruction set. Programming. FRAM Vs flash for low power and reliability.

Peripheral Interfacing using 8051 and Mixed signal microcontroller. Serial data transfer - UART, SPI and I2C. Interrupts. I/O ports and port expansion. DAC, ADC, PWM, DC motor, Stepper motor and LCD interfacing.

Text Books

1. *J.L.Antonakos, "An Introduction to the Intel Family of Microprocessors", Pearson, 1999.*
2. *M.A.Mazidi & J.C.Mazidi "Microcontroller and Embedded systems using Assembly & C. (2/e)", Pearson Education, 2007.*

References

1.	*John H. Davies, "MSP430 Microcontroller Basics", Elsevier Ltd., 2008*
2.	*B.B. Brey, "The Intel Microprocessors, (7/e), Eastern Economy Edition", 2006.*
3.	*K.J. Ayala, "The 8051 Microcontroller ", (3/e), Thomson Delmar Learning, 2004.*
4.	*I. S. MacKenzie and R.C.W.Phan., "The 8051 Microcontroller. (4/e)", Pearson education, 2008.*

Course Outcomes (CO)

At the end of the course student will be able

CO1	recall and apply the basic concept of digital fundamentals to Microprocessor based personal computer system.
CO2	identify the detailed s/w & h/w structure of the Microprocessor.
CO3	illustrate how the different peripherals are interfaced with Microprocessor.
CO4	distinguish and analyze the properties of Microprocessors & Microcontrollers.
CO5	analyze the data transfer information through serial & parallel ports.

Course Code	**:**	**ECMI19**
Course Title	**:**	DIGITAL SIGNAL PROCESSORS AND APPLICATIONS
Type of Course	**:**	MI
Prerequisites	**:**	**ECMI15**
Contact Hours	**:**	3
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To give an exposure to the various fixed point and floating point DSP architectures, to understand the techniques to interface sensors and I/O circuits and to implement applications using these processors.

Course Content

Fixed-point DSP architectures. Basic Signal processing system. Need for DSPs. Difference between DSP and other processor architectures. TMS320C54X, ADSP21XX, DSP56XX architecture details. Addressing modes. Control and repeat operations. Interrupts. Pipeline operation. Memory Map and Buses.

Floating-point DSP architectures. TMS320C3X, DSP96XX architectures. Cache architecture. Floating-point Data formats. On-chip peripherals. Memory Map and Buses.

On-chip peripherals. Hardware details and its programming. Clock generator with PLL. Serial port. McBSP. Parallel port. DMA. EMIF. I^2C. Real-time-clock (RTC). Watchdog timer.

Interfacing. Serial interface- Audio codec. Sensors - Humidity/temperature sensor, flow sensor, accelerometer, pulse sensor and finger print scanner. A/D and D/A interfaces. Parallel interface- Memory interface. RF transceiver interface – Wi-Fi and Zigbee modules.

DSP tools and applications. Implementation of Filters, DFT, QPSK Modem, Speech processing. Video processing, Video Encoding /Decoding. Biometrics. Machine Vision. High performance computing (HPC).

Text Books

1. *B.Venkataramani & M.Bhaskar, "Digital Signal Processor, Architecture, Programming and Applications",(2/e), McGraw- Hill,2010*
2. *S.Srinivasan & Avtar Singh, "Digital Signal Processing, Implementations using DSP Microprocessors with Examples from TMS320C54X", Brooks/Cole, 2004.*

References

1.	*S.M.Kuo & W.S.S.Gan," Digital Signal Processors: Architectures, Implementations, and Applications", Printice Hall, 2004*
2.	*C.Marven & G.Ewers, "A Simple approach to digital signal processing", Wiley Inter science, 1996.*
3.	*R.A.Haddad & T.W.Parson, "Digital Signal Processing: Theory, Applications and Hardware", Computer Science Press NY, 1991.*

Course Outcomes (CO)

At the end of the course student will be able

CO1	learn the architecture details of fixed point DSPs.
CO2	learn the architecture details of floating point DSPs
CO3	infer about the control instructions, interrupts, pipeline operations, memory and buses.
CO4	illustrate the features of on-chip peripheral devices and its interfacing with real time application devices.
CO5	learn to implement the signal processing algorithms and applications in DSPs

Course Code	:	**ECMI20**
Course Title	:	ANALOG COMMUNICATION
Type of Course	:	MI
Prerequisites	:	**ECMI10**
Contact Hours	:	3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To develop a fundamental understanding on Communication Systems with emphasis on analog modulation techniques and noise performance.

Course Content

Basic blocks of Communication System. Amplitude (Linear) Modulation – AM, DSB-SC, SSB-SC and VSB-SC. Methods of generation and detection. FDM. Super Heterodyne Receivers.

Angle (Non-Linear) Modulation - Frequency and Phase modulation. Transmission Bandwidth of FM signals, Methods of generation and detection. FM Stereo Multiplexing.

Noise - Internal and External Noise, Noise Calculation, Noise Figure. Noise in linear and nonlinear AM receivers, Threshold effect.

Noise in FM receivers, Threshold effect, Capture effect, FM Threshold reduction, Pre-emphasis and De-emphasis.

Pulse Modulation techniques – Sampling Process, PAM, PWM and PPM concepts, Methods of generation and detection. TDM. Noise performance.

Text Books

1. *S.Haykins, Communication Systems, Wiley, (4/e), Reprint 2009.*
2. *Kennedy, Davis, Electronic Communication Systems (4/e), McGraw Hill, Reprint 2008.*

References

1.	*B.Carlson, Introduction to Communication Systems, McGraw-Hill, (4/e), 2009.*
2.	*J.Smith, Modern Communication Circuits (2/e), McGraw Hill, 1997.*
3.	*J.S.Beasley&G.M.Miler, Modern Electronic Communication (9/e), Prentice-Hall, 2008.*

Course Outcomes (CO)

At the end of the course student will be able

CO1	Understand the basics of communication system and analog modulation techniques
CO2	Apply the basic knowledge of signals and systems and understand the concept of Frequency modulation.
CO3	Apply the basic knowledge of electronic circuits and understand the effect of Noise in communication system and noise performance of AM system
CO4	Understand the effect of noise performance of FM system.
CO5	Understand TDM and Pulse Modulation techniques.

Course Code	**:**	**ECMI21**
Course Title	**:**	ANTENNAS AND PROPAGATION
Type of Course	**:**	MI
Prerequisites	**:**	**ECMI12**
Contact Hours	**:**	3
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To impart knowledge on basics of antenna theory and to analyze and design a start of art antenna for wireless communications.

Course Content

Radiation fundamentals. Potential theory. Helmholtz integrals. Radiation from a current element. Basic antenna parameters. Radiation field of an arbitrary current distribution. Small loop antennas.

Receiving antenna. Reciprocity relations. Receiving cross section, and its relation to gain. Reception of completely polarized waves. Linear antennas. Current distribution. Radiation field of a thin dipole. Folded dipole. Feeding methods. Baluns.

Antenna arrays. Array factorization. Array parameters. Broad side and end fire arrays. Yagi-Uda arrays Log-periodic arrays.

Aperture antennas. Fields as sources of radiation. Horn antennas. Babinet's principle. Parabolic reflector antenna. Microstrip antennas.

Wave Propagation: Propagation in free space. Propagation around the earth, surface wave propagation, structure of the ionosphere, propagation of plane waves in ionized medium, Determination of critical frequency, MUF. Fading, tropospheric propagation, Super refraction.

Text Books

1. *R.E.Collin, "Antennas and Radio Wave Propagation", McGraw – Hill, 1985.*
2. *W.L.Stutzman & G.A.Thiele, "Antenna Theory and Design", Wiley.*

References

1.	*K.F.Lee, "Principles of Antenna Theory", Wiley, 1984.*
2.	*F.E. Terman, "Electronic Radio Engineering (4/e)", McGraw Hill.*
3.	*J.R. James, P. S. Hall, and C. Wood, "Microstrip Antenna Theory and Design", IEE, 1981.*
4.	*C.A.Balanis, "Modern Antenna Handbook", Wiley India Pvt. Limited, 2008.*

Course Outcomes (CO)

At the end of the course student will be able

CO1	select the appropriate portion of electromagnetic theory and its application to antennas.
CO2	distinguish the receiving antennas from transmitting antennas, analyze and justify their characteristics.
CO3	assess the need for antenna arrays and mathematically analyze the types of antenna arrays.
CO4	distinguish primary from secondary antennas and analyze their characteristics by applying optics and acoustics principles.
CO5	outline the factors involved in the propagation of radio waves using practical antennas.

Course Code	:	**ECMI22**
Course Title	:	ANALOG INTEGRATED CIRCUITS
Type of Course	:	MI
Prerequisites	:	**ECMI17**
Contact Hours	:	3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To introduce the theoretical & circuit aspects of an Op-amp.

Course Content

Operational Amplifiers, DC and AC characteristics, typical op-amp parameters: Finite gain, finite bandwidth, Offset voltages and currents, Common-mode rejection ratio, Power supply rejection ratio, Slew rate, Applications of Op-amp: Precision rectifiers. Summing amplifier, Integrators and differentiators, Log and antilog amplifiers. Instrumentation amplifiers, voltage to current converters.

Active filters: Second order filter transfer function (low pass, high pass, band pass and band reject), Butterworth, Chebyshev and Bessel filters. Switched capacitor filter. Notch filter, all pass filters, self-tuned filters
Opamp as a comparator, Schmitt trigger, Astable and monostable multivibrators, Triangular wave generator, Multivibrators using 555 timer, Data converters: A/D and D/A converters

PLL- basic block diagram and operation, four quadrant multipliers. Phase detector, VCO, Applications of PLL:Frequency synthesizers, AM detection, FM detection and FSK demodulation.
CMOS differential amplifiers**:** DC analysis and small signal analysis of differential amplifier with Restive load, current mirror load and current source load, Input common-mode range and Common-mode feedback circuits. OTAs vsOpamps. Slew rate, CMRR, PSRR. Two stage amplifiers, Compensation in amplifiers (Dominant pole compensation).

Text Books

1. *S.Franco, Design with Operational Amplifiers and Analog Integrated*
2. *Circuits (3/e) TMH, 2003.*
3. *Sedra and Smith, Microelectronics Circuits, Oxford Univ. Press, 2004*

References

1.	*Coughlin, Driscoll, OP-AMPS and Linear Integrated Circuits, Prentice Hall, 2001.*

Course Outcomes (CO)

At the end of the course student will be able

CO1	infer the DC and AC characteristics of operational amplifiers and its effect on output and their compensation techniques.
CO2	elucidate and design the linear and nonlinear applications of an op-amp and special application ICs.
CO3	explain and compare the working of multi vibrators using special application IC 555 and general purpose op-amp.
CO4	classify and comprehend the working principle of data converters.
CO5	illustrate the function of application specific ICs such as Voltage regulators, PLL and its application in communication

Course Code	:	**ECMI23**
Course Title	:	DIGITAL COMMUNICATION
Type of Course	:	MI
Prerequisites	:	**ECMI20**
Contact Hours	:	3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To understand the key modules of digital communication systems with emphasis on digital modulation techniques.
CLO2	To get introduced to the basics of source and channel coding/decoding and Spread Spectrum Modulation.

Course Content

Base band transmission. Sampling theorem, Pulse code modulation (PCM), DM, Destination SNR in PCM systems with noise. Matched filter. Nyquist criterion for zero ISI. Optimum transmit and receive filters. Correlative Coding, M-ary PAM. Equalization- zero-forcing and basics of adaptive linear equalizers.

BASK, BFSK, and BPSK- Transmitter, Receiver, Signal space diagram, Error probabilities.

M-ary PSK, M-ary FSK, QAM, MSK and GMSK- Optimum detector, Signal constellation, error probability.

Linear block codes-Encoding and decoding. Cyclic codes – Encoder, Syndrome Calculator. Convolutional codes – encoding, Viterbi decoding. TCM.

Spread Spectrum (SS) Techniques- Direct Sequence Spread Spectrum modulation, Frequency-hop Spread Spectrum modulation - Processing gain and jamming margin.

Text Books

1. *S.Haykin, "Communication Systems", Wiley, (4/e), 2001.*
2. *J.G.Proakis, "Digital Communication", Tata McGraw – Hill, (4/e), 2001.*

References

1.	*B.Sklar, "Digital Communications: Fundamentals & Applications", Pearson Education, (2/e), 2001.*
2.	*A.B.Carlson, " Communication Systems", McGraw Hill, 3/e,2002*
3.	*R.E.Zimer & R.L.Peterson," Introduction to Digital Communication", PHI,3/e, 2001*

Course Outcomes (CO)

At the end of the course student will be able

CO1	Apply the knowledge of signals and system and explain the conventional digital communication system.
CO2	Apply the knowledge of statistical theory of communication and evaluate the performance of digital communication system in the presence of noise.
CO3	Describe and analyze the performance of advance modulation techniques.
CO4	Apply the knowledge of digital electronics and describe the error control codes like block code, cyclic code.
CO5	Describe and analyze the digital communication system with spread spectrum modulation.

Course Code	**:**	**ECMI24**
Course Title	**:**	MICROWAVE COMPONENTS AND CIRCUITS
Type of Course	**:**	MI
Prerequisites	**:**	**ECMI16**
Contact Hours	**:**	3
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	The subject introduces the essential Microwave Circuit Theory and the design aspects of Microwave Integrated Circuit components.

Course Content

Scattering matrix formulation. Passive microwave devices; terminations, bends, corners, attenuators, phase changers, directional couplers and hybrid junctions. Basics and design considerations of Microstripline, strip line, coplanar waveguide, Slot line and Finline.

Microwave measurements; frequency, wavelength, VSWR. Impedance determination. S-parameter measurements. Network analyzer.

Microwave network parameters. Basic circuit elements for microwaves. Transmission line sections and stubs. Richard transformation. Kuroda identities.

MIC filter design. Low pass to high pass, band pass and band stop transformations. Realization using microstrip lines and strip lines.

Design and realization of MIC components.3 dB hybrid design. Ratrace Hybrid Ring, Backward wave directional coupler, power divider; realization using microstrip lines and strip lines.

Text Books

1. *I.J.Bahl & P.Bhartia, "Microwave Solid state Circuit Design", Wiley, 2003.*
2. *D.M.Pozar, "Microwave Engineering (2/e)", Wiley, 2004.*

References

1.	*A. Das, "Microwave Engineering", Tata McGraw Hill, 2000*
2.	*B.Bhat, S. K. Koul, "Stripline like transmission lines for Microwave Integrated Circuits", New age International Pvt. Ltd. Publishers 2007.*
3.	*G. Matthaei, E.M.T. Jones , L. Young , George Matthaei, Leo Young , George L. Matthaei "Microwave filters, Impedance Matching Network, Coupling Structures (Updated)",Hardcover, 1,096 Pages, Published 1980 by Artech House Publishers ISBN-13: 978-0-89006-099-5, ISBN: 0-89006-099-1*

Course Outcomes (CO)

At the end of the course student will be able

CO1	Learn the basics of S parameters and use them in describing the components
CO2	Expose to the Microwave Measurements Principle
CO3	Realize the importance of the theory of Microwave circuit theory.
CO4	Work out the complete design aspects of various M.I.C. Filters
CO5	Confidently design all M.I.C. components to meet the industry standard

Course Code	**:**	**ECMI25**
Course Title	**:**	VLSI SYSTEMS
Type of Course	**:**	MI
Prerequisites	**:**	**ECMI14**
Contact Hours	**:**	3
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To introduce various aspects of VLSI circuits and their design including testing**.**

Course Content

VLSI design methodology, VLSI technology- NMOS, CMOS and BICMOS circuit fabrication. Layout design rules. Stick diagram. Latch up.

Characteristics of MOS and CMOS switches. Implementation of logic circuits using MOS and CMOS technology, multiplexers and memory, MOS transistors, threshold voltage, MOS device design equations. MOS models, small-signal AC analysis. CMOS inverters, propagation delay of inverters, Pseudo NMOS, Dynamic CMOS logic circuits, power dissipation.

Programmable logic devices- anti-fuse, EPROM and SRAM techniques. Programmable logic cells. Programmable inversion and expander logic. Computation of interconnect delay, Techniques for driving large off-chip capacitors, long lines, Computation of interconnect delays in FPGAs Implementation of PLD, EPROM, EEPROM, static and dynamic RAM in CMOS.

An overview of the features of advanced FPGAs, IP cores, Softcore processors, Various factors determining the cost of a VLSI, Comparison of ASICs, FPGAs , PDSPs and CBICs . Fault tolerant VLSI architectures

VLSI testing -need for testing, manufacturing test principles, design strategies for test, chip level and system level test techniques.

Text Books

1. *N. H. E. Weste, D.F. Harris, "CMOS VLSI design", (3/e), Pearson , 2005.*
2. *J. Smith, "Application Specific Integrated Circuits, Pearson", 1997.*

References

1.	*M.M.Vai, "VLSI design", CRC Press, 2001.*
2.	*Pucknell & Eshraghian, "Basic VLSI Design", PHI, (3/e), 2003.*
3.	*Uyemura, "Introduction to VLSI Circuits and Systems", Wiley, 2002.*

Course Outcomes (CO)

At the end of the course student will be able

CO1	Describe the techniques used for VLSI fabrication, design of CMOS logic circuits, switche and memory
CO2	Describe the techniques used the design of CMOS logic circuits, switches and memory in VLSI
CO3	Generalize the design techniques and analyze the characteristics of VLSI circuits such as are speed and power dissipation
CO4	Explain and compare the architectures for FPGA, PAL and PLDs and evaluate the characteristics such as area, power dissipation and reliability
CO5	Describe the techniques for fault tolerant VLSI circuits
CO6	Use the advanced FPGAs to realize Digital signal processing systems

Course Code	:	**ECMI26**
Course Title	:	WIRELESS COMMUNICAITON
Type of Course	:	MI
Prerequisites	:	**ECMI23**
Contact Hours	:	3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To get an understanding of mobile radio communication principles, types and to study the recent trends adopted in cellular and wireless systems and standards**.**

Course Content

Introduction to Wireless Communication. Cellular concept. System design fundamentals. Coverage and Capacity improvement in Cellular system. Technical Challenges.

Mobile Radio Propagation; Reflection, Diffraction, Fading. Multipath propagation. Statistical characterization of multipath fading. Diversity Techniques.

Path loss prediction over hilly terrain. Practical link budget design using Path loss models. Design parameters at base station. Antenna location, spacing, heights and configurations.

Multiple access techniques; FDMA, TDMA and CDMA. Spread spectrum. Power control. WCDMA. CDMA network design. OFDM and MC-CDMA.

GSM.3G, 4G (LTE), NFC systems, WLAN technology. WLL. Hyper LAN. Ad hoc networks. Bluetooth.

Text Books:

1. *T.S.Rappaport, Wireless Communication Principles (2/e), Pearson, 2002.*
2. *A.F.Molisch, Wireless Communications, Wiley, 2005.*

References

1.	*P.MuthuChidambaraNathan, Wireless Communications, PHI, 2008.*
2.	*W.C.Y.Lee, Mobile Communication Engineering. (2/e), McGraw- Hill, 1998.*
3.	*A.Goldsmith, Wireless Communications, Cambridge University Press, 2005.*
4.	*S.G.Glisic, Adaptive CDMA, Wiley, 2003.*

Course Outcomes (CO)

At the end of the course student will be able

CO1	Apply the knowledge of basic communication systems and its principles.
CO2	Describe the cellular concept and analyze capacity improvement Techniques.
CO3	Mathematically analyze mobile radio propagation mechanisms.
CO4	Summarize diversity reception techniques.
CO5	Design Base Station (BS) parameters and analyze the antenna configurations.

Course Code	**:**	**ECMI27**
Course Title	**:**	FIBER OPTIC COMMUNICATION
Type of Course	**:**	MI
Prerequisites	**:**	**ECMI12 & ECMI20**
Contact Hours	**:**	3
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To expose the students to the basics of signal propagation through optical fibers, fiber impairments, components and devices and system design.

Course Content

Optical Fibers: Structure, Wave guiding. Step-index and graded index optical fibers. Modal analysis. Classification of modes. Single Mode Fibers.

Pulse dispersion. Material and waveguide dispersion. Polarization Mode Dispersion. Absorption, scattering and bending losses. Dispersion Shifted Fibers, Dispersion Compensating Fibers.

Optical Power Launching and Coupling. Lensing schemes for coupling improvement. Fiber-to-fiber joints. Splicing techniques. Optical fiber connectors.

Optical sources and detectors. Laser fundamentals. Semiconductor Laser basics. LEDs. PIN and Avalanche photodiodes, Optical TX/RX Circuits.

Design considerations of fiber optic systems: Analog and digital modulation. Noise in detection process. Bit error rate. Optical receiver operation. Power Budget and Rise time Budget. WDM.

Text Books

1. *G.Keiser, "Optical Fiber Communications (5/e)", McGraw Hill, 2013.*
2. *G.P.Agarwal, "Fiber Optic Communication Systems", (3/e), Wiley, 2002.*

References

1.	*M.M.K.Liu, "Principles and Applications of Optical Communications", Tata McGraw Hill, 2010.*
2.	*A.Ghatak & K.Thygarajan, "Introduction to Fiber Optics", Cambridge, 1999.*
3.	*J.Gowar, "Optical Communication Systems", (2/e), PHI, 2001.*
4.	*A.Selvarajan, S.Kar and T.Srinivas, "Optical Fiber Communication Principles and Systems", Tata McGraw Hill, 2002.*

Course Outcomes (CO)

At the end of the course student will be able

CO1	Recognize and classify the structures of Optical fiber and types.
CO2	Discuss the channel impairments like losses and dispersion.
CO3	Analyze various coupling losses.
CO4	Classify the Optical sources and detectors and to discuss their principle.
CO5	Familiar with Design considerations of fiber optic systems.

Course Code	:	**ECMI28**
Course Title	:	MICROWAVE ELECTRONICS
Type of Course	:	MI
Prerequisites	:	**ECMI24**
Contact Hours	:	3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To impart knowledge on basics of microwave electron beam devices and their applications in X band frequency.

Course Content

Limitations of conventional vacuum tubes, Klystrons: Re-entrant cavities, Two cavity klystron, Velocity modulation process, Bunching process ,Power output and efficiency; Multi-cavity klystron , Reflex klystron-Velocity modulation process, Mode Characteristics ,Electronic admittance spiral.

Travelling-wave tubes: Slow-wave structures, Helix TWT- Amplification process, Convection current, Wave modes and gain; coupled cavity TWT, Backward wave oscillator.

Crossed -field devices: Magnetrons- Principle of operation, characteristics, Hull cut-off condition; Carcinotron, Gyrotron.

Microwave transistors and FETs: Microwave bipolar transistors-Physical structures, characteristics, Power-frequency limitations; Microwave tunnel diode, Microwave unipolar transistor – Physical structure, principle of operation, characteristics, High electron-mobility transistors.

Transferred electron and Avalanche transit-time devices: Gunn diode, Gunn diode as an oscillator. IMPATT, TRAPATT and BARITT.

Text Books

1. *S.Y.Liao, "Microwave Devices and Circuits (3/e)", PHI, 2005.*
2. *R. F. Soohoo, "Microwave Electronics", Wesley publication, 1971.*

References

1.	*R.E.Collin, "Foundations for Microwave Engineering (2/e)", Wiley India, 2007.*
2.	*D.M.Pozar," Microwave Engineering (3/e)", Wiley India, 2009.*
3.	*K C Gupta, Indian Institute of Technology, Kanpur," Microwaves", Wiley Eastern Limited, 1995.*

Course Outcomes (CO)

At the end of the course student will be able

CO1	Apply the basic knowledge of waveguide and microwave resonator circuits.
CO2	Asses the methods used for generation and amplification of the microwave power.
CO3	Distinguish between the linear and cross field electron beam microwave tubes.
CO4	Critically analyze the operating principles and performances of the microwave semiconductor devices.
CO5	Identify the suitable microwave power sources of given specification for the selected application.

ESSENTIAL LABORATORY REQUIREMENT (ELR)

Course Code	**:**	ECLR10
Course Title	**:**	DEVICES AND NETWORKS LABORATORY
Type of Course	**:**	ELR
Prerequisites	**:**	ECPC13
Contact Hours	**:**	2
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Content

List of Experiments:

1. Study Experiment
2. PN Junction Diode Characteristics
3. Zener diode characteristics and its application
4. Characteristics study of Bipolar Junction Transistor (BJT)
5. Characteristics study of JFET
6. Response study of Series RLC
7. Constant K High pass Filter
8. Attenuators
9. Clippers and Clampers
10. Mini Project

Course Outcomes (CO)

At the end of the course student will be able

CO1	Demonstrate theoretical device/circuit operation in properly constructed analog circuits.
CO2	Able to operate standard test equipment like multi-meters, oscilloscopes, power supplies, waveform generators, and to analyze, test, and implement circuits in breadboard.
CO3	Able to analyze the operation of an active device and compare its performance with the expected performance given in the data sheets.
CO4	Able to apply troubleshooting techniques to test the circuits.
CO5	Able to analyze the circuits and concepts using the Mini project.

Course Code	**:**	ECLR11
Course Title	**:**	DIGITAL ELECTRONICS LABORATORY
Type of Course	**:**	ELR
Prerequisites	**:**	ECPC14
Contact Hours	**:**	2
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To introduce basic postulates of Boolean algebra and shows the correlation between Boolean expressions
CLO2	To introduce the methods for simplifying Boolean expressions
CLO3	To outline the formal procedures for the analysis and design of combinational circuits and sequential circuits
CLO4	To learn combinational and sequential circuit simulations using Verilog HDL

Course Content

1. Study of logic gates and verification of Boolean Laws.
2. Design of adders and subtractors, code converters.
3. Design of Multiplexers & Demultiplexers.
4. Design of magnitude comparators.
5. Design of encoders and decoders.
6. Study and implementation of flip-flops.
7. Design and implementation of counters using flip-flops.
8. Design and implementation of shift registers.
9. Simulation of combinational circuits using Verilog.
10. Simulation of Sequential circuits using Verilog.

References

1.	John F.Wakerly, Digital Design, Fourth Edition, Pearson/PHI, 2006
2.	John.M Yarbrough, Digital Logic Applications and Design, Thomson Learning, 2002.
3.	Charles H.Roth. Fundamentals of Logic Design, Thomson Learning, 2003.
4.	Donald P.Leach and Albert Paul Malvino, Digital Principles and Applications, 6th Edition, TMH, 2003.
5.	Charles H. Roth, Jr., Lizy Kurian John Digital Systems Design Using VHDL, 2nd Edition, PWS Publishers, 1998.
6.	Thomas L. Floyd, Digital Fundamentals, 8th Edition, Pearson Education Inc, New Delhi, 2003
7.	Donald D. Givone, Digital Principles and Design, TMH, 2003
8.	M. M. Mano, “Digital Design”, 3rd ed., Pearson Education, Delhi, 2003.
9.	Samir Palnitkar,” Verilog HDL: A Guide to Digital Design and Synthesis, 2nd Ed, Pearson Education Inc, New Delhi, 2001

Course Outcomes (CO)

At the end of the course student will be able

CO1	Demonstrate theoretical device/circuit operation in properly constructed digital circuits.
CO2	Able to correctly operate standard electronic test equipment digital multi-meters, power supplies to analyze, test, and implement digital circuits.
CO3	Able to correctly analyze a circuit and compare its theoretical performance to actual performance.
CO4	Able to apply troubleshooting techniques to test digital circuits.
CO5	Able to code a given digital logic design in HDL language.

Course Code	:	ECLR12
Course Title	:	ELECTRONIC CIRCUITS LABORATORY
Type of Course	:	ELR
Prerequisites	:	ECPC17
Contact Hours	:	2
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To analyze various biasing circuits
CLO2	To design the amplifiers
CLO3	To design the oscillators
CLO4	To design power amplifiers
CLO5	To design MOS based amplifiers and current mirror circuits

Course Content

Hardware Experiments

1. Stability of Q point
2. Single stage RC coupled CE amplifier
3. Single stage RC coupled Current series CE feedback amplifier
4. Darlington emitter follower
5. Differential Amplifier
6. RC phase shift oscillator
7. Colpitt's Oscillator
8. Power amplifier – Class A & class AB

Simulation Experiments

9. MOS CS amplifier with resistive load, diode connected load, current source load
10. MOS current mirrors

Course Outcomes (CO)

At the end of the course student will be able

CO1	Demonstrate theoretical device/circuit operation in properly constructed analog circuits
CO2	Able to correctly operate standard electronic test equipment digital multi-meters, power supplies to analyze, test, and implement digital circuits
CO3	Able to correctly analyze a circuit and compare its theoretical performance to actual performance
CO4	Learn different techniques employed for the enhancement of Gain and Bandwidth
CO5	Able to map the Circuits implemented to that of real time application

Course Code	:	ECLR13
Course Title	:	MICROPROCESSOR AND MICROCONTROLLER LABORATORY
Type of Course	:	ELR
Prerequisites	:	ECPC14
Contact Hours	:	2
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	This course deals with several languages used for programming a Microprocessors and Microcontrollers through industry-standard compilers, Macro Assemblers, Debuggers, Real-time Kernels, and system-level simulators. Using the hardware kits to get the hands-on experience on 16-bit Microprocessor, 8-bit and 16-bit Microcontrollers and also interfacing the different peripherals.

Course Content

List of Experiments:

Intel 8086 – 16bit μP- Emulator.

1. Addressing modes of 8086 Microprocessor.
2. Block move and simple arithmetic operations.
3. Identification and displaying the activated key using DOS and BIOS function calls.

Intel 8051 (8-bit Microcontroller) - Proteus VSM Simulator and Trainer Kit.

4. Addressing modes of 8051 Microcontroller.
5. Delay generation - i) Nested loop and ii) Timers.
6. Toggling the ports and counting the pulses.
7. LCD Interfacing.
8. Generation of different waveforms using DAC (0808)
9. ADC interfacing.

Mixed-Signal Microcontroller –16bit –MSP430 series and Code Composer studio

10.PWM generation and speed control of Motors using MSP430.

Course Outcomes (CO)

At the end of the course student will be able

CO1	Train their practical knowledge through laboratory experiments.
CO2	Understand and write the assembly language programs to control the systems.
CO3	Learn system-level simulator and design complete Microcontroller based modules.
CO4	Study Code Composer Studio to develop and debug embedded applications
CO5	Do projects in IoT applications.

Course Code	**:**	ECLR14
Course Title	**:**	ANALOG VLSI & EMBEDDED SYSTEM LABORATORY
Type of Course	**:**	ELR
Prerequisites	**:**	ECPC21& ECPC23
Contact Hours	**:**	2
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Content

List of Experiments:

1. Study the characteristics of negative feedback amplifier
2. Design of an instrumentation amplifier
3. Study the characteristics of regenerative feedback system-Schmitt trigger
4. Design of a second order Butterworth band-pass filter for the given higher and lower cut-off frequencies
5. Design of a function generator-Square, Triangular wave

List of Experiments: USING XILINX

1. Comparators, parity generators & ALU
2. Flip-Flops, Shift-Registers & Counters Using Cadence
3. Dc transfer characteristics of an Inverter
4. Design, Simulation and Layout of basic digital blocks
5. Mini Project on VLSI Design

Course Outcomes (CO)

At the end of the course student will be able

CO1	Study the characteristics of negative feedback amplifier.
CO2	Design of an instrumentation amplifier.
CO3	Study the characteristics of regenerative feedback system- Schmitt trigger.
CO4	Design of a second order Butterworth band-pass filter for the given higher and lower cut-off frequencies.
CO5	Design of a function generator- DSquare, Triangular wave.
CO6	To study, design and experimentally verify Comparators, Parity Generators and ALU using XILINX.
CO7	Design of Flip-Flops, Shift-Registers & Counters Using XILINX.
CO8	Design and to study the DC transfer characteristics of an Inverter using Cadence.
CO9	Able to apply troubleshooting techniques to design, layout, simulate and test the digital circuits as blocks.
CO10	Able to map the Circuits implemented to that of real time application.

Course Code	:	ECLR15
Course Title	:	DIGITAL SIGNAL PROCESSING LABORATORY
Type of Course	:	ELR
Prerequisites	:	ECPC15
Contact Hours	:	2
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To program and analyse the signal processing functions such as convolution, correlation etc. using MATLAB tool.
CLO2	To learn and implement algorithms for FIR, IIR filters and DFT using FFT using MATLAB tool.
CLO3	To learn the addressing modes and implement the DSP algorithms in digital signal processors.
CLO4	To implement FIR and DFT in digital signal processor.

Course Content

List of Experiments:
MATLAB tool-based simulation experiments

1. Realization of correlation of two discrete signals
2. Realization of convolution
3. FIR filter design
4. IIR filter design
5. DFT implementation
6. SNR and Power spectral density estimation of signals

TMS320C5416 Digital Signal Processor kit-based Experiments

1. Study of various addressing modes and arithmetic sequence generation
2. Convolution using MAC, MACD and MACP instructions. Convolution using overlap add and overlap save method
3. Wave pattern generation
4. FIR filter implementation
5. DFT implementation using FFT radix-2 algorithm
6. Serial interface and data acquisition

Course Outcomes (CO)

At the end of the course student will be able

CO1	To write MATLAB program for signal processing functions
CO2	To implement algorithms to realize digital filters and transforms
CO3	To write and execute application program in digital signal processors
CO4	To implement signal processing algorithms in digital signal processors
CO5	To learn real time interfacing and data acquisition of signals

Course Code	:	ECLR16
Course Title	:	COMMUNICATION ENGINEERING LABORATORY
Type of Course	:	ELR
Prerequisites	:	ECPC18 & ECPC19
Contact Hours	:	2
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To get an understanding about the design of amplitude modulation techniques.
CLO2	To learn the fundamental design of analog pulse modulation schemes by varying amplitude, position and width of the pulse signal.
CLO3	To design digital modulation circuits by keying the amplitude and frequency of the carrier signal.
CLO4	To learn frequency multiplier circuit design using phase locked loop (PLL) IC.
CLO5	To implement analog and digital modulation circuits using Circuit and System level simulators.

Course Content
List of Experiments:

1. Amplitude Modulation and Demodulation
2. DSBSC Modulation
3. Pulse Amplitude Modulation and Demodulation
4. Pulse Width Modulation and Demodulation
5. Pulse Position Modulation using PLL (IC 565)
6. Amplitude Shift Keying (ASK) Modulation and Demodulation
7. Frequency Shift Keying (FSK) Modulation and Demodulation
8. Frequency Multiplier using PLL
9. Sample and Hold circuit
10. Simulation of analog and digital modulation techniques using Circuit and System level simulators.

Course Outcomes (CO)

At the end of the course student will be able

CO1	To design analog modulation schemes such as amplitude modulation and DSBSC modulation.
CO2	To design analog pulse modulation schemes by varying amplitude, position and width of the pulse signal.
CO3	To perform the digital modulation by designing circuits for keying the amplitude and frequency of the carrier signal.
CO4	To perform frequency multiplication using phase locked loop.
CO5	To study the various modulation techniques using Circuit and System level simulators.

Course Code	:	ECLR17
Course Title	:	MICROWAVE &FIBER OPTIC LABORATORY
Type of Course	:	ELR
Prerequisites	:	ECPC24
Contact Hours	:	2
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Content

List of Experiments:

Microwave Experiments

1. Study the characteristics of microwave sources (Gunn Diode, Reflex Klystron)
2. Impedance Measurement of unknown devices.
3. Study the characteristics of Reciprocal devices (Directional Coupler, E-Plane Tee, H-Plane Tee etc.,)
4. Study the characteristics of Non-Reciprocal devices (Isolator, Circulator)
5. Study the Characteristics of horn Antenna.
6. Microwave CAD -Design and analysis of Planar Antenna

Fiber Optic Communication Experiments

1. Characteristics of Optical Sources - Laser Diode and LED
2. Characteristics of Photodetectors - PIN Photodetector and Avalanche Photodiode (APD)
3. Characteristics of Optical Fiber-Measurement of Numerical Aperture, Attenuation, Bending Loss and Fiber Dispersion
4. Analog and Voice Communication through Optical Link
5. Performance Measurement in Optical System-BER and Q-factor Estimation, Optical Receiver Sensitivity Characteristics
6. Photonics CAD - WDM Link

Course Outcomes (CO)

At the end of the course student will be able

CO1	Understand the characteristics of optical sources and photodetectors in the fiber optic communication systems.
CO2	Understand the characteristics and various propagation effects of the optical fibers.
CO3	Construct analog and voice communication through optical fibers.
CO4	Analyze the performance parameters of the fiber optic communication systems through simulation software.
CO5	Interpret the operating principle of wavelength division multiplexing systems.

HONORS (HO)

Course Code	**:**	**ECHO11**
Course Title	**:**	**SPECTRAL ANALYSIS OF SIGNALS**
Type of Course	**:**	**HO**
Prerequisites	**:**	**ECPC15**
Contact Hours	**:**	3
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To give an exhaustive survey of methods available for power spectrum estimation.

Course Content

Periodogram and correlogram. Blackman – Tukey, Bartlett, Welch and Daniel methods. Window design considerations.

Parametric methods for rational spectra. Covariance structure of ARMA processes. AR, MA and ARMA signals. Multivariate ARMA signals.

Parametric methods for line spectra. Models of sinusoidal signals in noise. Nonlinear least squares, high order Yule-Walker, min-norm, Pisarenko, MUSIC and ESPRIT methods.

Filter bank methods. Filter-bank interpretation of the periodogram. Refined filter-bank and Capon methods.

Spatial methods. Array model. Nonparametric methods; beam forming and Capon method. Parametric methods; nonlinear least squares, Yule-Walker, min-norm, Pisarenko, MUSIC and ESPRIT methods.

References

1.	P.Stoica & R.Moses, "Spectral Analysis of signals", Pearson, 2005.
2.	Marple, "Introduction to Spectral Analysis", Prentice Hall.
3.	S.M.Key, "Fundamentals of Statistical Signal Processing", Prentice Hall PTR, 1998.
4.	Recent literature in Spectral Analysis of Signals.

Course Outcomes (CO)

At the end of the course student will be able

CO1	Derive and analyse the statistical properties of the conventional spectral estimators, namely the periodogram, averaged & modified periodogram and Blackman-Tukey methods.
CO2	Formulate modern, parametric, spectral estimators based upon autoregressive (AR), moving average (MA), and autoregresive moving average (ARMA) models, and detail their statistical properties. Describe the consequence of the term resolution as applied to a spectral estimator.
CO3	Define techniques for calculating moments in spectral and temporal domains; Analyze filter bank method, capon methods for spectrum estimation.
CO4	Demonstrate knowledge and understanding of the principles of parametric and non-parametric array processing algorithms.
CO5	Select an appropriate array processing algorithms for frequency estimation and sonar, radar applications.

Course Code	**:**	**ECHO12**
Course Title	**:**	**DETECTION AND ESTIMATION**
Type of Course	**:**	**HO**
Prerequisites	**:**	**MAIR45**
Contact Hours	**:**	**3**
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	The objective of this course is to make the students conversant with those aspects of statistical decision and estimation which are indispensable tools required for the optimal design of digital communication systems.

Course Content

Binary hypothesis testing; Bayes, minimax and Neyman-Pearson tests. Composite hypothesis testing.

Signal detection in discrete time: Models and detector structures. Coherent detection in independent noise. Detection in Gaussian noise. Detection of signals with random parameters. Detection of stochastic signals. Performance evaluation of signal detection procedures.

Bayesian parameter estimation; MMSE, MMAE and MAP estimates. Nonrandom parameter estimation. Exponential families. Completeness theorem. ML estimation. Information inequality. Asymptotic properties of MLEs.

Discrete time Kalman- Bucy filter. Linear estimation. Orthogonality principle. Wiener-Kolmogorov filtering – causal and non-causal filters.

Signal detection in continuous time: Detection of deterministic signals in Gaussian noise. Coherent detection in white Gaussian noise.

References

1.	H.V.Poor, "An Introduction to Signal Detection and Estimation (2/e) Springer", 1994.
2.	B.C.Levy, "Principles of Signal Detection and Parameter Estimation", Springer, 2008.
3.	H.L.Vantrees, "Detection, Estimation and Modulation theory", Part I, Wiley, 1987.
4.	M.D.Srinath & P.K.Rajasekaran, "Statistical Signal Processing with Applications", Wiley, 1979.
5.	J.C.Hancock & P.A. Wintz, "Signal Detection Theory", Mc-Graw Hill, 1966.
6.	Recent literature in Detection and Estimation.

Course Outcomes (CO)

At the end of the course student will be able

CO1	Summarize the fundamental concept on Statistical Decision Theory and Hypothesis Testing
CO2	Summarize the various signal estimation techniques with additive noise
CO3	Summarizer with Bayesian parameter estimation (minimum mean square error (MMSE), minimum mean absolute error (MMAE), maximum a-posterior probability (MAP) estimation methods).
CO4	Compare optimal filtering, linear estimation, and Wiener/Kalman filtering.
CO5	Construct Wiener and Kalman filters (time discrete) and state space models.

Course Code	:	**ECHO13**
Course Title	:	**WAVELET SIGNAL PROCESSING**
Type of Course	:	**HO**
Prerequisites	:	**ECPC15**
Contact Hours	:	**4**
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To expose the students to the basics of wavelet theory and to illustrate the use of wavelet processing for data compression and noise suppression.

Course Content

Limitations of standard Fourier analysis. Windowed Fourier transform. Continuous wavelet transform. Time-frequency resolution.

Multiresolution analysis and properties. The Haar wavelet, Structure of subspaces in MRA

Haar decomposition-1, Haar decomposition-2, Wavelet reconstruction, Haar wavelet and link to filter bank, demo on wavelet decomposition, Wavelet packets

Wavelet methods for signal processing. Noise suppression. Representation of noise-corrupted signals using frames. Algorithm for reconstruction from corrupted frame representation.

Wavelet methods for image processing. Burt- Adelson and Mallat's pyramidal decomposition schemes. 2D-dyadic wavelet transform.

References

1.	E.Hernandez & G.Weiss, A First Course on Wavelets, CRC Press, 1996.
2.	L.Prasad & S.S.Iyengar, Wavelet Analysis with Applications to Image Processing, CRC Press, 1997.
3.	A.Teolis, Computational Signal Processing with Wavelets, Birkhauser, 1998
4.	R.M. Rao & A.S. Bopardikar, Wavelet Transforms, Addition Wesley, 1998.
5.	J.C. Goswami & A.K. Chan, Fundamentals of Wavelets, John Wiley, 1999.
6.	Recent literature in Wavelet Signal Processing.

Course Outcomes (CO)

At the end of the course student will be able

CO1	Understand about windowed Fourier transform and difference between windowed Fourier transform and wavelet transform.
CO2	Understand wavelet basis and characterize continuous and discrete wavelet transforms
CO3	Understand multi resolution analysis and identify various wavelets and evaluate their time-frequency resolution properties
CO4	Implement discrete wavelet transforms in signal processing applications
CO5	Understand about wavelet methods in image processing

Course Code	:	**ECHO14**
Course Title	:	**RF CIRCUITS**
Type of Course	:	**HO**
Prerequisites	:	**NONE**
Contact Hours	:	**3**
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To impart knowledge on basics of IC design at RF frequencies.

Course Content

Characteristics of passive IC components at RF frequencies – interconnects, resistors, capacitors, inductors and transformers – Transmission lines. Noise – classical two-port noise theory, noise models for active and passive components High frequency amplifier design – zeros as bandwidth enhancers, shunt-series amplifier, fdoublers ,neutralization and uni-lateralization

Low noise amplifier design – LNA topologies, power constrained noise optimization, linearity and large signal performance

Mixers – multiplier-based mixers, subsampling mixers, diode-ring mixers

RF power amplifiers – Class A, AB, B, C, D, E and F amplifiers, modulation of power amplifiers, linearity considerations

Oscillators & synthesizers – describing functions, resonators, negative resistance oscillators, synthesis with static moduli, synthesis with dithering moduli, combination synthesizers – phase noise considerations.

References

1.	Thomas H. Lee, “The Design of CMOS Radio-Frequency Integrated Circuits”, 2nd ed., Cambridge, UK: Cambridge University Press,2004.
2.	B.Razavi, “RF Microelectronics”, 2nd Ed., Prentice Hall, 1998.
3.	A.A. Abidi, P.R. Gray, and R.G. Meyer, eds., “Integrated Circuits for Wireless Communications”, New York: IEEE Press,1999.
4.	R. Ludwig and P. Bretchko, “RF Circuit Design, Theory and Applications”, Pearson,2000.
5.	Mattuck,A., “Introduction to Analysis”,Prentice-Hall,1998.
6.	Recent literature in RF Circuits.

Course Outcomes (CO)

At the end of the course student will be able

CO1	Understand the Noise models for passive components and noise theory
CO2	Analyze the design of a high frequency amplifier
CO3	Appreciate the different LNA topologies & design techniques
CO4	Distinguish between different types of mixers
CO5	Analyse the various types of synthesizers, oscillators and their characteristics.

Course Code	:	**ECHO15**
Course Title	:	**NUMERICAL TECHNIQUES FOR MIC**
Type of Course	:	**HO**
Prerequisites	:	**ECPC25**
Contact Hours	:	**3**
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	This subject will prepare the student to face the challenging problem of the most important component of Research namely the numerical analysis.

Course Content

Over view of Numerical Techniques for Microwave integrated Circuits: Introduction, Quasi Static and Full wave Analysis, Outline if Finite element method, Integral Equation Technique, Planar Circuit Analysis, Spectral Domain Approach, The Method of Lines, The Mode Matching Method, The Transverse Resonance Technique

The Finite Element Method: Introduction, The Method of Weighted Residuals, The Variational Method Using a Variational Expression, The Finite Element Method, Integral Formulation of Problems, Antennas and Scattering from Conductors ,Waveguides-Hollow, Dielectric and Optical Finite Difference in space and Time Matrix Computations. A Finite Element Computer Program for Micro strips

Planar Circuit Analysis: Introduction, Planar Circuit Analysis' Function Approach Impedance Green's Functions Contour Integral Approach Analysis of Planar Components of Composite Configurations Planar Circuits with Anisotropic Spacing Media Applications of the Planar Circuits Concept Summary

Spectral Domain Approach: Introduction, General Approach for Shielded Microstrip Lines, the Admittance Approach Formulations for Slot lines, Fin lines, and Coplanar Waveguides Numerical Computation

Transverse Resonance Technique: Introduction, Inhomogeneous Waveguides Uniform along a Traverse Coordinate, Conventional Traverse Resonance Technique for Transversely Discontinuous Waveguides, Generalized Transverse Resonance Technique for Transversely Discontinuous Inhomogeneous Analysis of Discontinuities and Junctions by the Generalized Transverse Resonance Technique, Examples of Computer Programs.

References

1.	T.Itoh, Numerical Techniques for Microwave Integrated Circuits., John Wiley and sons,1989.
2.	Cam Nguyen,Analysis Methods FOR RF,Microwave AND Millimeter_wave Planar Transmission Line Structures, John Wiley & Sons, INC.2000.
3.	Bharathi Bhat, Shiban K.Koul, Analysis, Design and Applications of Fin lines. Artech House. 1987.
4.	Recent literature in numerical techniques for microwave integrated circuits.

Course Outcomes (CO)

At the end of the course student will be able

CO1	Bring awareness of the need for numerical analysis of M.I.C. And prepare to formulate all popular numerical techniques of M.I.C.
CO2	Make one formulate and write coding for Finite Element Method
CO3	Prepare a person to be strong in the planar circuit Analysis
CO4	Bring awareness of the most popular quasi state analysis Spectral Domain Techniques
CO5	Prepare the student formulate and write coding for the Transverse Resonance Techniques

Course Code	**:**	**ECHO16**
Course Title	**:**	**APPLIED PHOTONICS**
Type of Course	**:**	**HO**
Prerequisites	**:**	**NONE**
Contact Hours	**:**	**3**
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To prepare the students understand the fundamental principles of light-matter interaction and photonic band gap structures.
CLO2	To enable the students appreciate the diverse applications of fiberoptic sensors.

Course Content

Introduction to photonics; optical waveguide theory; Interference of light waves -numerical techniques and simulation

Photonic waveguide components Optical Modulators and Switches Electro-optics - Acousto-optics - Magneto-optics

Photonic Band gap Structures: Concept of photonic crystal; band gap and band structures in 1D, 2D and 3D photonic crystal structures;

Photo-refractive materials, non-linear optics, recent trends in bio and nano-photonics

Optical fiber sensors - Sensing using optical fibers - Types:-Amplitude, Inter-ferometric, Wavelength, Polarimetric – Distributed Sensors

References

1.	A. Ghatak and K. Thyagarajan, "Introduction to Fiber Optics", Cambridge University Press,2006.
2.	Pochi Yeh and Amnon Yariv, Photonics: Optical Electronics in Modern Communications, 2007
3.	F. T. S. Yu and S.Yin, "Fiber Optic Sensors", Marcel Dekker, Inc2002
4.	G. W. Hanson, "Fundamentals of Nanoelectronics ",Pearson Education, 1stedition,2008
5.	B. Saleh and M. Teich, "Fundamentals of Photonics", Wiley & Sons, 2007
6.	Recent literature in Applied Photonics

Course Outcomes (CO)

At the end of the course student will be able

CO1	Understand the interference of light and optical waveguide theory.
CO2	Understand the significance of photonic band gap structures and their application
CO3	Analyze the different types of optical modulators.
CO4	Compare the merits and demerits of different types of fiber optic sensors.
CO5	Understand the application of nonlinear optics in bio and nano-photonics.

Course Code	**:**	**ECHO17**
Course Title	**:**	**ADVANCED RADIATION SYSTEMS**
Type of Course	**:**	**HO**
Prerequisites	**:**	**ECPC20**
Contact Hours	**:**	**3**
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To prepare the students understand the operating principles of various RF radiating systems.
CLO2	To enable the students appreciate the diverse applications of radiating systems.
CLO3	To design the suitable antenna systems to serve a defined application.

Course Content

Antenna Fundamentals

Antenna fundamental parameters, Radiation integrals, Radiation from surface and line current distributions – dipole, monopole, loop antenna; Broadband antennas and matching techniques, Balance to unbalance transformer, Introduction to numerical techniques.

Apertures Antennas

Field equivalence principle, Radiation from Rectangular and Circular apertures, Uniform aperture distribution on an infinite ground plane; Slot antenna; Horn antenna; Reflector antenna, aperture blockage, and design consideration.

Arrays

General structure of phased array, linear array theory, variation of gain as a function of pointing direction, frequency scanned arrays, digital beam forming, and MEMS technology in phased arrays-Retro directive and self-phased arrays.

Micro Strip Antenna

Radiation Mechanism from patch; Excitation techniques; Microstrip dipole; Rectangular patch, Circular patch, and Ring antenna – radiation analysis from transmission line model, cavity model; input impedance of rectangular and circular patch antenna; Application of microstrip array antenna.

Terahertz Planar Antennas

Electronics band gap materials - Photonic Band-gap Structures- Tera Hertz Patch antennas-Special antenna structures.

References

1.	Balanis. A, “Antenna Theory Analysis and Design”, John Wiley and Sons, New York, 3rd Edition, 1982.
2.	Frank B. Gross, “Frontiers in Antennas”, Mc Graw Hill, 2011.
3.	S. Drabowitch, A. Papiernik, H.D.Griffiths, J.Encinas, B.L.Smith, “Modern Antennas”, Springer Publications, 2nd Edition, 2007.
4.	Krauss.J.D, “Antennas”, John Wiley and sons, New York, 2nd Edition, 1997.
5.	I.J. Bahl and P. Bhartia, “Microstrip Antennas”, Artech House,Inc.,1980
6.	W.L.Stutzman and G.A.Thiele, “Antenna Theory and Design”, John Wiley& Sons Inc., 2nd Edition, 1998.
7.	Jim R. James, P.S.Hall ,”Handbook of Microstrip Antennas” IEE Electromagnetic wave series 28, Volume 2,1989.

Course Outcomes (CO)

At the end of the course student will be able

CO1	Understand the various antenna parameters and different impedance matching techniques.
CO2	Understand the working principle of apertures antennas.
CO3	Analyze how the electronic beam formation is done using array of antennas.
CO4	Compare the merits and demerits of various microwave patch antenna structures.
CO5	Understand the photonic band gap structures and its application in tera hertz antennas

Course Code	**:**	**ECHO18**
Course Title	**:**	**BIO MEMS**
Type of Course	**:**	**HO**
Prerequisites	**:**	**NONE**
Contact Hours	**:**	**3**
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To train the students in the design aspects of Bio MEMS devices and Systems. To make the students aware of applications in various medical specialists especially the Comparison of conventions methods and Bio MEMS usage.

Course Content

Introduction-The driving force behind Biomedical Applications-Biocompatibility-Reliability Considerations-Regularity Considerations-Organizations-Education of Bio MEMS-Silicon Micro fabrication-Soft Fabrication techniques

Micro fluidic Principles- Introduction-Transport Processes- Electro kinetic Phenomena-Micro valves –Micro mixers- Micro-pumps.

SENSOR PRINCIPLES and MICRO SENSORS: Introduction-Fabrication-Basic Sensors-Optical fibers- Piezo electricity and SAW devices-Electrochemical detection-Applications in Medicine

MICRO ACTUATORS and DRUG DELIVERY: Introduction-Activation Methods-Micro actuators for Micro fluidics-equivalent circuit representation-Drug Delivery

MICRO TOTAL ANALYSIS: Lab on Chip-Capillary Electrophoresis Arrays-cell, molecule and Particle Handling-Surface Modification-Microsphere-Cell based Bioassay Systems Detection and Measurement Methods-Emerging Bio MEMS Technology-Packaging, Power, Data and RF Safety-Biocompatibility, Standards

References

1.	S.S. Saliterman,” Fundamentals of Bio MEMS and Medical Micro devices”, Wiley Interscience, 2006.
2.	A. Folch ,”Introduction to Bio MEMS”, CRC Press,2012
3.	G.A. Urban, “Bio MEMS”, Springer,2006
4.	W. wang, S.A. Soper,” Bio MEMS”, 2006.
5.	M. J. Madou, “Fundamental of Micro fabrication”,2002.
6.	G.T. A. Kovacs, “Micro machined Transducers Source book”, 1998.
7.	Recent literature in Bio MEMS.

Course Outcomes (CO)

At the end of the course student will be able

CO1	Learn and realize the MEMS applications in Bio Medical Engineering
CO2	Understand the Micro fluidic Principles and study its applications.
CO3	Learn the applications of Sensors in Health Engineering.
CO4	Learn the principles of Micro Actuators and Drug Delivery system
CO5	Learn the principles and applications of Micro Total Analysis

Course Code	:	**ECHO19**
Course Title	:	**ANALOG IC DESIGN**
Type of Course	:	**HO**
Prerequisites	:	**ECPC21**
Contact Hours	:	**3**
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To develop the ability design and analyze MOS based Analog VLSI circuits to draw the equivalent circuits of MOS based Analog VLSI and analyse their performance.
CLO2	To develop the skills to design analog VLSI circuits for a given specification.

Course Content

Basic MOS Device Physics – General Considerations, MOS I/V Characteristics, Second Order effects, MOS Device models. Short Channel Effects and Device Models. Single Stage Amplifiers – Basic Concepts, Common Source Stage, Source Follower, Common Gate Stage, Cascode Stage.

Differential Amplifiers – Single Ended and Differential Operation, Basic Differential Pair, Common-Mode Response, Differential Pair with MOS loads, Gilbert Cell. Passive and Active Current Mirrors – Basic Current Mirrors, Cascode Current Mirrors, Active Current Mirrors.

Frequency Response of Amplifiers – General Considerations, Common Source Stage, Source Followers, Common Gate Stage, Cascode Stage, Differential Pair. Noise – Types of Noise, Representation of Noise in circuits, Noise in single stage amplifiers, Noise in Differential Pairs.

Feedback Amplifiers – General Considerations, Feedback Topologies, Effect of Loading. Operational Amplifiers – General Considerations, One Stage Op Amps, Two Stage Op Amps, Gain Boosting, Common-Mode Feedback, Input Range limitations, Slew Rate, Power Supply Rejection, Noise in Op Amps. Stability and Frequency Compensation.

Band gap References, Introduction to Switched Capacitor Circuits, Nonlinearity and Mismatch.

References

1.	B.Razavi, “Design of Analog CMOS Integrated Circuits”, McGraw Hill Edition2002.
2.	Paul. R.Gray, Robert G. Meyer, “Analysis and Design of Analog Integrated Circuits”, Wiley, (4/e), 2001.
3.	D. A. Johns and K. Martin, “Analog Integrated Circuit Design”, Wiley,1997.
4.	R. Jacob Baker, “CMOS Circuit Design, Layout, and Simulation”, Wiley, (3/e),2010.
5.	P.E.Allen, D.R. Holberg, “CMOS Analog Circuit Design”, Oxford University Press,2002.
6.	Recent literature in Analog IC Design.

Course Outcomes (CO)

At the end of the course student will be able

CO1	Draw the equivalent circuits of MOS based Analog VLSI and analyze their performance.
CO2	Design analog VLSI circuits for a givens pecification.
CO3	Analyse the frequency response of the different configurations of a amplifier.
CO4	Understand the feedback topologies involved in the amplifier design.
CO5	Appreciate the design features of the differential amplifiers.

Course Code	:	**ECHO20**
Course Title	:	**VLSI SYSTEM TESTING**
Type of Course	:	**HO**
Prerequisites	:	**ECPC23**
Contact Hours	:	**3**
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To expose the students, the basics of testing techniques for VLSI circuits and Test Economics.

Course Content

Basics of Testing: Fault models, Combinational logic and fault simulation, Test generation for Combinational Circuits. Current sensing based testing. Classification of sequential ATPG methods. Fault collapsing and simulation

Universal test sets: Pseudo-exhaustive and iterative logic array testing. Clocking schemes for delay fault testing. Testability classifications for path delay faults. Test generation and fault simulation for path and gate delay faults.

CMOS testing: Testing of static and dynamic circuits. Fault diagnosis: Fault models for diagnosis, Cause- effect diagnosis, Effect-cause diagnosis.

Design for testability: Scan design, Partial scan, use of scan chains, boundary scan, DFT for other test objectives, Memory Testing.

Built-in self-test: Pattern Generators, Estimation of test length, Test points to improve testability, Analysis of aliasing in linear compression, BIST methodologies, BIST for delay fault testing.

References

1.	N. Jha& S.D. Gupta, “Testing of Digital Systems”, Cambridge,2003.
2.	W. W. Wen, “VLSI Test Principles and Architectures Design for Testability”, Morgan Kaufmann Publishers.2006
3.	Michael L. Bushnell &Vishwani D. Agrawal,” Essentials of Electronic Testing for Digital, memory & Mixed signal VLSI Circuits”, Kluwar Academic Publishers.2000.
4.	P. K. Lala,” Digital circuit Testing and Testability”, Academic Press.1997.
5.	M. Abramovici, M. A. Breuer, and A.D. Friedman, “Digital System Testing and Testable Design”, Computer Science Press,1990.
6.	Recent literature in VLSI System Testing.

Course Outcomes (CO)

At the end of the course student will be able

CO1	Apply the concepts in testing which can help them design a better yield in IC design.
CO2	Tackle the problems associated with testing of semiconductor circuits at earlier design levels so as to significantly reduce the testing costs.
CO3	Analyze the various test generation methods for static & dynamic CMOS circuits.
CO4	Identify the design for testability methods for combinational & sequential CMOS circuits.
CO5	Recognize the BIST techniques for improving testability.

Course Code	:	**ECHO22**
Course Title	:	**DESIGN OF ASICS**
Type of Course	:	**HO**
Prerequisites	:	**VLSI Design**
Contact Hours	:	**(3-1-0) 4**
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To prepare the student to be an entry-level industrial standard ASIC or FPGA designer.
CLO2	To give the student an understanding of issues and tools related to ASIC/FPGA design and implementation.
CLO3	To give the student an understanding of High-performance algorithms.
CLO4	To give the student an understanding of basics of System on Chip and Platform based design.

Course Content

Introduction to Technology, Types of ASICs, VLSI Design flow, Design and Layout Rules, Programmable ASICs – Anti-fuse, SRAM, EPROM, EEPROM based ASICs. Programmable ASIC logic cells and I/O cells. Programmable interconnects. Advanced FPGAs and CPLDs and Soft-core processors. Self-Study: Multi-core processors, High performance computing (HPC), Cache, High speed memories (DDR4), High speed serdes (56Gbps, PAM4), GPU.

ASIC physical design issues, System Partitioning, Floorplanning and Placement. Algorithms: K-L, FM, Simulated annealing algorithms. Full Custom Design: Basics, Needs & Applications. Schematic and layout basics, Full Custom Design Flow.

Semicustom Approach: Synthesis (RTL to GATE netlist) - Introduction to Constraints (SDC), Introduction to Static Timing Analysis (STA). Place and Route (Logical to Physical Implementation): Floorplan and Power-Plan, Placement, Clock Tree Synthesis (clock planning), Routing, Timing Optimization, GDS generation.

Overview of Extraction, Logical equivalence and STA: Parasitic Extraction Flow, STA: Timing Flow, LEC. Introduction to Physical Verification flow and Tools used: Introduction, DRC, LVS and basics of DFM. High performance algorithms for FPGA & ASICs – Multiplier, Canonic Signed Digit Arithmetic, KCM, Distributed Arithmetic, High performance digital filters for sigma-delta ADC.

System-On-Chip Design - SoC Design Flow, Platform-based and IP based SoC Designs, Basic Concepts of Bus-Based Communication Architectures. Case study: FSM design, clock domain crossing, FIFOs. Core (ARM) and IOs (I2C, PWM, GPIO, SPI, NAND, Ethernet, USB, High speed serdes etc. are interconnected through AXI/APB buses (protocols and interconnects)

References

1.	M.J.S. Smith : Application Specific Integrated Circuits, Pearson, 2003
2.	Sudeep Pasricha and NikilDutt, On-Chip Communication Architectures System on Chip Interconnect, Elsevier, 2008
3.	H.Gerez, Algorithms for VLSI Design Automation, John Wiley, 1999
4.	Jan.M.Rabaey et al, Digital Integrated Circuit Design Perspective (2/e), PHI 2003
5.	David A.Hodges, Analysis and Design of Digital Integrated Circuits (3/e), MGH 2004
6.	Hoi-Jun Yoo, Kangmin Leeand Jun Kyong Kim, Low-Power NoC for High-Performance SoC Design, CRC Press, 2008

Course Outcomes (CO)

At the end of the course student will be able

CO1	Demonstrate VLSI tool-flow and appreciate FPGA and CPLD architectures.
CO2	Understand the algorithms used for ASIC construction. Understand Full Custom Design Flow and Tool used.
CO3	Understand Semicustom Design Flow and Tool used - from RTL to GDS and Logical to Physical Implementation.
CO4	Understand about STA, LEC, DRC, LVS, DFM.
CO5	Understand the System on Chip Design and On-chip communication architectures with case studies.

Course Code	:	**ECHO23**
Course Title	:	**DIGITAL SYSTEM DESIGN**
Type of Course	:	**HO**
Prerequisites	:	**ECPC14**
Contact Hours	:	**(3-1-0) 4**
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To get an idea about designing complex, high speed digital systems and how to implement such design.

Course Content

Mapping algorithms into Architectures: Datapath synthesis, control structures, critical path and worst case timing analysis. FSM and Hazards.

Combinational network delay. Power and energy optimization in combinational logic circuit. Sequential machine design styles. Rules for clocking. Performance analysis.

Sequencing static circuits. Circuit design of latches and flip-flops. Static sequencing element methodology. Sequencing dynamic circuits. Synchronizers.

Data path and array subsystems: Addition / Subtraction, Comparators, counters, coding, multiplication and division. SRAM, DRAM, ROM, serial access memory, context addressable memory.

Reconfigurable Computing- Fine grain and Coarse grain architectures, Configuration architectures-Single context, Multi context, partially reconfigurable, Pipeline reconfigurable, Block Configurable, Parallel processing.

References

1.	N.H.E.Weste, D. Harris, CMOS VLSI Design (3/e), Pearson,2005.
2.	W.Wolf, FPGA- based System Design, Pearson,2004.
3.	S. Hauck, A.DeHon, ”Reconfigurable computing: the theory and practice of FPGA-based computation”, Elsevier, 2008.
4.	Franklin P. Prosser, David E. Winkel, Art of Digital Design, Prentice-Hall,1987.
5.	R.F.Tinde,” Engineering Digital Design”, (2/e), Academic Press,2000.
6.	C. Bobda, “Introduction to reconfigurable computing”, Springer, 2007.
7.	M. Gokhale, ”Paul S. Graham, Reconfigurable computing: accelerating computation with field- programmable gate arrays”, Springer,2005.
8.	C.Roth, “Fundamentals of Digital Logic Design”, Jaico Publishers, V ed.,2009.
9.	Recent literature in Digital System Design.

Course Outcomes (CO)

At the end of the course student will be able

CO1	Identify mapping algorithms into architectures.
CO2	Summarize various delays in combinational circuit and its optimization methods.
CO3	Summarize circuit design of latches and flip-flops.
CO4	Construct combinational and sequential circuits of medium complexity that is based on VLSIs, and programmable logic devices.
CO5	Summarize the advanced topics such as reconfigurable computing, partially reconfigurable, Pipeline reconfigurable architectures and block configurable.

Course Code	:	**ECHO24**
Course Title	:	**OPTIMIZATIONS OF DIGITAL SIGNAL PROCESSING STRUCTURES FOR VLSI**
Type of Course	:	**HO**
Prerequisites	:	**ECPC23 - VLSI SYSTEMS** **ECPE18 - DIGITAL SIGNAL PROCESSORS AND APPLICATIONS** **ECPC15 - DIGITAL SIGNAL PROCESSING**
Contact Hours	:	**(3-1-0) 4**
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To enable students to develop a practical understanding of VLSI implementing DSP algorithms with optimized hardware.
CLO2	To enable students to design filters with high speed and low power using pipelining methodologies
CLO3	To understand Systolic Architecture designs and efficient date driven architectures for DSP applications
CLO4	To encourage students to know the limitations of synchronous designs and exploration of Asynchronous design techniques

Course Content

An overview of DSP concepts, Pipelining of FIR filters. Parallel processing of FIR filters. Pipelining and parallel processing for low power, Combining Pipelining and Parallel Processing.

Transformation Techniques: Iteration bound, Retiming, Folding and Unfolding

Pipeline interleaving in digital filters. Pipelining and Parallel processing for IIR filters. Low power IIR filter design using pipelining and parallel processing, Pipelined adaptive digital filters.

Systolic Architecture Design: Systolic Array Design Methodology, FIR Systolic Arrays, Selection of Scheduling Vector. Redundant arithmetic: Redundant Number Representations, Carry-Free Radix-2 addition and subtraction, Hybrid radix-4 addition, Radix-2 hybrid redundant multiplication architectures.

Synchronous pipelining and clocking styles, clock skew and clock distribution in bit level pipelined VLSI designs. Wave pipelining, constraint space diagram and degree of wave pipelining, Implementation of wave-pipelined systems, Asynchronous pipelining.

References

1.	K.K.Parhi, VLSI Digital Signal Processing Systems, John-Wiley, reprint 2011
2.	FPGA-based Implementation of Signal Processing Systems, 2nd Edition by Roger Woods et al., 2017
3.	Digital Signal Processing with Field Programmable Gate Arrays by Uwe Meyer-Baese, reprint 2007
4.	Magdy A. Bayoumi, VLSI Design Methodologies for Digital Signal Processing, 2012
5.	VLSI Design Methodologies for Digital Signal Processing Architectures by Parhi and Nishitan, First Edition, 2005
6.	VLSI Signal Processing Technology edited by Magdy A. Bayoumi and Earl E. Swartzlander, First Edition, 2012

Course Outcomes (CO)

At the end of the course student will be able

CO1	Understand the overview of DSP concepts and design architectures for DSP algorithms.
CO2	Improve the overall performance of DSP system through various transformation and optimization techniques.
CO3	Perform pipelining and parallel processing on FIR and IIR systems to achieve high speed and low power.
CO4	Representation of a network of processing elements (PEs) that rhythmically compute and pass data through the system, and able to design basic arithmetic units and realize their architecture with higher radices
CO5	Understand clock-based issues, different clock styles and design asynchronous and wave pipelined systems.

Course Code	:	**ECHO26**
Course Title	:	**VLSI DIGITAL SIGNAL PROCESSING SYSTEMS**
Type of Course	:	**HO**
Prerequisites	:	**ECPC23 - VLSI SYSTEMS** **ECPE18 - DIGITAL SIGNAL PROCESSORS AND APPLICATIONS** **ECPC15 - DIGITAL SIGNAL PROCESSING**
Contact Hours	:	**3**
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To enable students to design VLSI systems with high speed and low power.
CLO2	To encourage students to develop a working knowledge of the central ideas of implementation of DSP algorithm with optimized hardware.

Course Content

An overview of DSP concepts, Representations of DSP algorithms. Systolic Architecture Design: FIR Systolic Array, Matrix-Matrix Multiplication, 2D Systolic Array Design. Digital Lattice Filter Structures: Schur Algorithm, Derivation of One-Multiplier Lattice Filter, Normalized Lattice Filter, Pipelining of Lattice Filter.

Scaling and Round off Noise - State variable description of digital filters, Scaling and Round off Noise computation, Round off Noise in Pipelined IIR Filters, Round off Noise Computation using state variable description, Slow-down, Retiming and Pipelining.

Bit level arithmetic Architectures- parallel multipliers, interleaved floor-plan and bit-plane-based digital filters, Bit serial multipliers, Bit serial filter design and implementation, Canonic signed digit arithmetic, Distributed arithmetic.

Redundant arithmetic -Redundant number representations, carry free radix-2 addition and subtraction, Hybrid radix-4 addition, Radix-2 hybrid redundant multiplication architectures, data format conversion, Redundant to Non redundant converter.

Numerical Strength Reduction – Sub expression Elimination, Multiple Constant Multiplication, Sub expression sharing in Digital Filters, Additive and Multiplicative Number Splitting.

References

1.	K.K.Parhi, "VLSI Digital Signal Processing Systems", John-Wiley, 2007
2.	U. Meyer -Baese, Digital Signal Processing with FPGAs, Springer, 2004
3.	Recent literature in VLSI Digital Signal Processing Systems.

Course Outcomes (CO)

At the end of the course student will be able

CO1	Acquire the knowledge of round off noise computation and numerical strength reduction.
CO2	Ability to design Bit level and redundant arithmetic Architectures.

Course Code	:	**ECHO27**
Course Title	:	**ASYNCHRONOUS SYSTEM DESIGN**
Type of Course	:	**HO**
Prerequisites	:	**ECPC14**
Contact Hours	:	**3**
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	This subject introduces the fundamentals and performance of Asynchronous system
CLO2	To familiarize the dependency graphical analysis of signal transmission graphs
CLO3	To learn software languages and its syntax and operations for implementing Asynchronous Designs

Course Content

Fundamentals: Handshake protocols, Muller C-element, Muller pipeline, Circuit implementation styles, theory. Static data-flow structures: Pipelines and rings, Building blocks, examples

Performance: A quantitative view of performance, quantifying performance, Dependency graphic analysis. Handshake circuit implementation: Fork, join, and merge, Functional blocks, mutual exclusion, arbitration and Metastability.

Speed-independent control circuits: Signal Transition graphs, Basic Synthesis Procedure, Implementation using state-holding gates, Summary of the synthesis Process, Design examples using Petrify. Advanced 4- phase bundled data protocols and circuits: Channels and protocols, Static type checking, more advanced latch control circuits.

High-level languages and tools: Concurrency and message passing in CSP, Tangram program examples, Tangram syntax-directed compilation, Martin's translation process, Using VHDL for Asynchronous Design. An Introduction to Balsa: Basic concepts, Tool set and design flow, Ancillary Balsa Tools

The Balsa language: Data types, Control flow and commands, Binary/Unary operators, Program structure. Building library Components: Parameterized descriptions, Recursive definitions. A simple DMA controller: Global Registers, Channel Registers, DMA control structure, The Balsa description.

References

1.	Asynchronous Circuit Design- Chris. J. Myers, John Wiley &Sons, 2001.
2.	Handshake Circuits An Asynchronous architecture for VLSI programming –
3.	Principles of Asynchronous Circuit Design-Jens Sparso, Steve Furber, Kluver Academic Publishers, 2001.
4.	Asynchronous Sequential Machine Design and Analysis, Richard F. Tinder,2009
5.	A Designer's Guide to Asynchronous VLSI, Peter A. Beerel, Recep O. Ozdag, Marcos Ferretti,2010
6.	Recent literature in Asynchronous System Design

Course Outcomes (CO)

At the end of the course student will be able

CO1	Understand the fundamentals of Asynchronous protocols
CO2	Analyze the performance of Asynchronous System and implement handshake circuits
CO3	Understand the various control circuits and Asynchronous system modules
CO4	Gain the experience in using high level languages and tools for Asynchronous Design
CO5	Learn commands and control flow of Balsa language for implementing Asynchronous Designs

Course Code	:	**ECHO28**
Course Title	:	**PHYSICAL DESIGN AUTOMATION**
Type of Course	:	**HO**
Prerequisites	:	**NONE**
Contact Hours	:	**3**
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	Understand the concepts of Physical Design Process such as partitioning, Floor planning, Placement and Routing.
CLO2	Discuss the concepts of design optimization algorithms and their application to physical design automation.
CLO3	Understand the concepts of simulation and synthesis in VLSI Design Automation
CLO4	Formulate CAD design problems using algorithmic methods

Course Content

VLSI design automation tools**-** algorithms and system design. Structural and logic design. Transistor level design. Layout design. Verification methods. Design management tools.

Layout compaction, placement and routing. Design rules, symbolic layout. Applications of compaction. Formulation methods. Algorithms for constrained graph compaction. Circuit representation. Wire length estimation. Placement algorithms. Partitioning algorithms.

Floor planning and routing- floor planning concepts. Shape functions and floor planning sizing. Local routing. Area routing. Channel routing, global routing and its algorithms.

Simulation and logic synthesis- gate level and switch level modeling and simulation. Introduction to combinational logic synthesis. ROBDD principles, implementation, construction and manipulation. Two level logic synthesis.

High-level synthesis- hardware model for high level synthesis. Internal representation of input algorithms. Allocation, assignment and scheduling. Scheduling algorithms. Aspects of assignment. High level transformations.

References

1.	S.H. Gerez, “Algorithms for VLSI Design Automation”, JohnWiley, 1998.
2.	N.A.Sherwani, “Algorithms for VLSI Physical Design Automation”, (3/e),Kluwer, 1999.
3.	S.M. Sait, H. Youssef, “VLSI Physical Design Automation”, World scientific,1999.
4.	M.Sarrafzadeh, “Introduction to VLSI Physical Design”, McGraw Hill (IE),1996.
5.	Recent literature in Physical Design Automation.

Course Outcomes (CO)

At the end of the course student will be able

CO1	Know how to place the blocks and how to partition the blocks while for designing the layout for IC.
CO2	Solve the performance issues in circuit layout.
CO3	Analyze physical design problems and Employ appropriate automation algorithms for partitioning, floor planning, placement and routing
CO4	Decompose large mapping problem into pieces, including logic optimization with partitioning, placement and routing
CO5	Analyze circuits using both analytical and CAD tools

Course Code	**:**	**ECHO29**
Course Title	**:**	**MIXED - SIGNAL CIRCUIT DESIGN**
Type of Course	**:**	**HO**
Prerequisites	**:**	**NONE**
Contact Hours	**:**	**3**
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To make the students to understand the design and performance measures concept of mixed signal circuit.

Course Content

Concepts of Mixed-Signal Design and Performance Measures. Fundamentals of Data Converters. Nyquist Rate Converters and Over sampling Converters.

Design methodology for mixed signal IC design using gm/Id concept.

Design of Current mirrors. References. Comparators and Operational Amplifiers.

CMOS Digital Circuits Design: Design of MOSFET Switches and Switched-Capacitor Circuits, Layout Considerations.

Design of frequency and Q tunable continuous time filters.

References

1.	R. Jacob Baker, Harry W. Li, David E. Boyce, CMOS, Circuit Design, Layout, and Simulation, Wiley-IEEE Press,1998
2.	David A. Johns and Ken Martin, Analog Integrated Circuit Design, John Wiley and Sons,1997.

Course Outcomes (CO)

At the end of the course student will be able

CO1	Appreciate the fundamentals of data converters and also optimized their performances.
CO2	Understand the design methodology for mixed signal IC design using gm/Id concept.
CO3	Analyze the design of current mirrors and operational amplifiers
CO4	Design the CMOS digital circuits and implement its layout.
CO5	Design the frequency and Q tunable time domain filters.

Course Code	**:**	**ECHO30**
Course Title	**:**	**DIGITAL SIGNAL PROCESSING FOR MEDICAL IMAGING**
Type of Course	**:**	**HO**
Prerequisites	**:**	**ECPC15**
Contact Hours	**:**	**4**
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Content

Sources of Medical Images: Physics of X-ray, CT, PET, MRI, and ultrasound, advantages and disadvantages of each imaging modality.

Image Enhancement: Contrast adjustment, denoising (convolution, FFT), deblurring (solving an ill-conditioned sparse linear system), edge detection (numerical approximation to a partial derivative), anisotropic diffusion (numerical solution of partial differential equations), super-resolution.

Registration: Intensity-based methods, including a variety of cost functions (correlation, least squares, mutual information, robust estimators), and optimization techniques (fixed-point iteration, gradient descent, etc.). Implement registration for rigid and non-rigid transformations. MRI motion compensation.

Segmentation & tissue classification: Thresholding, region growing and watershed. More depth on the method of snakes (adaptive mesh), level set method (numerical solution of partial differential equations), and clustering (classifiers).

Reconstruction Methods: Reconstruction techniques for CT (filtered back projection) and MRI (using the FFT). Theory of the Radon transform, the Fourier transform, and how they relate to each other.

References

1.	Jerry L. Prince, Jonathan M. Links, Medical imaging signals and systems, Pearson education, second edition, 2014
2.	Mark. A. Haidekkar, Medical Imaging technology, Springer briefs in physics,2013.
3.	Paul suetens, Fundamentals of medical imaging, second edition, Cambridge university press, 2009.
4.	Recent literature in Digital Signal Processing for Medical Imaging.
5.	Geoff Dougherty, Digital image processing for medical applications, Cambridge press

Course Outcomes (CO)

At the end of the course student will be able

CO1	Describe about different medical imaging modalities and its advantages and disadvantages
CO2	Describe the signal processing techniques involved in medical image enhancement techniques
CO3	Describe the signal processing techniques involved in image registration
CO4	Describe the signal processing techniques involved in segmentation and classification
CO5	Describe the signal processing techniques involved in image reconstruction.

Course Code	:	**ECHO31**
Course Title	:	**Advanced Techniques for Wireless Reception**
Type of Course	:	**HO**
Prerequisites	:	
Contact Hours	:	**3**
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To get an understanding of signal processing techniques for emerging wireless systems.

Course Content

Wireless signaling environment. Basic signal processing for wireless reception. Linear receivers for synchronous CDMA. Blind and group-blind multiuser detection methods. Performance issues.

Robust multiuser detection for non-Gaussian channels; asymptotic performance , implementation aspects.

Adaptive array processing in TDMA systems. Optimum space-time multiuser detection. Turbo multiuser detection for synchronous and turbo coded CDMA.

Narrowband interface suppression. Linear and nonlinear predictive techniques. Code- aided techniques. Performance comparison.

Signal Processing for wireless reception: Bayesian and sequential Montecarlo signal processing. Blind adaptive equalization of MIMO channels .Signal processing for fading channels. Coherent detection based on the EM algorithm. Decision-feedback differential detection. Signal processing for coded OFDM systems.

References

1.	X.Wang & H.V.Poor, “Wireless Communication Systems”, Pearson, 2004.
2.	R.Janaswamy, “Radio Wave Propagation and Smart Antennas for Wireless Communication”, Kluwer, 2001.
3.	M.Ibnkahla, “Signal Processing for Mobile Communications”, CRC Press, 2005.
4.	A.V.H. Sheikh, “Wireless Communications Theory & Techniques”, Kluwer Academic Publications, 2004.
5.	A. Paulraj Arogyaswami, R. Nabar, and D.Gore, ”Introduction to Space-time Wireless Communications”, Cambridge University Press, 2003.
6.	Recent literature in Advanced Techniques for Wireless Reception.

Course Outcomes (CO)

At the end of the course student will be able

CO1	Discuss the Wireless signaling environment and Performance issues.
CO2	Analyze the channel modeling and multiuser detection.
CO3	Analyze the Adaptive array processing and turbo coded CDMA.
CO4	Analyze Linear and nonlinear predictive techniques.
CO5	Analyze the Signal Processing Techniques for wireless reception.

Course Code	:	**ECHO32**
Course Title	:	**Error Control Coding**
Type of Course	:	**HO**
Prerequisites	:	
Contact Hours	:	**3**
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To explain the importance of modern coding techniques in the design of digital communication systems.

Course Content

Review of modern algebra. Galois fields. Linear block codes; encoding and decoding. Cyclic codes. Non-binary codes.

Convolutional codes. Generator sequences. Structural properties. ML decoding. Viterbi decoding. Sequential decoding.

Modulation codes. Trellis coded modulation. Lattice type Trellis codes. Geometrically uniform trellis codes. Decoding of modulation codes.

Turbo codes. Turbo decoder. Interleaver. Turbo decoder. MAP and log MAP decoders. Iterative turbo decoding. Optimum decoding of turbo codes.

Space-time codes. MIMO systems. Space-time codes. MIMO systems. Space-time block codes (STBC) – decoding of STBC.

References

1.	S.Lin & D.J.Costello, “Error Control Coding (2/e)”, Pearson, 2005.
2.	B.Vucetic & J.Yuan, “Turbo codes”, Kluwer, 2000
3.	C.B.Schlegel & L.C.Perez, “Trellis and Turbo Coding”, Wiley,2004.
4.	B.Vucetic & J.yuan, “Space-Time Coding”, Wiley, 2003.
5.	R.Johannaesson & K.S.Zigangirov, “Fundamentals of Convolutional Coding”, Universities Press, 2001.
6.	Recent literature in Error Control Coding.

Course Outcomes (CO)

At the end of the course student will be able

CO1	Understand the need for error correcting codes in data communication and storage systems.
CO2	Identify the major classes of error detecting and error correcting codes and how they are used in practice. Construct codes capable of correcting a specified number of errors.
CO3	Use the mathematical tools for designing error correcting codes, including finite fields.
CO4	Explain the operating principles of block codes, cyclic codes, convolution codes, modulation codes, Turbo codes etc.
CO5	Design an error correcting code for a given application.

Course Code	**:**	**ECHO33**
Course Title	**:**	**Digital Communication Receivers**
Type of Course	**:**	**HO**
Prerequisites	**:**	
Contact Hours	**:**	**3**
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To expose the students to the latest trends in the design of digital communication receivers with particular emphasis on synchronization, channel estimation and signal processing aspects.

Course Content

Baseband PAM. Clock recovery circuits. Error tracking and spectral – line generating synchronizers. Squaring and Mueller and Muller synchronizers.

Channel models. Receivers for PAM. Optimum ML receivers. Synchronized detection. Digital matched filter.

ML synchronization algorithms – DD and NDA. Timing parameter and carrier phase estimation – DD and NDA.

Performance analysis of carrier and symbol synchronizers. Feedback and feed forward synchronizers. Cycle slipping Acquisition of carrier phase and symbol timing.

Fading channels. Statistical characterization. Flat and frequency selective fading channels. Optimal receivers for data detection and synchronization parameter estimation. Realizable receiver structures for synchronized detection.

References

1.	H.Meyer , M. Moeneclaey, and S. A. Fechtel, "Digital Communication Receivers", Wiley, 1998.
2.	U.Mengali & A.N.D.Andrea, "Synchronization Techniques for Digital Receivers", Kluwer , 1997.
3.	N.Benuveruto & G.Cherubini, "Algorithms for Communication Systems and their Applications", Wiley, 2002.
4.	H.Meyer & G.Ascheid, "Synchronization in Digital Communications", John Wiley, 1990.
5.	Recent literature in Digital Communication Receivers.

Course Outcomes (CO)

At the end of the course student will be able

CO1	Summarize baseband PAM and Synchronizers.
CO2	Model and distinguish the channels.
CO3	Interpret optimum receivers and matched filter receivers.
CO4	Summarize phase and carrier estimation methods.
CO5	Compare carrier and symbol synchronizers.

Course Code	**:**	**ECHO34**
Course Title	**:**	**ADVANCED DIGITAL SIGNAL PROCESSING**
Type of Course	**:**	**HO**
Prerequisites	**:**	**ECPC15**
Contact Hours	**:**	**4**
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To provide rigorous foundations in discrete-time stochastic process, optimum filter, adaptive filter, power spectrum estimation and frequency estimation.

Course Content

Discrete-Time Random Process: Random Process: Ensemble average, Gaussian processes, Stationary process, autocovariance and autocorrelation matrices, ergodicity, white noise, power spectrum. Filtering random processes. Spectral factorization. ARMA, AR and MA processes. Harmonic processes. Linear mean square estimation. Parameter estimation Bias and consistency.

Optimum Linear filter and linear prediction: FIR Wiener filter. Orthogonality principle in linear mean square estimation. IIR Wiener filter: Non-causal Wiener filter and causal Wiener filter. Linear prediction. Forward and backward linear prediction. Levinson-Durbin algorithm.

Adaptive Filters: Adaptive filters. FIR adaptive filter. The steepest decent adaptive filter. LMS algorithm. Convergence of adaptive algorithms. Normalized LMS algorithm. Adaptive noise cancellation. Exponentially weighted RLS algorithm

Power Spectrum Estimation: Spectrum estimation. Estimation of autocorrelation. Periodogram method. Performance of the periodogram. Nonparametric methods: Bartlett's method, Welch method and Blackman-Tukey method. Performance comparisons. Minimum variance spectrum estimation. Parametric methods: AR spectrum estimation. Model parameter-Yule Walker equations.

Frequency Estimation: Eigen analysis of autocorrelation matrix. Pisarenko Harmonic Decomposition. MUSIC method. ESPRIT method. Minimum variance frequency estimation. Propagator method.

References

1.	M.H.Hayes," Statistical Digital Signal Processing and Modeling", John-Wiley, 2001.
2.	S.Haykin, "Adaptive Filter Theory (4/e)", Prentice- Hall, 2002.
3.	D.G.Manolakis, V. K. Ingle, and S. M. Kogon ,"Statistical and Adaptive Signal Processing", McGraw-Hill, 2005
4.	S.L. Marple,"Digital Spectral Analysis", 1987.
5.	Recent literature in Advanced Digital Signal Processing.

Course Outcomes (CO)

At the end of the course student will be able

CO1	To understand and analyze discrete-time random processes and employ the concept of stochastic processes to analyses linear systems
CO2	To select linear filtering and prediction techniques to engineering problems.
CO3	To describe the most important adaptive filter generic problems and various adaptive filter algorithms.
CO4	To derive and analyses the statistical properties of the conventional spectral estimators, nonparametric and parametric estimation method.
CO5	To select an appropriate array processing algorithm for frequency estimation