Vision and Mission of the Department

Vision:

To empower the Electronics and Communication Engineering students with technological excellence, professional commitment and social responsibility.

Mission:

- ME1. Attaining academic excellence in Electronics and Communication Engineering through dedication to duty, innovation in learning and research, state of the art laboratories and industry driven skill development.
- ME2. Establishing suitable environment for the students to develop professionalism and face life challenges with ethical integrity.
- ME3. Nurturing the students to understand the societal needs and equip them with technical expertise to provide appropriate solutions.
- ME4. Providing breeding ground to obtain entrepreneurial skills and leadership qualities for self and social growth.

Program Educational Objectives (PEOs):

- PEO1. Graduates will be capable of developing specification and design procedures, prototyping and test methodologies for modern electronics and communication systems and gadgets that perform analog and digital processing functions.
- PEO2. Graduates will be able to work and adapt to changes in allied areas of Electronics and Communication Engineering through personal success and life long learning.
- PEO3. Graduates will be able to identify technological requirements for the society and provide cost effective solutions.
    - These objectives will be evidenced by professional visibility (publications, presentations, inventions, patents and awards), entrepreneurial activities, international activities (participation in international conferences, collaborative research and employment abroad)

Program Outcomes:
Engineering Graduates will be able to:

1. **Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
2. **Problem analysis**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
3. **Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
4. **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
5. **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
6. **The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
7. **Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
8. **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
9. **Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10. **Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
11. **Project management and finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one’s own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
12. **Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Program Specific Outcomes:
Engineering Graduates will be able to

PSO1. Design circuits and systems for complex engineering problems in Electronics and Communication and allied areas.

PSO2. Apply research methodologies to provide solutions for contemporary problems in the areas including RF, Signal Processing, Image Processing, VLSI, Optical Communication, Networks and Embedded Systems for given specifications.

PSO3. Actively contribute as a member or leader in diverse teams, and communicate effectively on complex engineering activities and involve in life-long learning, by applying reasoning and ethical principles.

PEO- Mission Mapping:

	ME1	ME2	ME3	ME4
PEO1	S	M	M	L
PEO2	L	S	M	M
PEO3	M	L	S	M

PEO-PO-PSO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
PEO1															
PEO2															
PEO3															

PO-GA Mapping:

	GA1	GA2	GA3	GA4	GA5	GA6	GA7	GA8	GA9	GA10	GA11	GA12
PO1												
PO2												
PO3												
PO4												
PO5												
PO6												
PO7												
PO8												
PO9												
PO10												
PO11												
PO12												

TCE PROFICIENCY SCALE (CDIO Curriculum Framework)

TCE Proficiency Scale (TPS)	Proficiency	Cognitive	Affective	Psychomotor
TPS1	To have been exposed to	Remember	Receive	Perception, Set
TPS2	To be able to interpret and imitate	Understand	Respond	Guided Response
TPS3	To be skilled in the practice or implement	Apply	Value	Mechanism
TPS4	To be able to participate in and contribute	Analyse	Organise	Complex Overt Responses
TPS5	To be able to judge and adapt	Evaluate	Organise	Adaptation
TPS6	To be able to lead and innovate	Create	Characterize	Origination

Credit Distribution

S.No	Category	Credits	
		Regular	**Lateral**
A	**Foundation Courses**	**53 – 58**	**23-28**
	Humanities and Social Science (HSS)	**9 -11**	**6-8**
	Basic Science (BS)	**21**	**6**
	Engineering Science (ES)	**23 – 26**	**11-14**
B	Professional Core Courses	**55**	**45**
C	**Elective Courses**	**24 – 48**	**24-48**
	Programme Specific Elective	**12-24**	**12-24**
	Programme Elective for Expanded Scope	**6 – 12**	**6-12**
	General Elective	**3-6**	**3-6**
	Foundation Elective	**3-6**	**3-6**
D	Project work, seminar, internship in industry or at Higher Learning institutions	**15**	**15**
E	Mandatory Courses – Environment Science, Induction Programme, Indian Constitution, Essence of Indian Tradition knowledge, consumer Affairs (as per UGC guideline)	**Non-Credit (Not included for CGPA)**	**Non-Credit (Not included for CGPA)**
	Minimum Credits to be earned for the award of the Degree	**160 (from A to D) and the successful completion of Mandatory Courses**	**120 (from A to D) and the successful completion of Mandatory Courses**

- General electives are courses offered by different departments that do not have any prerequisites and could be of interest to students of any branch
- All students have to undertake co-curricular and extra-curricular activities that include activities related to NCC, NSS, Sports, Professional Societies, participation in identified activities which promote the growth of Departments and the College.

THIAGARAJAR COLLEGE OF ENGINEERING, MADURAI- 625 015
(A Govt. Aided Autonomous Institution affiliated to Anna University)

CATEGORIZATION OF COURSES
(CHOICE BASED CREDIT SYSTEM)

Degree: B.E. Programme: ECE Batch: 2018-19 onwards

A. FOUNDATION COURSES: Total Credits to be earned: 53-58

a. Humanities and Social Science (09-11)

S.No.	Course Code	Name of the Course	Number of Hours / Week			Credit
			L	T	P	
THEORY						
1.	18EG140	English	2	-	-	2
2.	18EC610	Accounting and Finance	3	-	-	3
3.	18EC490	Project Management	3	-	-	3
THEORY CUM PRACTICAL						
1.	18EG460	Professional Communication	-	1	2	2
PRACTICAL						
1.	18EG170	English Laboratory	-	-	2	1

b. Basic Science (21)

S.No.	Course Code	Name of the Course	Number of Hours / Week			Credit
			L	T	P	
THEORY						
1.	18MA110	Engineering Calculus	3	1	-	4
2.	18PHB20	Physics	3	-	-	3
3.	18CHB30	Chemistry	3	-	-	3
4.	18MA210	Matrices and Ordinary Differential Equations	2	1	-	3
5.	18EC310	Complex Analysis and Linear Algebra	2	1		3
6.	18EC410	Optimization and Numerical Methods	2	1		3
PRACTICAL						
1.	18PH180	Physics Laboratory	-	-	2	1
2.	18CH190	Chemistry Laboratory	-	-	2	1

c. Engineering Science (23-26)

S.No.	Course Code	Name of the Course	Number of Hours / Week			Credit
			L	T	P	
THEORY						
1.	18ES150	Engineering Exploration	3	-	-	3
2.	18EC240	Semiconductor Physics	3	-	-	3
3.	18EC630	Data Structures and Algorithms	2	-	-	2
4.	18XXPE0	Engineering Sciences Elective	3	-	-	3
THEORY CUM PRACTICAL						
1.	18ME160	Engineering Graphics	3	-	2	4
2.	18EC360	Programming for Problem Solving	2	-	2	3
3.	18ES390	Design Thinking	1	-	2	2
4.	18ES590	System Thinking	1	-	1	2
PRACTICAL						
1.	18EC280	Electronics Workshop	-	-	2	1
2.	18ES290	Lateral Thinking	-	-	2	1
3.	18EC670	Data Structures and Algorithms Laboratory	-	-	2	1

Engineering Sciences Elective

S.No.	Course Code	Name of the Course	Number of Hours / Week			Credit
			L	T	P	
THEORY						
1.	18ECEA0	MEMS Technology	3	-	-	3
2.	18ECEB0	Machine Learning for All	3	-	-	3
3.	18ECEC0	IOT Sensors and Device	3	-	-	3
4.	18ECED0	Blockchain Technology	3	-	-	3
5.	18ECEE0	5G Wireless Networks	3	-	-	3
THEORY CUM PRACTICAL						
	-	-	-	-	-	-

B. PROFESSIONAL CORE COURSES Credits to be earned: 55

Sl. No.	Course Code	Name of the Course	Number of Hours / Week			Credit
			L	T	P	
THEORY						
1.	18EC220	Network Theory	2	1	-	3
2.	18EC230	Electronic Devices	3	-	-	3
3.	18EC320	RF Passive Devices and Circuits	2	1	-	3
4.	18EC330	Electronic Circuits	3	-	-	3
5.	18EC340	Signals and Systems	2	1	-	3
6.	18EC350	Microprocessors and Microcontrollers	2	1	-	3
7.	18EC420	RF Active Circuits	2	1	-	3
8.	18EC430	CMOS VLSI Systems	3	-	-	3
9.	18EC440	Signal Processing	2	1	-	3
10.	18EC510	Data Communication Networks	2	1	-	3
11.	18EC530	Analog and Digital Communication Systems	2	1	-	3
12.	18EC620	Control Systems	2	1	-	3
13.	18EC710	Consumer Electronics	1	-	-	1
THEORY CUM PRACTICAL						
14.	18EC260	Digital System Design	2	-	2	3
15.	18EC520	Antenna and Wave Propagation	2	-	2	3
16.	18EC560	Digital Image Processing	2	-	2	3
17.	18EC660	Digital Communication Transceiver	1	-	2	2
PRACTICAL						
18.	18EC270	Circuits and Devices Laboratory	-	-	2	1
19.	18EC370	Microprocessor and Microcontroller Laboratory	-	-	2	1
20.	18EC380	Electronic Circuits Laboratory	-	-	2	1
21.	18EC470	RF Circuits Laboratory	-	-	2	1
22.	18EC480	Signal Processing Laboratory	-	-	2	1
23.	18EC570	Data Communication Networking Laboratory	-	-	2	1
24.	18EC580	Analog and Digital Communications Laboratory	-	-	2	1

C. ELECTIVE COURSES: Credits to be earned: 24-48

a. Programme Specific Elective Credits to be earned:12-24

Sl. No.	Course Code	Name of the Course	Number of Hours / Week			Credit
			L	T	P	
THEORY						
1.	18ECPA0	Computer Vision and Applications	3	-	-	3
2.	18ECPB0	Data Compression	3	-	-	3
3.	18ECPD0	Wireless Communication Systems	2	1	-	3
4.	18ECPF0	FPGA Based Digital System Design	3	-	-	3
5.	18ECPH0	Electronic Measurement and Instruments	3	-	-	3
6.	18ECPJ0	Network Security	3	-	-	3
7.	18ECPK0	Optical Communication	3	-	-	3
8.	18ECPM0	Planar Antennas for Wireless Applications	2	-	2	3
9.	18ECPN0	Electromagnetic Interference and Compatibility	3	-	-	3
10.	18ECPQ0	Statistical Signal Processing	2	1	-	3
11.	18ECPT0	Deep Learning For Speech Processing	2	1	-	3
12.	18ECPU0	VLSI Device Modeling	3	-	-	3
13.	18ECPY0	ASIC Design	3	-	-	3
14.	18ECPZ0	IoT System and Applications	3	-	-	3
15.	18ECRA0	Real Time Embedded Systems	3	-	-	3
THEORY CUM PRACTICAL						
16.	18ECPC0	DSP Architecture and Programming	2	-	2	3
17.	18ECPE0	Biomedical Signal Processing	2	-	2	3
18.	18ECPG0	Analog System Design	2	-	2	3

b. Programme Elective for Expanded Scope Credits to be earned: 06-12

Sl. No.	Course Code	Name of the Course	Number of Hours / Week			Credit
			L	T	P	
THEORY						
1.	18ECPL0	Medical Imaging and Processing	3	-	-	3
2.	18ECPP0	RF MEMS Design and Technology	3	-	-	3
3.	18ECPR0	LDPC and Polar Codes	2	1	-	3
4.	18ECPS0	Physical Channel Processing in 5G NR	2	1	-	3
5.	18ECPV0	Low Power CMOS VLSI System	3	-	-	3
6.	18ECPW0	CAD for VLSI	3	-	-	3
7.	18ECRB0	Adhoc and Sensor Networks	3	-	-	3
8.	18ECRC0	Multimedia Compression Techniques	3	1	-	4
9.	18ECRD0	Signal Processing in 5G NR	3	1	-	4
10.	18ECRE0	Algorithms for VLSI Design Automation	3	1	-	4
11.	18ECRF0	Low Power VLSI Design	3	1	-	4
12.	18EC1A0	Field Tests for a 5G Future	1	-	-	1
13.	18EC1B0	Deep Learning with Tensorflow	1	-	-	1
14.	18EC1C0	Synchronization for 5G NR	1	-	-	1

15.	18EC1D0	Speech Signal Processing	1	-	-	1
16.	18EC1E0	VLSI Implementation of Communication Transceivers	1	-	-	1
17.	18EC1F0	Embedded System Design	1	-	-	1
THEORY CUM PRACTICAL						
	-	-	-	-	-	-

c. General Elective Credits to be earned: 03-06

Sl. No.	Course Code	Name of the Course	Number of Hours / Week			Credit
			L	T	P	
THEORY						
1.	18ECGA0	Consumer Electronics	3	-	-	3
2.	18ECGB0	Multimedia Systems	3	-	-	3
3.	18ECGD0	Telecom Systems	3	-	-	3
4.	18ECGE0	Applied Image Processing	3	-	-	3

d. Electives from foundation courses- HSS, BS, ES Credits to be earned: 03-06

D. Project Credits to be earned: 15

S.No.	Course Code	Name of the Course	Number of Hours / Week			Credit
			L	T	P	
1.	18ES690	Engineering Design Project	2	-	4	3
2.	18ES790	Capstone Design Project	-	-	6	3
3.	18EC810	Project	-	-	18	9

E. Mandatory Courses (Not included for CGPA)

S.No.	Course Code	Name of the Course	Number of Hours / Week			Credit
			L	T	P	
THEORY						
1.	18CHAA0	Environmental Sciences	-	-	2	0
2.	18CHAB0	Constitution of India	-	-	2	0
3.	18CHAC0	Essence of Indian Knowledge	-	-	2	0
THEORY CUM PRACTICAL						
-	-	-	-	-	-	-
PRACTICAL						
-	-	-	-	-	-	-

Minimum credits to be earned for the award of the degree = 160

THIAGARAJAR COLLEGE OF ENGINEERING, MADURAI- 625 015
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CATEGORIZATION OF COURSES
(CHOICE BASED CREDIT SYSTEM)

Degree: B.E. **Programme: ECE** **Batch: 2021-22 onwards**

F. FOUNDATION COURSES: **Total Credits to be earned: 53-58**

d. Humanities and Social Science (09-11)

S.No.	Course Code	Name of the Course	Number of Hours / Week			Credit
			L	T	P	
THEORY						
1.	18EG140	English	2	-	-	2
2.	18EC610	Accounting and Finance	3	-	-	3
3.	18EC490	Project Management	3	-	-	3
THEORY CUM PRACTICAL						
1.	18EG460	Professional Communication	-	1	2	2
PRACTICAL						
1.	18EG170	English Laboratory	-	-	2	1

e. Basic Science (21)

S.No.	Course Code	Name of the Course	Number of Hours / Week			Credit
			L	T	P	
THEORY						
1.	18MA110	Engineering Calculus	3	1	-	4
2.	18PHB20	Physics	3	-	-	3
3.	18CHB30	Chemistry	3	-	-	3
4.	18MA210	Matrices and Ordinary Differential Equations	2	1	-	3
5.	18EC310	Complex Analysis and Linear Algebra	2	1		3
6.	18EC410	Optimization and Numerical Methods	2	1		3
PRACTICAL						
1.	18PH180	Physics Laboratory	-	-	2	1
2.	18CH190	Chemistry Laboratory	-	-	2	1

f. Engineering Science (23-26)

S.No.	Course Code	Name of the Course	Number of Hours / Week			Credit
			L	T	P	
THEORY						
1.	18ES150	Engineering Exploration	3	-	-	3
2.	*21EC240*	*Electronic Materials*	3	-	-	3
3.	18EC630	Data Structures and Algorithms	2	-	-	2
4.	18XXPE0	Engineering Sciences Elective	3	-	-	3
THEORY CUM PRACTICAL						
1.	18ME160	Engineering Graphics	3	-	2	4
2.	18EC360	Programming for Problem Solving	2	-	2	3
3.	18ES390	Design Thinking	1	-	2	2
4.	18ES590	System Thinking	1	-	1	2
PRACTICAL						
1.	18EC280	Electronics Workshop	-	-	2	1
2.	18ES290	Lateral Thinking	-	-	2	1
3.	18EC670	Data Structures and Algorithms Laboratory	-	-	2	1

Engineering Sciences Elective

S.No.	Course Code	Name of the Course	Number of Hours / Week			Credit
			L	T	P	
THEORY						
1.	18ECEA0	MEMS Technology	3	-	-	3
2.	18ECEB0	Machine Learning for All	3	-	-	3
3.	18ECEC0	IOT Sensors and Device	3	-	-	3
4.	18ECED0	Blockchain Technology	3	-	-	3
5.	18ECEE0	5G Wireless Networks	3	-	-	3
THEORY CUM PRACTICAL						
	-	-	-	-	-	-

G. PROFESSIONAL CORE COURSES **Credits to be earned: 55**

Sl. No.	Course Code	Name of the Course	Number of Hours / Week			Credit
			L	T	P	
THEORY						
25.	18EC220	Network Theory	2	1	-	3
26.	*18EC231*	*Electronic Devices*	3	-	-	3
27.	18EC320	RF Passive Devices and Circuits	2	1	-	3
28.	18EC330	Electronic Circuits	3	-	-	3
29.	18EC340	Signals and Systems	2	1	-	3
30.	18EC350	Microprocessors and Microcontrollers	2	1	-	3
31.	18EC420	RF Active Circuits	2	1	-	3
32.	18EC430	CMOS VLSI Systems	3	-	-	3
33.	18EC440	Signal Processing	2	1	-	3
34.	18EC510	Data Communication Networks	2	1	-	3
35.	18EC530	Analog and Digital Communication Systems	2	1	-	3
36.	18EC620	Control Systems	2	1	-	3
37.	18EC710	Consumer Electronics	1	-	-	1
THEORY CUM PRACTICAL						
38.	18EC260	Digital System Design	2	-	2	3
39.	18EC520	Antenna and Wave Propagation	2	-	2	3
40.	18EC560	Digital Image Processing	2	-	2	3
41.	18EC660	Digital Communication Transceiver	1	-	2	2
PRACTICAL						
42.	18EC270	Circuits and Devices Laboratory	-	-	2	1
43.	18EC370	Microprocessor and Microcontroller Laboratory	-	-	2	1
44.	18EC380	Electronic Circuits Laboratory	-	-	2	1
45.	18EC470	RF Circuits Laboratory	-	-	2	1
46.	18EC480	Signal Processing Laboratory	-	-	2	1
47.	18EC570	Data Communication Networking Laboratory	-	-	2	1
48.	18EC580	Analog and Digital Communications Laboratory	-	-	2	1

H. ELECTIVE COURSES: Credits to be earned: 24-48

a. Programme Specific Elective Credits to be earned:12-24

Sl. No.	Course Code	Name of the Course	Number of Hours / Week			Credit
			L	T	P	
THEORY						
19.	18ECPA0	Computer Vision and Applications	3	-	-	3
20.	18ECPB0	Data Compression	3	-	-	3
21.	18ECPD0	Wireless Communication Systems	2	1	-	3
22.	18ECPF0	FPGA Based Digital System Design	3	-	-	3
23.	18ECPH0	Electronic Measurement and Instruments	3	-	-	3
24.	18ECPJ0	Network Security	3	-	-	3
25.	18ECPK0	Optical Communication	3	-	-	3
26.	18ECPM0	Planar Antennas for Wireless Applications	2	-	2	3
27.	18ECPN0	Electromagnetic Interference and Compatibility	3	-	-	3
28.	18ECPQ0	Statistical Signal Processing	2	1	-	3
29.	18ECPT0	Deep Learning for Speech Processing	2	1	-	3
30.	18ECPU0	VLSI Device Modeling	3	-	-	3
31.	18ECPY0	ASIC Design	3	-	-	3
32.	18ECPZ0	IoT System and Applications	3	-	-	3
33.	18ECRA0	Real Time Embedded Systems	3	-	-	3
THEORY CUM PRACTICAL						
34.	18ECPC0	DSP Architecture and Programming	2	-	2	3
35.	18ECPE0	Biomedical Signal Processing	2	-	2	3
36.	18ECPG0	Analog System Design	2	-	2	3

b. Programme Elective for Expanded Scope Credits to be earned: 06-12

Sl. No.	Course Code	Name of the Course	Number of Hours / Week			Credit
			L	T	P	
THEORY						
18.	18ECPL0	Medical Imaging and Processing	3	-	-	3
19.	18ECPP0	RF MEMS Design and Technology	3	-	-	3
20.	18ECPR0	LDPC and Polar Codes	2	1	-	3
21.	18ECPS0	Physical Channel Processing in 5G NR	2	1	-	3
22.	18ECPV0	Low Power CMOS VLSI System	3	-	-	3
23.	18ECPW0	CAD for VLSI	3	-	-	3
24.	18ECRB0	Adhoc and Sensor Networks	3	-	-	3
25.	18ECRC0	Multimedia Compression Techniques	3	1	-	4
26.	18ECRD0	Signal Processing in 5G NR	3	1	-	4
27.	18ECRE0	Algorithms for VLSI Design Automation	3	1	-	4
28.	18ECRF0	Low Power VLSI Design	3	1	-	4
29.	18EC1A0	Field Tests for a 5G Future	1	-	-	1

30.	18EC1B0	Deep Learning with Tensorflow	1	-	-	1
31.	18EC1C0	Synchronization for 5G NR	1	-	-	1
32.	18EC1D0	Speech Signal Processing	1	-	-	1
33.	18EC1E0	VLSI Implementation of Communication Transceivers	1	-	-	1
34.	18EC1F0	Embedded System Design	1	-	-	1
THEORY CUM PRACTICAL						
	-	-	-	-	-	-

d. General Elective Credits to be earned: 03-06

Sl. No.	Course Code	Name of the Course	Number of Hours / Week			Credit
			L	T	P	
THEORY						
5.	18ECGA0	Consumer Electronics	3	-	-	3
6.	18ECGB0	Multimedia Systems	3	-	-	3
7.	18ECGD0	Telecom Systems	3	-	-	3
8.	18ECGE0	Applied Image Processing	3	-	-	3

d. Electives from foundation courses- HSS, BS, ES Credits to be earned: 03-06

I. Project Credits to be earned: 15

S.No.	Course Code	Name of the Course	Number of Hours / Week			Credit
			L	T	P	
1.	18ES690	Engineering Design Project	2	-	4	3
2.	18ES790	Capstone Design Project	-	-	6	3
3.	18EC810	Project	-	-	18	9

J. Mandatory Courses (Not included for CGPA)

S.No.	Course Code	Name of the Course	Number of Hours / Week			Credit
			L	T	P	
THEORY						
1.	18CHAA0	Environmental Sciences	-	-	2	0
2.	18CHAB0	Constitution of India	-	-	2	0
3.	18CHAC0	Essence of Indian Knowledge	-	-	2	0
THEORY CUM PRACTICAL						
-	-	-	-	-	-	-
PRACTICAL						
-	-	-	-	-	-	-

Minimum credits to be earned for the award of the degree = 160

SCHEDULING OF COURSES FOR 2018-19 onwards (B.E. ECE Programme)*

Semester	Theory						Theory cum Practical	Practical			Special Courses	Audit Courses (Mandatory Non-credit}	Credits
	1	2	3	4	5	6	7	8	9	10	11	12	
I	18MA110 Engineering Calculus (4)	18PHB20 Physics (3)	18CHB30 Chemistry (3)	18EG180 English (2)	18ES150 Engg Exploration (3)	-	18ME160 Engg Graphics (4)	18EG170 English Lab. (1)	18PH180 Physics Lab. (1)	18CH190 Chemistry Lab. (1)	-	-	22
II	18MA210 Matrices and Ordinary Differential Equations (3)	18EC220 Network Theory (3)	18EC230** Electronic Devices (3)	18EC240** Semiconductor Physics (3)	-	-	18EC260 Digital System Design (3)	18EC270 Circuits and Devices Lab (1)	18EC280 Workshop (1)	-	18ES290 Lateral Thinking (1)	18CHAA0 Environmental Sciences (0)	18
III	18EC310 Complex Analysis and Linear Algebra (3)	18EC320 RF Passive Devices and Circuits (3)	18EC330 Electronic Circuits (3)	18EC340 Signals and Systems (3)	18EC350 Microprocessors and Microcontrollers (3)	-	18EC360 Programming for Problem Solving (3)	18EC370 Microprocessor and Microcontroller Lab (1)	18EC380 Electronic Circuits Lab (1)	-	18ES390 Design Thinking (TCP) (2)		22
IV	18EC410 Optimization and Numerical Methods (3)	18EC420 RF Active Circuits (3)	18EC430 CMOS VLSI Systems (3)	18EC440 Signal Processing (3)	18YYFX0 Foundation Elective I (3)	-	18EG460 Professional Communication (2)	18EC470 RF Circuits Lab (1)	18EC480 Signal Processing Lab (1)	-	18EC490 Project Management (3)	18CHAB0 Constitution of India (0)	22
V	18EC510 Data Communication Networks (3)	18EC520 Antenna and Wave Propagation (TCP) (3)	18EC530 Analog and Digital Communications (3)	18ECPX0 Prog. Elective -I (3)	18YYGX0 Gen. Elective .I (3)	-	18EC560 Digital Image Processing (3)	18EC570 Data Commn. Networking Lab `(1)	18EC580 Analog and Digital Commn. Lab (1)	-	18ES590 System Thinking (2)	Essence of Indian Knowledge (0)	22

Semester	Theory						Theory cum Practical	Practical			Special Courses	Audit Courses (Mandatory Non-credit}	Credits
	1	2	3	4	5	6	7	8	9	10	11	12	
VI	18EC610 Accounting and Finance (3)	18EC620 Control Systems (3)	18EC630 Data Structures and Algorithms (2)	18ECPX0 Prog. Elective II (3)	18ECPX0 Prog. Elective/ 18YYFX0 Foundation Elective II (3)	Engg Sciences Elective (3)	18EC660 Digital Communication System Design (2)	18EC670 Data Structures and Algorithms Lab (1)	-	-	18ES690 Engineering Design Project (3)	-	23
VII	18EC710 Consumer Electronics (1)	18ECPX0 Prog. Elec.III (3)	18ECPX0 Prog. Elec IV (3)	18ECPX0 Prog. Elec.V (3)	18ECPX0 Prog. Elec. VI / 18YYFX0 General Elective (3)	-	-		-	-	18ES790 Capstone Design Project (3)	-	16
VIII	18XXPX0 Prog. Elec. VII (3)	18XXPX0 Prog. Elec. VIII (3)		-	-	-	-	-	-	18EC810 Project (9)	-	-	15

This schedule shows an optimal way of completing the B.E. Degree programme successfully in 4 Years** ***Total Credits for Curricular Activities: 160

*****For students joined from 2021-22 onwards, 18EC230 Electronic Devices is replaced by 18EC231 Electronic Devices & 18EC240 Semiconductor Physics is replaced by 21EC240 Electronic Materials.***

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015

B.E Degree (Electronics and Communication Engineering) Program

COURSES OF STUDY
(For the students admitted from the Academic year 2018-19 onwards)

FIRST SEMESTER

Course code	Name of the Course	Category	Number of Hours / Week			Credits
			L	T	P	
THEORY						
18MA110	Engineering Calculus	BS	3	1	-	4
18PHB20	Physics	BS	3	-	-	3
18CHB30	Chemistry	BS	3	-	-	3
18EG140	English	HSS	2	-	-	2
18ES150	Engineering Exploration	ES	3	-	-	3
THEORY CUM PRACTICAL						
18ME160	Engineering Graphics	ES	3	-	2	4
PRACTICAL						
18EG170	English Laboratory	HSS	-	-	2	1
18PH180	Physics Laboratory	BS	-	-	2	1
18CH190	Chemistry Laboratory	BS	-	-	2	1
Total			**17**	**1**	**8**	**22**

SECOND SEMESTER

Course code	Name of the Course	Category	Number of Hours / Week			Credits
			L	T	P	
THEORY						
18MA210	Matrices and Ordinary Differential Equations	BS	2	1	-	3
18EC220	Network Theory	PC	2	1	-	3
18EC230**	Electronic Devices	PC	3	-	-	3
18EC240**	Semiconductor Physics	ES	3	-	-	3
THEORY CUM PRACTICAL						
18EC260	Digital System Design	PC	2	-	2	3
PRACTICAL						
18EC270	Circuits and Devices Laboratory	PC	-	-	2	1
18EC280	Electronics Workshop	ES	-	-	2	1
18ES290	Lateral Thinking	ES	-	-	2	1
Non-credit course (Mandatory) – Audit Course						
18CHAA0	Environment Sciences	ES	1	-	1	-
Total			**13**	**2**	**9**	**18**

***For students joined from 2021-22 onwards,*
18EC230 Electronic Devices is replaced by 18EC231 Electronic Devices &
18EC240 Semiconductor Physics is replaced by 21EC240 Electronic Materials.

THIRD SEMESTER

Course code	Name of the Course	Category	Number of Hours / Week			Credits
			L	T	P	
THEORY						
18EC310	Complex Analysis and Linear Algebra	BS	2	1	-	3
18EC320	RF Passive Devices and Circuits	PC	2	1	-	3
18EC330	Electronic Circuits	PC	3	-	-	3
18EC340	Signals and Systems	PC	2	1	-	3
18EC350	Microprocessors and Microcontrollers	PC	2	1	-	3
THEORY CUM PRACTICAL						
18EC360	Programming for Problem Solving	ES	2	-	2	3
18ES390	Design Thinking	ES	1	-	2	2
PRACTICAL						
18EC370	Microprocessor and Microcontroller Laboratory	PC	-	-	2	1
18EC380	Electronic Circuits Laboratory	PC	-	-	2	1
	Total		**14**	**4**	**8**	**22**

FOURTH SEMESTER

Course code	Name of the Course	Category	Number of Hours / Week			Credits
			L	T	P	
THEORY						
18EC410	Optimization and Numerical Methods	BS	2	1	-	3
18EC420	RF Active Circuits	PC	2	1	-	3
18EC430	CMOS VLSI Systems	PC	3	-	-	3
18EC440	Signal Processing	PC	2	1	-	3
18YYFX0	Foundation Elective I	BS	3	-	-	3
18EC490	Project Management	HSS	3	-	-	3
THEORY CUM PRACTICAL						
18EG460	Professional Communication	HSS	-	1	2	2
PRACTICAL						
18EC470	RF Circuits Laboratory	PC	-	-	2	1
18EC480	Signal Processing Laboratory	PC	-	-	2	1
AUDIT COURSE - NON-CREDIT MANDATORY COURSE						
18CHAB0	Constitution of India	HSS	-	-	2	0
	Total		**15**	**4**	**8**	**22**

FIFTH SEMESTER

Course code	Name of the Course	Category	Number of Hours / Week			Credits
			L	T	P	
THEORY						
18EC510	Data Communication Networks	PC	2	1	-	3
18EC530	Analog and Digital Communication Systems	PC	2	1	-	3
18ECPX0	Programme Elective -I	PE	3	-	-	3
18YYGX0	General Elective - I	GE	3	-	-	3
THEORY CUM PRACTICAL						
18EC520	Antenna and Wave Propagation	PC	2	-	2	3
18EC560	Digital Image Processing	PC	2	-	2	3
18ES590	System Thinking	ES	1	-	1*	2
PRACTICAL						

18EC570	Data Communication Networking Laboratory	PC	-	-	2	1
18EC580	Analog and Digital Communications Laboratory	PC	-	-	2	1
AUDIT COURSE - NON-CREDIT MANDATORY COURSE						
18CHAC0	Essence of Indian Knowledge	HSS	-	-	2	0
Total			**15**	**2**	**11**	**22**

*One hour per week is allotted for off the classroom work

SIXTH SEMESTER

Course code	Name of the Course	Category	Number of Hours / Week			Credits
			L	**T**	**P**	
THEORY						
18EC610	Accounting and Finance	HSS	3	-	-	3
18EC620	Control Systems	PC	2	1	-	3
18EC630	Data Structures and Algorithms	ES	2	-	-	2
18ECPX0	Programme Elective-II	PE	3	-	-	3
18YYZX0	Programme / Foundation Elective - I	PE/FE	3	-	-	3
18ESEX0	Engineering Sciences Elective	ES	3	-	-	3
THEORY CUM PRACTICAL						
18EC660	Digital Communication Transceiver	PC	1	-	2	2
PRACTICAL						
18EC670	Data Structures and Algorithms Laboratory	ES	-	-	2	1
PROJECT						
18ES690	Engineering Design Project	Project	1	-	4	3
Total			**18**	**1**	**8**	**23**

SEVENTH SEMESTER

Course code	Name of the Course	Category	Number of Hours / Week			Credits
			L	**T**	**P**	
THEORY						
18EC710	Consumer Electronics	PC	1	-	-	1
18ECPX0	Programme Elective -III	PE	3	-	-	3
18ECPX0	Programme Elective -IV	PE	3	-	-	3
18ECPX0	Programme Elective -V	PE	3	-	-	3
18YYZX0	Programme-VI / General Elective - II	PE/GE	3	-	-	3
THEORY CUM PRACTICAL						
-	-	-	-	-	-	-
PRACTICAL						
-	-	-	-	-	-	-
PROJECT						
18ES790	Capstone Design Project	Project	-	-	6	3
Total			**13**	**-**	**6**	**16**

EIGHTH SEMESTER

Course code	Name of the Course	Category	Number of Hours / Week			Credits
			L	T	P	
THEORY						
18ECPX0	Programme Elective -VII	PE	3	-	-	3
18ECPX0	Programme Elective -VIII	PE	3	-	-	3
THEORY CUM PRACTICAL						
-	-	-	-	-	-	-
PRACTICAL						
-	-	-	-	-	-	-
PROJECT						
18EC810	Project	Project	-	-	18	9
Total			**6**	**-**	**18**	**15**

BS : Basic Science
HSS : Humanities and Social Science
ES : Engineering Science
PC : Programme Core
PE : Programme Elective
GE : General Elective
FE : Foundation Elective
L : Lecture
T : Tutorial
P : Practical

Note:

1 Hour Lecture/week is equivalent to 1 Credit
1 Hour Tutorial/week is equivalent to 1 Credit
2 Hours Practical/week is equivalent to 1 Credit

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015
B.E Degree (Electronics and Communication Engineering) Program
SCHEME OF EXAMINATIONS
(For the students admitted from the Academic Year 2018-19 onwards)

SECOND SEMESTER

Course code	Name of the Course	Duration of Terminal Exam\ in Hrs.	Marks			Minimum Marks for Pass	
			Continuous Assessment*	Terminal Exam**	Max. Marks	Terminal Exam	Total
THEORY							
18MA210	Matrices and Ordinary Differential Equations	3	50	50	100	25	50
18EC220	Network Theory	3	50	50	100	25	50
18EC230***	Electronic Devices	3	50	50	100	25	50
18EC240***	Semiconductor Physics	3	50	50	100	25	50
THEORY CUM PRACTICAL							
18EC260	Digital System Design	3	50	50	100	25	50
PRACTICAL							
18EC270	Circuits and Devices Laboratory	3	50	50	100	25	50
18EC280	Electronics Workshop	3	50	50	100	25	50
18ES290	Lateral Thinking	-	50	50	100	25	50
AUDIT COURSE - NON-CREDIT MANDATORY COURSE							
18CHAA0	Environmental Sciences	-	50	50	100	25	50

****For students joined from 2021-22 onwards, 18EC230 Electronic Devices is replaced by 18EC231 Electronic Devices & 18EC240 Semiconductor Physics is replaced by 21EC240 Electronic Materials*.

THIRD SEMESTER

Course code	Name of the Course	Duration of End Semester Exam\ in Hrs.	Marks			Minimum Marks for Pass	
			Continuous Assessment*	End Semester Exam**	Max. Marks	End Semester Exam	Total
THEORY							
18EC310	Complex Analysis and Linear Algebra	3	50	50	100	25	50
18EC320	RF Passive Devices and Circuits	3	50	50	100	25	50
18EC330	Electronic Circuits	3	50	50	100	25	50
18EC340	Signals and Systems	3	50	50	100	25	50

18EC350	Microprocessors and Microcontrollers	3	50	50	100	25	50
THEORY CUM PRACTICAL							
18EC360	Programming for Problem Solving	3	50	50	100	25	50
18ES390	Design Thinking	-	50	50	100	25	50
PRACTICAL							
18EC370	Microprocessor and Microcontroller Laboratory	3	50	50	100	25	50
18EC380	Electronic Circuits Laboratory	3	50	50	100	25	50

FOURTH SEMESTER

Course code	Name of the Course	Duration of End Semester Exam\ in Hrs.	Marks			Minimum Marks for Pass	
			Continuous Assessment*	End Semester Exam**	Max. Marks	End Semester Exam	Total
THEORY							
18EC410	Optimization and Numerical Methods	3	50	50	100	25	50
18EC420	RF Active Circuits	3	50	50	100	25	50
18EC430	CMOS VLSI Systems	3	50	50	100	25	50
18EC440	Signal Processing	3	50	50	100	25	50
18YYFX0	Foundation Elective I	3	50	50	100	25	50
18EC490	Project Management	3	50	50	100	25	50
THEORY CUM PRACTICAL							
18EG460	Professional Communication	-	50	50	100	25	50
PRACTICAL							
18EC470	RF Circuits Laboratory	3	50	50	100	25	50
18EC480	Signal Processing Laboratory	3	50	50	100	25	50
AUDIT COURSE - NON-CREDIT MANDATORY COURSE							
18CHAB0	Constitution of India	-	50	50	100	25	50

FIFTH SEMESTER

Course code	Name of the Course	Duration of End Semester Exam\ in Hrs.	Marks			Minimum Marks for Pass	
			Continuous Assessment*	End Semester Exam**	Max. Marks	End Semester Exam	Total
THEORY							
18EC510	Data Communication Networks	3	50	50	100	25	50
18EC530	Analog and Digital Communication Systems	3	50	50	100	25	50
18ECPX0	Programme Elective -I	3	50	50	100	25	50
18YYGX0	General Elective - I	3	50	50	100	25	50
THEORY CUM PRACTICAL							
18EC520	Antennas and Wave Propagation	3	50	50	100	25	50
18EC560	Digital Image Processing	3	50	50	100	25	50
18ES590	System Thinking	-	50	50	100	25	50
PRACTICAL							
18EC570	Data Communication Networking Laboratory	3	50	50	100	25	50
18EC580	Analog and Digital Communications Laboratory	3	50	50	100	25	50
AUDIT COURSE - NON-CREDIT MANDATORY COURSE							
18CHAC0	Essence of Indian Knowledge	-	50	50	100	25	50

SIXTH SEMESTER

Course code	Name of the Course	Duration of End Semester Exam\ in Hrs.	Marks			Minimum Marks for Pass	
			Continuous Assessment*	End Semester Exam**	Max. Marks	End Semester Exam	Total
THEORY							
18EC610	Accounting and Finance	3	50	50	100	25	50
18EC620	Control Systems	3	50	50	100	25	50
18EC630	Data Structures and Algorithms	3	50	50	100	25	50
18ECPX0	Programme Elective -II	3	50	50	100	25	50
18YYZX0	Programme / Foundation Elective - I	3	50	50	100	25	50

18ESEX0	Engineering Science Elective	3	50	50	100	25	50
THEORY CUM PRACTICAL							
18EC660	Digital Communication System Design	3	50	50	100	25	50
PRACTICAL							
18EC670	Data Structures and Algorithms Laboratory	3	50	50	100	25	50
Project							
18ES690	Engineering Design Project	-	50	50	100	25	50

SEVENTH SEMESTER

Course code	Name of the Course	Duration of End Semester Exam\ in Hrs.	Marks			Minimum Marks for Pass	
			Continuous Assessment*	End Semester Exam**	Max. Marks	End Semester Exam	Total
THEORY							
18EC710	Consumer Electronics	3	50	50	100	25	50
18ECPX0	Programme Elective -III	3	50	50	100	25	50
18ECPX0	Programme Elective -IV	3	50	50	100	25	50
18ECPX0	Programme Elective -V	3	50	50	100	25	50
18YYZX0	Programme-VI / General Elective - II	3	50	50	100	25	50
Project							
18ES790	Capstone Design Project	-	50	50	100	25	50

EIGTH SEMESTER

Course code	Name of the Course	Duration of End Semester Exam\ in Hrs.	Marks			Minimum Marks for Pass	
			Continuous Assessment*	End Semester Exam**	Max. Marks	End Semester Exam	Total
THEORY							
18ECPX0	Programme Elective -VII	PE	3	-	-	3	-
18ECPX0	Programme Elective -VIII	PE	3	-	-	3	50
Project							
18EC810	Project	-	50	50	100	25	50

*Continuous Assessment evaluation pattern will differ from course to course and for different tests. This will have to be declared in advance to students. The department will put a process in place to ensure that the actual test paper follow the declared pattern.

**End Semester Examination will be conducted for maximum marks of 100 and subsequently be reduced to 50 marks for the award of End semester examination marks.

****For students joined from 2021-22 onwards, 18EC230 Electronic Devices is replaced by 18EC231 Electronic Devices & 18EC240 Semiconductor Physics is replaced by 21EC240 Electronic Materials*.

CURRICULUM AND DETAILED SYLLABI

FOR

B. E. DEGREE PROGRAMME
(Electronics and Communication Engineering)

FIRST SEMESTER

FOR THE STUDENTS ADMITTED IN THE

ACADEMIC YEAR 2021-22

THIAGARAJAR COLLEGE OF ENGINEERING
(A Government Aided ISO 9001:2008 certified Autonomous Institution affiliated to Anna University)
MADURAI – 625 015, TAMILNADU

Phone : 0452 – 2482240, 41
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Approved in 56th Academic Council Meeting on 21.07.2018
Approved in 57th Academic Council Meeting on 05.01.2019
Approved in 61st Academic Council Meeting on 03.07.2021

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015
B. E. DEGREE PROGRAMME
(Electronics and Communication Engineering)

COURSES OF STUDY
(For the students admitted in the Academic Year 2021-22)

FIRST SEMESTER

Course Code	Name of the Course	Category	No. of Hours / Week			credits
			L	T	P	
THEORY						
18MA110	Engineering Calculus	BS	3	1	-	4
21PH120	Physics	BS	3	-	-	3
21CH130	Chemistry	BS	3	-	-	3
18EG140	English	HSS	2	-	-	2
18ES150	Engineering Exploration	ES	3	-	-	3
PRACTICAL						
18EG170	English Laboratory	HSS	-	-	2	1
21PH180	Physics Laboratory	BS	-	-	2	1
21CH190	Chemistry Laboratory	BS	-	-	2	1
18EC280	Electronics Workshop	ES	-	-	2	1
Total			**14**	**1**	**8**	**19**

BS : Basic Science
HSS : Humanities and Social Science
ES : Engineering Science
PC : Programme Core

L : Lecture
T : Tutorial
P : Practical

Note:
1 Hour Lecture is equivalent to 1 credit
1 Hour Tutorial is equivalent to 1 credit
2 Hours Practical is equivalent to 1 credit

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015
B. E. DEGREE PROGRAMME
(Electronics and Communication Engineering)

SCHEME OF EXAMINATIONS
(For the Students admitted in the academic year 2021-22)

FIRST SEMESTER

S.No.	Course Code	Name of the Course	Duration of Terminal Exam. in Hrs.	Marks			Minimum Marks for Pass	
				Continuous Assessment *	Terminal Exam **	Max. Marks	Terminal Exam	Total
THEORY								
1	18MA110	Engineering Calculus	3	50	50	100	25	50
2	21PH120	Physics	3	50	50	100	25	50
3	21CH130	Chemistry	3	50	50	100	25	50
4	18EG140	English	3	50	50	100	25	50
5	18ES150	Engineering Exploration	3	50	50	100	25	50
PRACTICAL								
6	18EG170	English Laboratory	3	50	50	100	25	50
7	21PH180	Physics Laboratory	3	50	50	100	25	50
8	21CH190	Chemistry Laboratory	3	50	50	100	25	50
9	18EC280	Electronics Workshop	3	50	50	100	25	50

* CA evaluation pattern will differ from course to course and for different tests. This will have to be declared in advance to students. The department will put a process in place to ensure that the actual test paper follow the declared pattern.

** Terminal Examination will be conducted for maximum marks of 100 and subsequently be reduced to 50 marks for the award of terminal examination marks

18MA110	ENGINEERING CALCULUS

Category	L	T	P	Credit
BS	3	1	0	4

Course Outcomes

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

CO1	Understand the concept of functions, limits and continuity	Understand
CO2	Compute derivatives and apply in solving engineering problems	Apply
CO3	Employ partial derivatives to find maxima minima of functions of multi variables	Apply
CO4	Demonstrate and apply the techniques of integration	Apply
CO5	Apply integrals of multivariable to find areas enclosed between two curves and volume enclosed between surfaces	Apply

Assessment Pattern

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	10	10	10	0
Understand	30	30	30	30
Apply	60	60	60	70
Analyse	0	0	0	0
Evaluate	0	0	0	0
Create	0	0	0	0

Syllabus

DIFFERENTIAL CALCULUS **(12 hours)**

Representation of functions - New functions from old functions - Limit of a function - Continuity - Limits at infinity - Derivative as a function - Differentiation rules(formula and problems only) –The mean value theorem - Maxima and Minima of functions of one variable - Application problems in engineering – Application problems using MATLAB.

FUNCTIONS OF SEVERAL VARIABLES **(12 hours)**

Partial derivatives – Chain rule - Vector functions and their Derivatives - Directional derivatives and gradient vector - Maxima and minima of functions of two variables - Lagrange Multipliers - Application problems in engineering - Application problems using MATLAB.

INTEGRAL CALCULUS **(12 hours)**

Area under curves - The definite integrals – Fundamental theorem of calculus - Integration by parts - Volume of solid of revolution - Area of surface of revolution - Improper integrals - Application problems in engineering - Application problems using MATLAB

MULTIPLE INTEGRAL **(12 hours)**

Iterated integrals - Double integrals over general regions - Double integrals in polar coordinates - Applications of double integrals (density, mass, moments & moments of inertia problems only) - Triple integrals - Triple integrals in cylindrical coordinates - Triple integrals in spherical coordinates - Change of variables in multiple integrals - Application problems in engineering

Text Book

1) James Stewart, "Calculus Early Transcendentals", 7e, Cengage Learning, New Delhi, 2017.
DIFFERENTIAL CALCULUS:[Sections: 1.1, 1.3, 2.2,2.5,2.6,2.8, 3.1-3.6,4.1,4.2], **FUNCTIONS OF SEVERAL VARIABLES:** Sections: 14.3, 14.5,13.1,13.2,14.6-14.8], **INTEGRAL CALCULUS:** [Sections: 5.1-5.4,7.1, 6.2, 8.2 and 7.8], **MULTIPLE INTEGRAL:** [Sections: 15.2-15.5, 15.7-15.10]

2) Lecture Notes on Engineering Mathematics-I Application Problems and Solution Manual, Department of Mathematics, Thiagarajar College of Engineering, Madurai.

Reference Books

1) Kuldeep Singh, "Engineering Mathematics Through Appplications",2e, Palgrave Macmillan, 2011.
2) Erwin Kreszig, "Advanced Engineering Mathematics",10th edition, Wiley, 2017.
3) George B. Thomas, " Thomas Calculus: early transcendentals ", Pearson, New Delhi, 2013.
4) R.K.Jain, S.R.K.Iyengar, "Advanced Engineering Mathematics"5e, Narosa Publishing House, 2016.

21PH120	PHYSICS

Category	L	T	P	Credit
BS	3	0	0	3

Course Outcomes

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

CO1	Apply the vector calculus approach and Newton's law in polar coordinates to solve problems in mechanics	Apply
CO2	Solve for the solutions and describe the behavior of a damped harmonic oscillator and waves.	Apply
CO3	Use the laws of electrostatics and magnetostatics to explain electromagnetic wave propagation	Apply
CO4	Explain the fundamentals of optical phenomena and its applications	Understand
CO5	Make use of Schrodinger equation to arrive at the energy values of particle in a box and linear harmonic oscillator	Apply

Assessment Pattern

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	20	20	20	20
Understand	30	30	30	30
Apply	50	50	50	50
Analyze	-	-	-	-
Evaluate	-	-	-	-
Create	-	-	-	-

Syllabus

Mechanics of Particles: Scalars and vectors under rotation transformation, coordinates - cartesian, polar, spherical, cylindrical – Forces in nature - Newton's second law of motion- Central forces - Conservative and non-conservative forces - Work-Energy theorem - Conservation of angular momentum - Satellite manoeuvres. Oscillations and Waves: Simple harmonic oscillators - Energy decay in a Damped harmonic oscillator – Q factor – Impedance matching- Wave groups and group velocity -Non-dispersive transverse and Longitudinal waves - Waves with dispersion - Water waves - Acoustic waves - Earthquake and Tsunami waves. Electromagnetic Fields and Waves: Motion of a charge in electric field – Electric potential - Charge distribution - Current and conservation of charge in materials - Magnetic force on an electric charge- Circular motion in a constant magnetic field -Vector potential - Stokes' theorem - Magnetic force on current loops - Gauss' law for magnetism–Maxwell's equation - Energy and momentum of EM waves - CT/MRI scan. Optics: Ray paths in inhomogeneous medium and its solutions - Two-slit Fraunhofer diffraction –Interference in non-reflecting films - Fabry-Perot interferometer- resolving power -Einstein's theory - CO_2 -Nd- YAG – Quantum Cascade lasers - Fiber optic sensors (Displacement/Pressure). Quantum Mechanics: Wave nature of particles - wave function -probability current density and expectation values - Schrodinger wave equation - Uncertainty principle - Particle in a box in 1D – Linear harmonic oscillator – Quantum tunnelling – Scanning tunnelling microscope – Quantum computation (qubit).

Text Books

1. Principles of Physics, Halliday, Resnick and Jearl Walker, 9th Edition, Wiley, 2011.
2. Paul A. Tipler and G. Mosca, Physics for Scientists and Engineers, 6th Edition, Freeman, 2008.

Reference Books

MECHANICS OF PARTICLES

1. Paul A. Tipler and Gene Mosca, Physics for Scientists and Engineers, 6th Edition, Freeman, 2008 (Chapters – 4, 9 & 10).
2. Manoj K. Harbola, Engineering Mechanics, 2nd Edition, Cengage, 2018

.
OSCILLATIONS AND WAVES

1. Paul A. Tipler and Gene Mosca, Physics for Scientists and Engineers, 6th Edition, Freeman, 2008 (Chapters – 14 & 15).
2. H. J. Pain, The Physics of Vibrations and Waves, 6th Edition, John Wiley, 2005 (Chapters 2, 5 & 6).

ELECTROMAGNETIC FIELDS AND WAVES

1. Principles of Physics, Halliday, Resnick and Jearl Walker, 9th Edition, Wiley, 2011, (Chapters - 23, 24, 32 & 33)
2. Paul M. Fishbane, Stephen G. Gasiorowicz and Stephen T. Thornton, Physics for Scientists and Engineers with Modern Physics, 3rd Edition, Pearson, 2005 (Chapters - 26, 28, 31 & 34).

OPTICS

1. Paul A. Tipler and Gene Mosca, Physics for Scientists and Engineers, 6th Edition, Freeman, 2008 (Chapters – 31 & 33).
2. Ajoy Ghatak, Optics, 5th Edition, Tata McGraw Hill, 2012 (Chapters – 3, 18, 20)

QUANTUM MECHANICS

1. Paul A. Tipler and Gene Mosca, Physics for Scientists and Engineers, 6th Edition, Freeman, 2008 (Chapters – 34 & 35).
2. Stephen T. Thornton and Andrew Rex, Modern Physics for Scientists and Engineers, 4th Edition, Cengage, 2013. (Chapters - 5 & 6).
3. R. Shankar, Fundamentals of Physics – I, II, Yale University Press, 2014, 2016

21CH130	CHEMISTRY

Category	L	T	P	Credit
BS	3	0	0	3

Course Outcomes

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

CO1	Identify the properties of water and its treatment methods	Understand
CO2	Summarize the Principles and Instrumentations of Spectroscopic techniques	Understand
CO3	Select the appropriate spectroscopic techniques for characterization of materials	Apply
CO4	Adapt the customized corrosion control methods	Apply
CO5	Dramatize the preparation, properties and applications of Engineering materials	Understand
CO6	Describe the mechanism of adhesion and lubrication	Understand

Assessment Pattern

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	20	20	20	20
Understand	40	40	40	40
Apply	40	40	40	40
Analyze	-	-	-	-
Evaluate	-	-	-	-
Create	-	-	-	-

Syllabus

Water: Water- sources- physical - characteristics - alkalinity - hardness of water – types - determination of hardness by EDTA method. Boiler trouble-Softening of water: External and Internal treatment methods. Waste water treatment process. Electrochemical technologies for energy storage and surface engineering: Electrochemistry and Surface Engineering –Basics –Corrosion - causes- factors- types - corrosion of metal and computer components- Corrosion control. Electroplating - Electroless process. Energy storage: Batteries - High energy density and Power density batteries - Primary and Secondary batteries– Hydrogen Generator - Hydrogen Economy- Fuel cells - Super capacitors – Batteries for automotive – standards and performance and challenges for E-mobility. Spectroscopic technique and applications: Principle and instrumentation: UV–Visible spectroscopy- atomic Absorption Spectroscopy - fluorescence spectroscopy - Inductively Coupled Plasma - Optical Emission Spectroscopy- Vibrational spectroscopy - Raman spectroscopy - surface enhanced raman spectroscopy - nuclear magnetic resonance spectroscopy- X-ray-diffraction. Application of spectroscopy. Engineering materials: Properties of materials: Structure of atom - bonding and their influences on the property of materials - melting point - brittleness, ductility - thermal conductivity- ionic and electrical conductivity- superconductivity - optical – magnetic properties, hydrophobic, hydrophilic. Polymers and polymer composites - types- structure and properties-applications. Ceramics and advanced ceramics - types-properties-applications-Nano-materials – types – structure and properties –applications.

Text Books

1. P.C. Jain and Monica Jain, A Textbook of Engineering Chemistry, DhanpatRai publications, New Delhi, 17th edition, 2018 (Unit I –IV)
2. C.N.Banwell and E.M.McCash,“ Fundamentals of Molecular Spectroscopy”,Tata McGraw-Hill (India), 5th Edition, 2013. (Unit – III)
3. V. Raghavan, Materials Science and Engineering; PHI Delhi, 6th edition, 2019.(Unit – IV)

Reference Books

1. Satya Prakash & Manisha Agarwal, Enginering Chemistry – Concepts in Chemistry for Engineering, Khanna Publishing, revised edition, 2020. (Unit I – IV)

2. Shashi Chawla, " A text book of Engineering Chemistry", Dhanpat Rai & Co.(pvt) ltd, 3rd edition, reprint 2017. (Unit I – IV)
3. Vikas Saini, Corrosion and Corrosion control, Scitus publications,2016 (Unit – II)
4. H.A.Kiehne, Battery Technology Hand book,CRC press, 2nd edition, 2003. (Unit – II)
5. Albert N.Link et al, Battery technology for electric vehicles, Earthscan, 2015. (Unit – II)
6. W.F. Smith, Principles of Materials Science and Engineering: An Introduction; Tata Mc-Graw Hill, 2008. (Unit – IV)
7. T.Pradeep, NANO: The Essentials: Understanding of Nano-science and Nanotechnology, Mc-Graw Hill Education, 2017 (Unit – IV)

18EG140	ENGLISH	Category	L	T	P	Credit
		HSS	2	0	0	2

Course Outcomes

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

CO1	Explain the basics of language in terms of vocabulary, grammar, pronunciation, syntax and semantics.	Understand
CO2	Explain the grammatical nuances and use them accordingly in respective contexts.	Understand
CO3	Read and comprehend the content in English in general and technical contexts as well.	Understand
CO4	Write with coherence and cohesion effectively.	Apply
CO5	Apply the language in established structure with precision in social and professional contexts.	Apply

Assessment Pattern

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	-	-	-	-
Understand	15	15	30	30
Apply	35	35	70	70
Analyse	-	-	-	-
Evaluate	-	-	-	-
Create	-	-	-	-

Syllabus:

MODULE- I: Basics of language – Phonetics - Phonemes, Syllables and Stress, Vocabulary – Word Analysis, Prefix, Suffix, Roots, Parts of Speech, Sentence Patterns.

MODULE- II: Basics of grammar – Tenses, Subject-Verb Agreement, Impersonal Passive Voice, Relative Clauses; Notions for Technical English – Noun Compounds, Classifications and Definitions, Cause and Effect, Purpose and Function, Numerical Adjectives, Reading Comprehension – Skimming, Scanning, Skipping (as tested in BEC Vantage Level)

MODULE-III: Writing with coherence and cohesion, Summarizing, Note-Making, Interpretation of Graphics, Writing Instructions and Recommendations, Paragraph and Essay Writing.

MODULE-IV: Writing with correct spelling, punctuation and grammar, Blog writing, E-mail Writing (BEC Vantage Writing-Unit I) – Formal Letters by students for Bonafide Certificate/Permission.

Suggested Reading:

Books:

1. Murphy, Raymond, English Grammar in Use with Answers; Reference and Practice for Intermediate Students, Cambridge: CUP, 2004
2. Jones, Daniel. An English Pronouncing Dictionary, Cambridge: CUP, 2006
1. Brook-Hart,Guy. Cambridge English- Business Benchmark-Upper Intermediate, CUP,2014.
2. Dhanavel, S.P. English and Communication Skills for Students of Science & Engineering, Orient BlackSwan, Chennai: 2016.
3. Swan, Michael. Practical English Usage.4th Edn. OUP. 2016.

Websites:

1. http://www.englishclub.com
2. http://owl.english.purdue.edu
3. https://www.oxfordonlineenglish.com
4. www.bbclearningenglish.com

18ES150	ENGINEERING EXPLORATION

Category	L	T	P	Credit
ES	1	2	-	3

Course Outcomes

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

CO1. Explain technological & engineering development, change and impacts of engineering	Understand
CO2. Draw a product in enough detail that others can accurately build it and write specification sheet for a given product	Apply
CO3. Complete initial steps (Define a problem, list criteria and constraints, brainstorm potential solutions and document the ideas) in engineering design process	Apply
CO4. Draw sketches to a design problem and provide a trade-off matrix	Apply
CO5. Communicate possible solutions through drawings and prepare project report	Apply
CO6. Use reverse engineering to suggest improvements in a tool design	Apply
CO7. Apply the concept of engineering fundamentals in Civil, Mechanical, Electrical and Computer Engineering	Apply

Assessment Pattern

S.No	**Bloom's category**	**Continuous Assessment Tests**			**End Semester Examinations**
		1	**2**	**3**	
1	Remember	20	20	20	20
2	Understand	20	20	20	20
3	Apply	60	60	60	60
4	Analyze	0	0	0	0
5	Evaluate	0	0	0	0
6	Create	0	0	0	0

Syllabus

What is Engineering: Engineering Requirement, Knowledge within Engineering disciplines, Engineering advancements **Engineering Design:** Problem definition, idea generation through brainstorming and researching, solution creation through evaluating and communicating, text/analysis, final solution and design improvement. **Defining problems and Brainstorming:** Researching design, sketching problem solving **Communicating solution**: Dimensioning orthographic drawing, perspective drawing **Modeling and Testing final output:** Product evaluation, reverse engineering, final project report. **Civil Engineering:** Structural forces structural analysis, bridge design components, structural design **Mechanical Engineering:** Types of motion, mechanical power system, mechanical power formula, mechanical design. **Electrical Engineering:** Reading analog multimeter, measuring current, voltage and resistance, electricity from chemicals, solar cells, magnets, Ohms law and watts law, circuit identification and circuit calculation, resistor color code, continuity **Computer Engineering:** Logic gates, algorithms, computer architecture, binary code

Reference Books

1. Ryan A.Brown, Joshua W.Brown and Michael Berkihiser: "Engineering Fundamentals: Design, Principles, and Careers", Goodheart-Willcox Publisher, Second Edition, 2014.
2. Saeed Moaveni ,"Engineering Fundamentals: An Introduction to Engineering", Cengage learning, Fourth Edition, 2011.

18EG170	ENGLISH LABORATORY	Category	L	T	P	Credit
		HSS	0	0	2	1

Course Outcomes

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

CO1	Pronounce words intelligibly through listening and watching contents on social, technical and day-to-day conversations and respond to questions related to them.	Apply
CO2	Apply appropriate lexicon in various contexts, by differentiating variations pertaining to spelling, pronunciation, meaning and grammar	Apply
CO3	Comprehend passages on various topics like general, business and science at various levels	Apply
CO4	Read texts in newspapers, magazines, and articles on a variety of issues with clarity to understand and to be understood	Apply
CO5	Prepare and present on a topic to a group of audience with ICT and other educational aids	Apply

Assessment Pattern

Internal: No Continuous Assessment Test will be conducted

Students' performance will be assessed in the classroom as given below

- Spoken Task - General / Technical Presentation / BEC Speaking Tests II: 25 Marks
- Listening Task - Answering questions : 25 Marks

External: Tested on Phonetics, Grammar, and Vocabulary in the lab for 1 hour : 80 Marks

Submission of Students Record on Practical Tasks in the Class and Lab : 20 Marks

List of Experiments:

S.No	Topic	Hours
	LAB ACTIVITES	
1	Listening	2
2	Vocabulary	2
3	Grammar	2
4	Phonetics	2
5	Reading Comprehension – I (General)	2
6	Reading Comprehension – II (BEC Vantage Level)	2
	CLASSROOM ACTIVITIES	
7	Reading Practice (Extensive Reading)	2
8	English through Audios & Videos (Note-Taking & answering questions)	2
9	Presentation - I	2
10	Presentation - II	2
11	Revision	2
12	Model Test	2
	Total	24

Software Used:

1. Business English Certificate-Vantage- Practice Software
2. English Software

Extensive Reading: (Not for Terminal Exam, Prescribed only for Spoken Tasks)

1. Khera, Shiv, You Can Win, Macmillan Books, New York, 2003.

Teaching Resources and Websites:

1. Oxford / Cambridge Online English Videos
2. Free Video Downloads from Youtube
3. https://learningenglish.voanews.com/
4. https://www.ted.com/talkshttp://
5. www.esl-galaxy.com/video.htm

21PH180	PHYSICS LABORATORY	Category	L	T	P	Credit
		BS	0	0	2	1

Course Outcomes

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

CO1	Analyze the mechanical & electrical oscillations and determine their resonance frequency	Apply
CO2	Analyze the interference and diffraction patterns for micron size objects	Apply
CO3	Investigate the V-I characters of photodiode at dark and bright illumination conditions	Apply
CO4	Determine the Planck’s constant by using LEDs	Apply
CO5	Plot the VI characteristics of solar cell	Apply
CO6	Determine the long and short time constant of an RC circuit	Apply
CO7	Identify the type of semiconductor and measure Hall coefficient	Apply
CO8	Determine the reversibility of classical and quantum logic gates	Apply
CO9	Identify the variation of magnetic field with distance for circular coils	Apply

List of Experiments

OPTICS

1. Laser Diffraction – Determination of wavelength of Laser and particle size in a thin film
2. Photo diode -V-I characteristics.
3. Air wedge-Determination of thickness of wire

QUANTUM MECHANICS

4. Photoelectric effect-Determination of Planck’s constant
5. Solar cell-Plotting and studying of VI characteristic
6. Study of Classical and quantum Logic gates.

ELECTROMAGNETIC THEORY

7. RC circuit - Determination of time constant
8. LCR Circuit - Determination of resonant frequency
9. Hall effect - Determination of Hall voltage
10. Helmohltz coil -Determination of magnetic field

MECHANICS

11. Torsional Pendulum -Determination of Rigidity modulus and moment of inertia

21CH190	CHEMISTRY LABORATORY

Category	L	T	P	Credit
BS	0	0	2	1

Course Outcomes

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

CO1	Estimate the chemical water quality parameters of sample water / effluent	Apply
CO2	Demonstrate presence of essential ions and pollutant in milk and food sample	Apply
CO3	Determine the physicochemical property of oil and lubricant	Apply
CO4	Estimate the strength of acid and pH of soil by conducto-metric and pH metric titration	Apply
CO5	Illustrate the strength of oxidisable materials present in given sample by potentio-metric method	Apply
CO6	Compare amount of pollutant present in effluent from various industries using colorimetric method and UV–visible spectroscopy	Apply
CO7	Calculate the efficiency of electroplating and electroless plating	Apply
CO8	Determine the rate of corrosion of metal & alloy using potentio-dynamic polarisation method	Apply

List of Experiments

Quantitative analysis (Any Five Experiment)
1. Estimation of total hardness of water sample
2. Estimation of COD of industrial effluent
3. Estimation of Chloride in a water sample
4. Determination of Ca^{2+} ion in milk sample
5. Estimation of adulterant in food sample
6. Determination of the Phosphoric Acid Content in Soft Drinks using pH meter
7. Find out saponification number of oil - oil adulteration
8. Determination Surface Tension of lubricants.
Electrochemical and photochemical analysis (Any Five Experiment)
1. Conductometric Titration (Strong acid vs Strong base)
2. Determination of pH of soil by pH metric Titration
3. Potentiometric redox Titration ($K_2Cr_2O_7$ vs FAS, $KMnO_4$ vs FAS)
4. Estimation of iron content of water sample using colorimeter
5. Estimation of fluoride content of water sample using colorimeter
6. Analysis of materials by UV-Vis spectroscopy
7. Estimation of current density of electroplating process using Hull cell
8. Electroplating of and Ni & Zn and determination of cathode efficiency
9. Electroless plating of copper
10. Determination of rate of corrosion of metal and alloy using potentiodynamic polarization technique (TAFEL)

Reference Books:

1. Vogel's Textbook of Quantitative Chemical Analysis (8THedition, 2014)
2. Laboratory Manual – Department of Chemistry, Thiagarajar College of Engineering (2021)

18EC280	ELECTRONICS WORKSHOP

Category	L	T	P	Credit
ES	0	0	2	1

Course Outcomes

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

COs	Course Outcome Statement	Weightage*** in %
CO1	Identify various basic electronic components and packages and for understanding the operational principles of instruments, power supply and equipment	10
CO2	Experiment the connection of circuits in general board and specific Printed circuit board.	20
CO3	Develop a schematic circuit and acquire the knowledge for preparing necessary tools and customizing the tools for PCB design	20
CO4	Develop a PCB layout for the required specification, learn to use tools for layout preparation under various design constraints	30
CO5	Acquire the skills of soldering and de-soldering in engineering practice and to learn the safety procedures	10
CO6	Test the assembled circuit in board with engineering IPC standards	10

*** Weightage depends on Bloom's Level, number of contact hours

Assessment Pattern

Cognitive Levels	Model Examination	Terminal Examination
Remember	0	0
Understand	10	10
Apply	10	10
Analyse	10	10
Evaluate	10	10
Create	15	15

List of Experiments/Activities with CO Mapping

1. **Identification of components and packages** (CO1)
   Experimenting with -
   Active and passive components:
      Resistor with various power rating, capacitors and inductors
   Through Hole Packages:
      Axial lead, Radial Lead, Single Inline Package (SIP), Dual Inline Package (DIP), Transistor Outline (TO), Pin Grid Array (PGA)
   Surface mount Packages:
      Metal Electrode Face (MELF), Leadless Chip Carrier (LCC), Small Outline Integrated Circuit (SOIC), Quad Flat Pack (QPF) and Thin QFP (TQFP), Ball Grid Array (BGA), Plastic Leaded Chip Carrier (PLCC)
2. **Exploration of instruments, power supply and equipment (CO1)**
   Experimenting with analog (MI and MC types) and digital meters. Fixed power supply, various power supply, function generator and oscilloscope
3. **Experimenting with breadboard and dotted board connections (CO2)**
   Experimenting with circuit-boards and its internal connection such as bread board and dotted boards
4. **Practising soldering and de-soldering procedures (CO3)**
   Experimenting with circuit board connection by practising soldering and removing the components from the PCB by de-soldering

5. **Development of schematic circuit (CO3)**
   Experimenting with software tool for schematic capture and developing schematic by knowing the specification of the circuit and functionality of the tool. Practicing on available library of components and working through wiring and schematic designing and making new component symbols
6. **Investigation of Printed circuit Board (CO4)**
   Understanding and investigation of the following:
   Various PCB Substrates: Standard FR-4 Epoxy Glass, Multifunctional FR-4, Tetra Functional FR-4, Cyanate Aster, Plyimide Glass, Teflon
   Term and keyword: Footprint, Pad stacks, Vias, Tracks, Color of Layers, PCB Track Size Calculation Formula
   Track rules: Track Length, Track Angle, Rack Joints, Track Size
   PCB tool terms: Schematic Entry, Netlisting, PCB Layout Designing, Prototype Designing, Design Rule Check (DRC), Design For Manufacturing (DFM), PCB Making, Printing, Etching, Drilling
7. **Development of PCB Layout design (CO4)**
   Connecting the schematic from the software netlist, Selecting the Components Footprints as per design, Picking and placing the Component, Making New Footprints, assigning Footprint to components
8. **Practising PCB fabrication (CO5)**
   Printing the design, etching, drilling, interconnecting and packaging electronic circuits (IPC) standards, gerber Generation, soldering and desoldering, component mounting, PCB testing.
   IPC Standard for Schematic Design, Designing, Materials, PCB Fabrication
9. **Assembling components and packing procedures (CO5)**
   For the given PCB the components are fixed and assembled with safety measure in terms of human and components
10. **Practicing circuit in PCB testing procedures (CO6)**
    Continuity testing of PCB without components and output signal measurement procedures with components

Learning Resources

1. Teachers Soft copy manual for Electronic components and symbols
2. https://img.ozdisan.com/content/library/IC_Packages.pdf
3. CAD for Schematic and PCB Design Software.
4. Printed circuit board design techniques for EMC compliance, a handbook for designers 2nd edition. Mark I.Montrose, Wily publication 2016
5. http://www.ipc.org/4.0_Knowledge/4.1_Standards/OEM-Standards/IPC-OEM-Stds-A4-English-1111-ONLINE.pdf

18MA210	MATRICES AND ORDINARY DIFFERENTIAL EQUATIONS	Category	L	T	P	Credit
		BS	3	0	0	3

Preamble

In engineering, particularly Solid Mechanics, Aerodynamics, Fluid Flow, Heat Flow and Robotics have application that requires an understanding of Vector Calculus and Differential Equations. Also Mathematical tool Laplace Transforms is very much essential to solve ordinary differential equations that occur in the above areas. Eigen values and Eigenvectors are extremely important while creating engineering models in control systems, designing bridges, communication systems and searching algorithms. The course is designed to impart the knowledge and understanding of the above concepts to all Engineers and apply them in their areas of specialization.

Prerequisite

18MA110 Engineering Calculus

Course Outcomes

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

CO Number	Course Outcome Statement	Weightage in %
CO1	Compute the Laplace transform and inverse Laplace transform of different functions	10%
CO2	Solve the given initial value problem using Laplace transform	15%
CO3	Apply matrix algebra techniques for transformations of conic sections into principle axes	25%
CO4	Solve the model developed for the given system using ordinary differential equation	25%
CO5	Compute divergence and curl of vector functions	10%
CO6	Apply the concepts of vector differentiation and vector integration to fluid flow and heat transfer problems	15%

CO Mapping with CDIO Curriculum Framework

CO	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components
		Cognitive	Affective	Psychomotor	
CO1	TPS2	K2	A2	-	1.1
CO2	TPS3	K3	A3	-	1.1
CO3	TPS3	K3	A3	-	1.1
CO4	TPS3	K3	A3	-	1.1
CO5	TPS2	K2	A2	-	1.1
CO6	TPS3	K3	A3	-	1.1

Mapping with Programme Outcomes and Programme Specific Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1.	S	M			-	-	-	-		-	-	
CO2.	S	S	S		-	-	-	-	M	-	-	M
CO3.	S	S		S	-	-	-	-		-	-	S
CO4.	S	S	S	S	-	-	-	-	M	-	-	M
CO5.	S	M										
CO6.	S	S	S									

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

Cognitive Levels	Continuous Assessment Tests			Assignment			Terminal Examination
	1	2	3	1	2	3	
Remember	10	10	10				10
Understand	30	30	30				20
Apply	60	60	60	100	100	100	70
Analyse	00	00	00				00
Evaluate	00	00	00				00
Create	00	00	00				00

Sample Questions for Course Outcome Assessment**

Course Outcome 1

1. Show that Laplace transform of $\frac{1}{\sqrt{t}}$ is $\frac{\sqrt{\pi}}{s}$.
2. Identify the inverse Laplace transform of $\log\left(\frac{s^2+1}{(s-1)^2}\right)$.
3. Discuss any three properties of Laplace transforms.

Course Outcome 2

1. Apply Laplace transform solve $y''+9y=\delta\left(t-\frac{\pi}{2}\right)$, $y(0)=2,\ y'(0)=0$.
2. By using Laplace transform, solve $x''(t)+3x'(t)+2x(t)=2(t^2+t+1)$; with $x(0)=2, x'(0)=0$.
3. Apply convolution theorem, Solve the Voltera integral equation of the second kind $y(t)-\int_0^t y(\tau)\sin(t-\tau)d\tau=t$.

Course Outcome 3

1. An elastic membrane in the $x_1\,x_2$ plane with boundary circle $x_1^2+x_2^2=1$ is stretched so that a point $P;(x_1,x_2)$ goes over into the point $Q;(y_1,y_2)$ given by
   $y_1=5x_1+3x_2$
   $y_2=3x_1+5x_2$
   Find the principal directions that is the directions of the position vector X of P for which the direction of the position vector Y of Q is the same or exactly opposite. Predict the boundary circle take under this deformation?
2. Discover the type of conic section the following quadratic form represents and transform it to principal axes: $Q=17x_1^2-30x_1x_2+17x_2^2=128$.
3. Diagonalize the matrix $\begin{bmatrix} 6 & 0 & 0 \\ 12 & 2 & 0 \\ 21 & -6 & 9 \end{bmatrix}$

Course Outcome 4

1. Reduce to first order and solve $y''-y'=0$
2. Compute the general solution for $y''+y'+(\pi^2+1/4)y=e^{-x/2}\sin\pi x$
3. Solve $(x^2D^2-4xD-6)y=c$

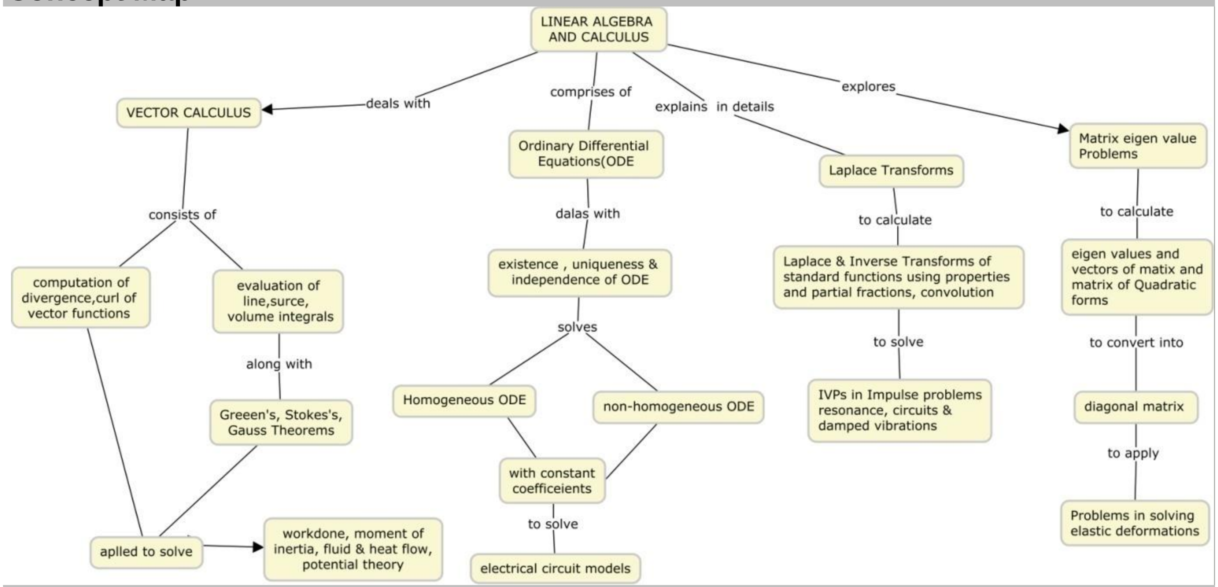
Course Outcome 5

1. Predict the value of $div(curl\vec{F})$.
2. If ϕ_1 and ϕ_2 are scalar point functions and $\vec{F}$ is a vector point function such that $\phi_1 \vec{F} = \nabla \phi_2$ then identify $\vec{F}.curl\,\vec{F}$.
3. Estimate $curl\,\vec{v}$, where $\vec{v} = \left[e^{-z^2}, e^{-x^2}, e^{-y^2}\right]$.

Course Outcome 6

1. Predict the work done by the force $\vec{F} = [y^2, -x^2]$ acting on a particle in $y = 4x^2$ from (0,0) to (1,4).
2. Compute the amount of fluid that crosses the surface in a flow per unit time at any one instant, if the velocity field is $\vec{v} = y\vec{i} + x\vec{j} + z\vec{k}$ over the boundary of the region enclosed by the paraboloid z = 1- x^2 - y^2 and the plane z = 0.
3. Apply Stokes theorem to compute $\int_C \vec{F}.\vec{r}'\,ds$ where $\vec{F} = [y, xz^3, -zy^3]$ and C is circle $x^2 + y^2 = 4, z = -3$.

Concept Map



Syllabus

LAPLACE TRANSFROMS: Laplace transform, Linearity, First Shifting theorem – Transforms of derivatives and integrals, ODEs – Unit step function, Second shifting theorem – Short Impulses, Dirac's delta function, partial fractions – Convolution, Integral Equations – Differentiation and integration of transforms. **MATRIX EIGEN VALUE PROBLEM:** The Matrix Eigen value Problem, Determining Eigenvalues and Eigenvectors – Some Applications of Eigen value Problems – Symmetric, Skew symmetric and orthogonal matrices – Eigen bases, Diagonalization, Quadratic forms. **ORDINARY DIFFERENTIAL EQUATION:** Homogeneous Linear ODEs of second order – Homogeneous Linear ODEs with constant coefficients – Euler Cauchy Equation – Existence and uniqueness of solutions, Wronskian - Nonhomogeneous ODE – Modelling: Electric Circuits- Solution by Variation of Parameters. **VECTOR CALCULUS:** Divergence of a Vector Field- Curl of a Vector Field- Line Integrals- Path independence of line integrals- Green's Theorem in the plane- Surface Integrals- Triple Integrals, Divergence Theorem of Gauss- Applications of the Divergence Theorem- Stoke's Theorem.

Learning Resources

1. Erwin Kreszig, "Advanced Engineering Mathematics",10th edition, Wiley, 2017.
    a. Laplace transforms : [sections 6.1,6.2,6.3,6.4,6.5,6.6]
    b. Matrix eigen value problem : [sections 8.1,8.2,8.3,8.4]
    c. Ordinary differential equations : [sections 2.1,2.2,2.5,2.6,2.7,2.9,2.10]
    d. Vector calculus : [sections 9.8.9.9,10.1,10.2,10.4,10.6, 10.7,10.8,10.9]
2. Peter V.O'Neil, "Advanced Engineering Mathematics", 7th ed., Cengage Learning, 2017.
3. Glyn James, “Advanced Modern Engineering Mathematics”, Pearson Education, New Delhi, 2016.
4. Jain R.K. and Iyengar S.R.K., “Advanced Engineering Mathematics”, Narosa Publications, New Delhi, 3rd Edition, 2007.
5. Made Easy Team, Engineering Mathematics, Made Easy Publications, 2018.

Course Contents and Lecture Schedule

Module No.	Topic	No. of Hours	Course Outcome
1.	**LAPLACE TRANSFORMS**		
1.1	Laplace Transform. Linearity. First Shifting Theorem (*s*-Shifting)	2	CO1
1.2	Transforms of Derivatives and Integrals. ODEs	2	CO2
1.3	Unit Step Function (Heaviside Function). Second Shifting Theorem (*t*-Shifting)	1	CO1
1.4	Short Impulses. Dirac’s Delta Function. Partial Fractions	1	CO1
1.5	Convolution. Integral Equations	2	CO2
1.6	Differentiation and integration of transforms	1	CO1
2	**MATRICES EIGEN VALUE PROBLEMS**		
2.1	Determining Eigenvalues and Eigenvectors	2	CO3
2.2	Some Applications of Eigenvalue Problems	1	CO3
2.3	Symmetric, Skew-Symmetric, and Orthogonal Matrices	2	CO3
2.4	Eigenbases. Diagonalization.	2	CO3
2.5	Quadratic Forms	2	CO3
3	**ORDINARY DIFFERENTIAL EQUATION**		
3.1	Homogeneous Linear ODEs of Second Order	2	CO4
3.2	Homogeneous Linear ODEs with Constant Coefficients	1	CO4
3.3	Euler–Cauchy Equations	1	CO4
3.4	Existence and Uniqueness of Solutions. Wronskian	1	CO4
3.5	Nonhomogeneous ODEs	2	CO4
3.6	Solution by Variation of Parameters	2	CO4
4	**VECTOR CALCULUS**		
4.1	Divergence and Curl of a Vector Field	2	CO5
4.2	Line Integrals	2	CO6
4.3	Green’s Theorem in the Plane	1	CO6
4.4	Surface Integrals	1	CO6
4.5	Triple Integrals. Divergence Theorem of Gauss	1	CO6
4.6	Applications of the Divergence Theorem	1	CO6
4.7	Stoke’s Theorem	1	CO6
	TOTAL No. of Hours	36	

Course Designers

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18EC220	NETWORK THEORY	Category	L	T	P	Credit
		PC	2	1	0	3

Preamble

A network refers to any interconnected set of objects. An 'electrical network' is an interconnection of electrical elements such as resistors, inductors, capacitors, transformers, diodes, sources, controlled sources and switches. All electrical and electronic devices can be represented by electric circuits. So formulation of equivalent circuit and the study of behavior of the networks are formulated by analyzing the equivalent circuit with network laws and theorems. The objective is to acquaint the students with the fundamental principles of circuit theory and network analysis.

Prerequisite

NIL

Course Outcomes

On the successful completion of the course students will be able to

CO#	Course Outcome Statement	Weightage in %
CO1	Apply Network solutions method to solve electrical networks	20
CO2	Apply Network theorems to simplify electrical networks.	15
CO3	Apply Sinusoidal Steady state analysis methods for RL, RC and RLC circuits.	15
CO4	Examine the transient and steady state response of RL, RC and RLC circuits in time domain.	15
CO5	Examine the transient and steady state response of RL, RC and RLC circuits in frequency domain.	15
CO6	Compute Linear two port network parameters.	20

CO Mapping with CDIO Curriculum Framework

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS3	Apply	Value	-	1.2.1, 2.1.1, 2.1.2, 2.4.2, 2.4.6, 2.5.1, 3.1.1, 3.2.3, 4.5.5, 4.6.2
CO2	TPS3	Apply	Value	-	1.2.1, 2.1.1, 2.1.2, 2.5.1, 3.1.1, 3.2.3, 4.5.5, 4.6.2
CO3	TPS3	Apply	Value	-	1.2.1,, 2.1.1, 2.1.2, 2.5.1, 3.1.1, 3.2.3, 4.5.5, 4.6.2
CO4	TPS4	Analyse	Organise	Complex Overt Responses	1.2.1, 2.1.1, 2.1.2, 2.1.3, 2.5.1
CO5	TPS4	Analyse	Organise	Complex Overt Responses	1.2.1, 2.1.1, 2.1.2, 2.1.3, 2.5.1
CO6	TPS3	Apply	Value	Mechanism	1.2.1, 2.1.1, 2.1.2, 2.5.1

Mapping with Programme Outcomes and Programme Specific Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	S	M	L	-	L	-	-	L	L	L	-	L	M	-	L
CO2	S	M	L	-	L	-	-	L	L	L	-	L	M	-	L
CO3	S	M	L	-	L	-	-	L	L	L	-	L	M	-	L
CO4	S	S	M	L	L	-	-	L	L	L	-	L	S	-	L
CO5	S	S	M	L	L	-	-	L	L	L	-	L	S	-	L
CO6	S	M	L	-	L	-	-	L	L	L	-	L	M	-	L

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

Cognitive Levels	Continuous Assessment Tests			Assignment			Terminal Examination
	1	2	3	1	2	3	
Remember	0	0	0	0	0	0	0
Understand	20	20	20	0	0	0	20
Apply	80	20	60	100	30	30	60
Analyse	0	60	20	0	40	40	20
Evaluate	0	0	0	0	0	0	0
Create	0	0	0	0	0	0	0

Assessment Pattern: Psychomotor

Psychomotor Skill	Assignment-1	Assignment-2	Assignment-3
Perception	-	-	-
Set	-	-	-
Guided Response	-	-	-
Mechanism	-	30	30
Complex Overt Responses	-	-	-
Adaptation	-	-	-
Origination	-	-	-

Sample Questions for Course Outcome Assessment

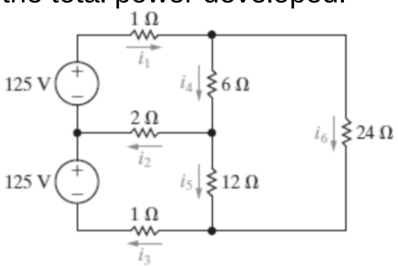
Course Outcome 1 (CO1):

1. A pair of automotive headlamps is connected to a 12 V battery via the arrangement shown below. In the figure, the triangular symbol is used to indicate that the terminal is connected directly to the metal frame of the car.

a) Construct a circuit model using resistors and an independent voltage source.

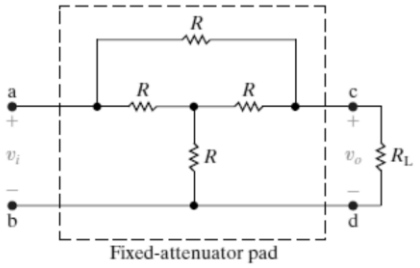
b) Identify the correspondence between the ideal circuit element and the symbol component that it represents.

2. The circuit shown below is a DC model of a residential power distribution circuit.
a) Use the node-voltage method to find the branch currents i_1-i_6
b) Test your solution for the branch currents by showing that the total power dissipated equals the total power developed.



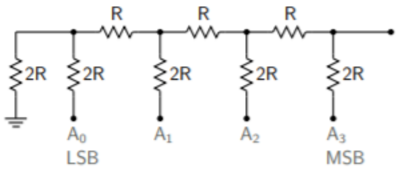
Course Outcome 2 (CO2):

1. The fixed-attenuator pad shown below is called a *bridged tee*. Use a Y-to- transformation to show that R_{ab}=R_L if R=R_L

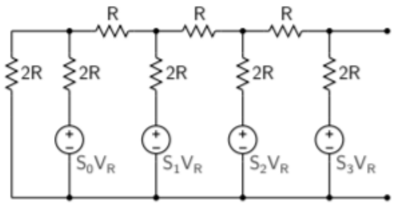


Fixed-attenuator pad

2. In the R-2R ladder of DAC shown below, Node Ak is connected to VR if input bit Sk is 1; else, it is connected to ground.



The original Network is equivalent to



Find out the Thevenin's resistance .

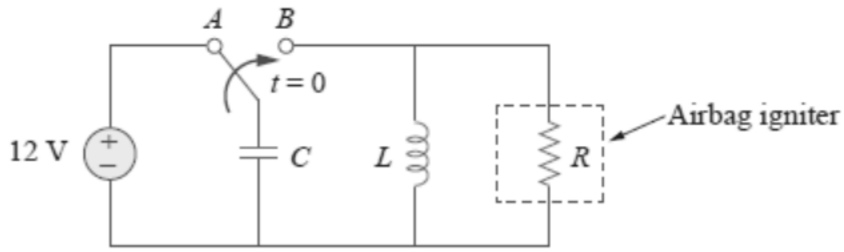
3. A loudspeaker is connected to an amplifier as shown in figure given below. If a 10-Ω loudspeaker draws the maximum power of 12 W from the amplifier, determine the maximum power a 4-Ω loudspeaker will draw.

Course Outcome 3 (CO3):

1. A personal computer with a monitor and keyboardrequires 40 W at 115 V (rms). Calculate the rms value of the current carried by itspower cord.
2. A laser printer for the personal computer in(a) is rated at 90 W at 115 V (rms). If this printeris plugged into the same wall outlet as the computer,what is the rms value of the current drawnfrom the outlet?
3. In a radio tuner resonance is produced by an incoming electromagnetic wave rather than an AC voltage source. The tuner circuit consists of an inductor (inductance coil) and a variable capacitor. Changing the station changes the value of the capacitance. Each radio station transmits electromagnetic waves at a particular frequency and all of these frequencies from the various stations reach the antenna of your radio. Only the frequency corresponding to the natural frequency of the tuner circuit will produce a large enough current to be picked up and then amplified. An FM radio tuner is set to receive a station. The tuner has a 1.4 microHenry ($1\mu H = 1 \times 10^{-6}$ H) inductance coil and a variable capacitor that is set to 1.8 picoFarad ($1pF = 1 \times 10^{-12}$ Farad). What is the frequency of the waves emitted by this station? (Hint: FM stations broadcast from 87.5MHz to 107.5 MHz. Recall that $1MHz = 1 \times 10^{6}$ Hz.)

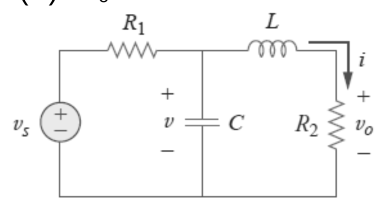
Course Outcome 4 (CO4):

1. In a RLC series circuit, the initial values are i_L=5A and $V_c(0)$=1V. The source voltage is V_s =12 sin 5t. Find i(t) for t > 0.
2. An automobile airbag igniter is modeled by the circuit shown below. Determine the time it takes the voltage across the igniter to reach its first peak after switching from *A* to *B*. Let R=3Ω , C=1/30F and *L* = *60*mH.

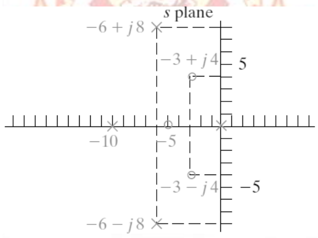


Course Outcome 5 (CO5):

1. Obtain the transfer function H(S)= v_o/i.

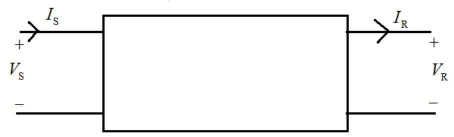


2. Obtain the network function for the given pole –zero plot shown below and Explain its stability.

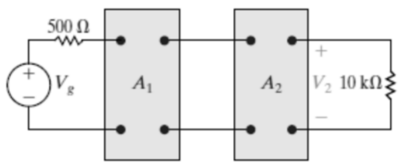


Course Outcome 6 (CO6):

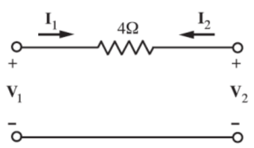
1. Representing a transmission line by the two port network, in terms of ABCD parameters,
   a) Express V_s which is the sending end voltage, in terms of V_R, Which is the receiving end voltage, and I_R the receiving end current,
   b) Express the sending end current I_s , in terms of V_R and I_R.



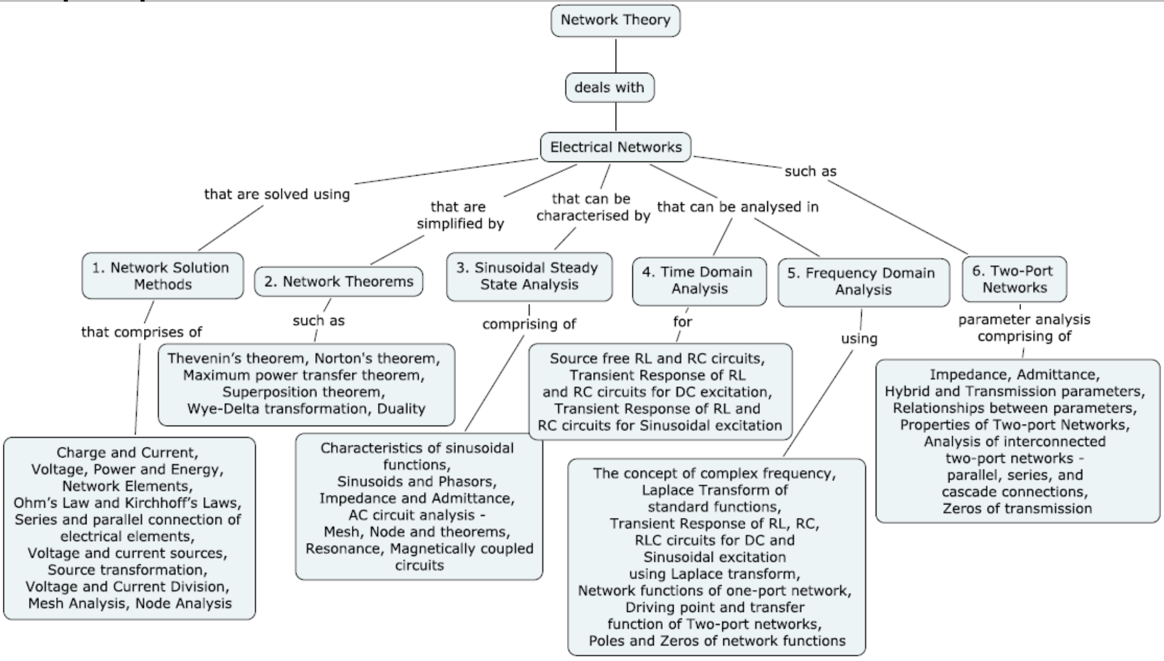
2. Two identical amplifiers are connected in cascade, as shown below. Each amplifier is described in terms of its *h* parameters. The values are h_{11}=1000Ω, h_{12}=.0015, h_{21}=100, h_{22}=mho. Find voltage gain V_2/V_g



3. Find the **ABCD** parameters for the 4Ω resistor in the network shown below. Also show that the **ABCD** Parameters for a single 16Ω resistor can be obtained by **$(ABCD)^4$**



Concept Map



Syllabus

Network Solution Methods : Charge and Current, Voltage, Power and Energy, Network Elements, Ohm's Law and Kirchhoff's Laws, Series and parallel connection of electrical elements, Voltage and current sources, Source transformation, Voltage and Current Division, Mesh Analysis, Node Analysis. **Network Theorems:** Thevenin's theorem, Norton's theorem, Maximum power transfer theorem, Superposition theorem, Wye-Delta transformation, Duality. **Sinusoidal Steady State Analysis:** Characteristics of sinusoidal functions, Sinusoids and Phasors, Impedance and Admittance, AC circuit analysis - Mesh, Node and theorems, Resonance, Magnetically coupled circuits. **Time Domain Analysis:** Source free RL and RC circuits, Transient Response of RL and RC circuits for DC excitation, Transient Response of RL and RC circuits for Sinusoidal excitation. **Frequency Domain Analysis:** The concept of complex frequency, Laplace Transform of standard functions, Transient Response of RL, RC, RLC circuits for DC and Sinusoidal excitation using Laplace transform, Network functions of one-port network, Driving point and transfer function of Two-port networks, Poles and Zeros of network functions. **Two-Port Networks**- Impedance, Admittance, Hybrid and Transmission parameters, Relationships between parameters, Properties of Two-port Networks, Analysis of interconnected two-port networks - parallel, series, and cascade connections, Zeros of transmission.

Learning Resources

1. Hayt, Kemmerley and Durbin, "Engineering Circuit Analysis", 8th edition, Tata McGraw-Hill, 2013.
2. DeCarlo, R.A. and Lin, P.M., "Linear Circuit Analysis: Time Domain, Phasor and Laplace Transform Approaches", Oxford University Press. 2003.
3. M.E. Van Valkenburg, "Network Analysis", 3rd edition, Pearson, 2006.
4. Charles Alexander and Matthew Sadiku, "Fundamentals of Electric Circuits", 6th Edition, 2017.
5. Dr. Nagendra Krishnapura IIT Madras , Basic Electrical Circuits , NPTEL video Lectures: https://nptel.ac.in/courses/117106108/
6. SC Dutta Roy, Circuit Theory, NPTEL Video Lectures: http://nptel.iitm.ac.in/video.php?subjectId=108102042

Course Contents and Lecture Schedule

No.	Topic	No. of Hours	COs
1	**Network Solution Methods**		
1.1	Charge and Current, Voltage, Power and Energy, Network Elements, Ohm's Law and Kirchhoff's Laws, Series and parallel connection of electrical elements	2	CO1
1.2	Voltage and current sources, Voltage and Current Division, Source transformation	1	CO1
1.3	Mesh analysis	2	CO1
1.4	Node Analysis	2	CO1
2	**Network Theorems**		
2.1	Thevenin's theorem	1	CO2
2.2	Norton's theorem	1	CO2
2.3	Maximum power transfer theorem	1	CO2
2.4	Superposition theorem	1	CO2
2.5	Wye-Delta transformation, Duality	1	CO2
3	**Sinusoidal Steady state analysis**		
3.1	Characteristics of sinusoidal functions	1	CO3
3.2	Sinusoids and Phasors	1	CO3
3.3	Impedance and Admittance	1	CO3
3.4	AC circuit analysis- Mesh, Node, theorems	1	CO3
3.5	Resonance, Magnetically coupled circuits	1	CO3
4	**Time Domain Analysis:**		
4.1	Source free RL and RC circuits	2	CO4
4.2	Transient Response of RL and RC circuits for DC excitation	2	CO4
4.3	Transient Response of RL and RC circuits for Sinusoidal excitation	2	CO4
5.	**Frequency Domain Analysis**		
5.1	The concept of complex frequency, Laplace Transform of standard functions	1	CO5
5.2	Transient Response of RL, RC and RLC circuits for DC and Sinusoidal excitation using Laplace transform	1	CO5
5.3	Network functions of one-port network, Driving point and transfer function of Two-port networks	2	CO5
5.4	Poles and Zeros of network functions	2	CO5
6	**Two-Port Networks**		
6.1	Network parameters - Impedance, Admittance, Hybrid and Transmission parameters	2	CO6
6.2	Relationships between parameters, Properties of Two-port networks	3	CO6
6.3	Analysis of interconnected Two-port networks -parallel, series, and cascade connections, zeros of transmission	2	CO6

Course Designers:

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18EC260	DIGITAL SYSTEM DESIGN	Category	L	T	P	Credit
		PC	2	0	2	3

Preamble

The course “18EC260: Digital System Design” is offered as theory cum practical course in concurrent with the course on “Electronic Devices”. The objective of this course is to give hands on training for the students to understand the theory of basic combinational and sequential circuits of digital systems. This course relies on extensive use of Hardware Description Language for describing and implementing digital logic designs on state-of-the-art FPGA.

Prerequisite

NIL

Course Outcomes

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

CO Number	Course Outcome Statement	Weightage*** in %
CO1	Understand the significance of Digital information Systems and the structure of various number systems.	10
CO2	Apply the principles of Boolean algebra to simplify the logic functions.	10
CO3	Design simple combinational logic circuits using basic gates.	15
CO4	Investigate the sequential behaviour of digital logic circuits using Finite State Machine	15
CO5	Understand the memory architecture and their essential building blocks.	10
CO6	Implement various combinational/sequential modules of digital system using HDL coding.	40

*** Weightage depends on Bloom’s Level, number of contact hours

CO Mapping with CDIO Curriculum Framework

CO #	**TCE Proficiency Scale**	**Learning Domain Level**			**CDIO Curricular Components (X.Y.Z)**
		Cognitive	**Affective**	**Psychomotor**	
CO1	TPS2	Understand	Respond	-	1.2.3, 2.4.6, 3.2.3
CO2	TPS3	Apply	Value	Mechanism	1.2.3,2.1.1, 2.3.4, 2.4.6, 2.5.1, 3.1.1, 3.2.3, 4.5.1, 4.6.1
CO3	TPS3	Apply	Value	Mechanism	1.2.3, 2.1.1, 2.3.4, 2.5.1, 3.1.1, 3.2.3, 4.5.1, 4.6.1
CO4	TPS3	Analyse	Organise	Complex Overt Responses	1.2.3, 2.1.1, 2.3.4, 2.5.1, 3.1.1, 3.2.3, 4.5.1, 4.6.1
CO5	TPS2	Understand	Respond	Guided Response	1.2.3, 2.4.6, 3.2.3,
CO6	TPS3	Analyse	Organise	Complex Overt Responses	1.2.3, 2.1.1, 2.3.4, 2.5.1, 3.1.1, 4.5.1, 4.6.1

Mapping with Programme Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO 11	PO 12	PSO1	PSO2	PSO2
CO1	M	L		-	-	-	-	L	L	L	-	L	L	-	L
CO2	S	M	L	-	S	-	-	L	L	L	-	L	M	L	L
CO3	S	M	L	-	S	-	-	L	L	L	-	L	M	L	L
CO4	S	M	L	L	S	-	-	L	L	L	-	L	M	L	L
CO5	S	S	M	L	M	-	-	L	L	L	-	L	S	-	L
CO6	S	S	M	L	S	-	-	L	L	L	-	L	S	L	L

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	0	0	0	0
Understand	20	20	20	20
Apply	80	60	60	60
Analyse	0	20	20	20
Evaluate	0	0	0	0
Create	0	0	0	0

Assessment Pattern: Psychomotor

Psychomotor Skill	Practical
Perception	-
Set	-
Guided Response	-
Mechanism	80
Complex Overt Responses	20
Adaptation	-
Origination	-

Sample Questions for Course Outcome Assessment

Course Outcome 1 (CO1):

1. Discuss the advantages of processing information in digital form.
2. Describe the software aspects of Digital design.
3. Convert the hexadecimal 64CD into binary, and then convert it from binary to octal

Course Outcome 2 (CO2):

1. Draw the logic diagram of the circuits that implements the original and simplified expressions of ABC+A'B+ABC'. Find the cost of both circuits.
2. Simplify the given Boolean function using four variable Maps
   A'B'C'D'+AC'D'+B'CD'+A'BCD+AB'C

Course Outcome 3 (CO3):

1. An 8×1 multiplexer has inputs A, B, and C connected to the selection input S_2,S_1 and S_0 respectively. The data input I_0 through I_7 are as follows:
   $I_1= I_2=I_7=0; I_3=I_5=1; I_0=I_4=D$ and $I_6=D'$
2. Design a combinational circuit that converts four bit gray code to 4 bit binary. Implement the circuit using Exclusive-OR gates. Using case statement, write the verilog model of the circuit.
3. A combinational circuit is specified by the following boolen functions:
   F1(A,B,C)=∑(1,4,6), F2(A,B,C)=∑(3,5), F3(A,B,C)=∑(2,4,6,7)
   Implement the circuit wth a decoder constructed with NAND gates and NAND or NOR gates connected to the decoder outputs. Minimize the number of inputs in the external gates.

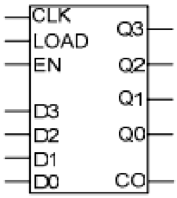
Course Outcome 4 (CO4):

1. A sequential circuit with two D flipflops A and B, two inputs x and y, and the output z is specified by the following next state and output equations.
   $$A(t+1) = xy'+xB$$

$$B(t+1) = xA+xB'$$
$$z = A$$

(a) Draw the logic diagram of the circuit
(b) List the state table for the sequential circuit.
(c) Draw the corresponding state diagram.

2. Use as many as necessary of the following counter with minimal external gates to design a counter that counts from 0 to 20.

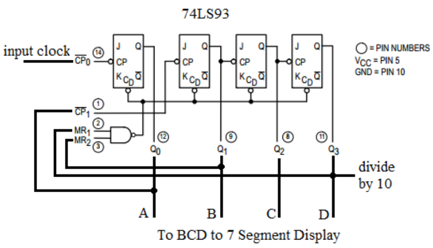


Course Outcome 5 (CO5):

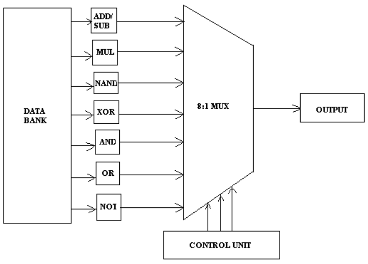
1. Investigate a 16×8 ROM that converts a four bit binary number to its corresponding two-digit BCD number by finding the truthtable. Each BCD may be represented using 4 bit. Draw the block diagram of the same memory.
2. Draw the block diagram of 8×4 ROM that implements the following Boolean function
   $A(x,y,z)=\sum(0,2,4,6)$
   $B(x,y,z)=\sum(0,1,3,5)$
   $C(x,y,z)=\sum(1,4)$
   $D(x,y,z)=\sum(0,1,3,5,7)$

Course Outcome 6 (CO6):

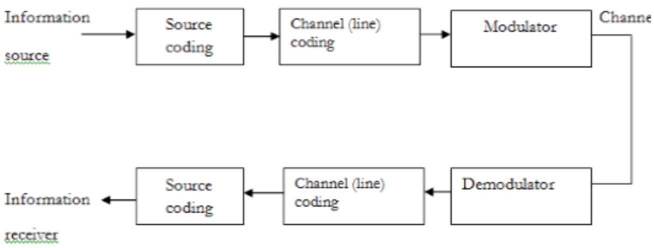
1. Implement the main components of an Digital clock



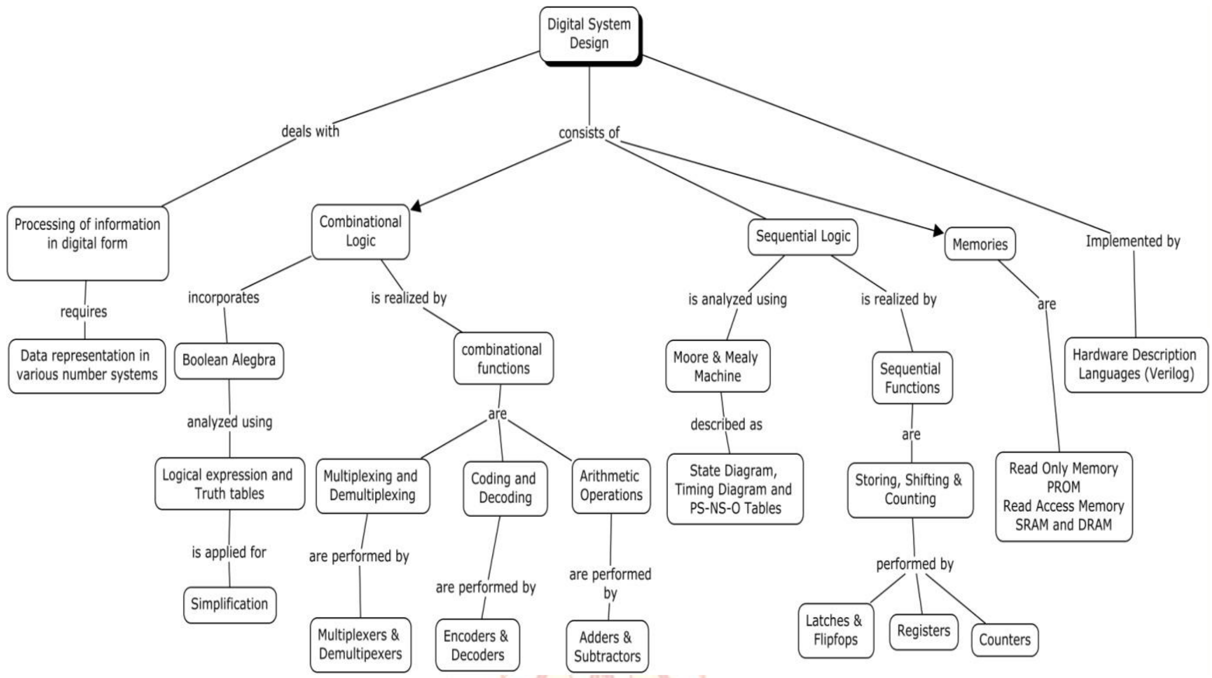
2. Implement the main components of an ALU



3. Implement the basic building blocks of digital communication system



Concept Map



Syllabus

Theory:

Digital Information Processing: Basis of Digital System, Software and Electronic aspects of Digital Design, Digital ICs, Number systems and Codes, Methods of base conversions, Code Converters and their Applications. **Boolean Algebra and Switching Functions:** Basic postulates and fundamental theorems of Boolean algebra; Standard representation of logic functions – Sum Of Product (SOP) and Product Of Sum (POS) forms; NAND and NOR Implementation - Simplification of switching functions – Karnaugh Maps and Quine-McCluskey tabular methods. **Combinational Logic Design:** Adders/subtractors, Fast adder, Magnitude comparator, Multiplexer Demultiplexer, Encoders, Decoders, Multiplier, and Parity generator, Standard IC Data Sheets and its Descriptions, HDL implementation of combinational circuits. **Sequential Logic Design:** Building blocks like S-R, JK and Master-Slave JK FF, Edge triggered FF, Universal Shift register, Ripple and Synchronous counters, HDL Implementation of Sequential Circuits, Design of synchronous Finite State Machine. **Memories:** Read Only Memory, Programmable ROM, Read Access Memory: SRAM, and DRAM.

Practical:

1. Implementation of combinational circuits
    a. Multiplexer and DeMultiplexer
    b. Encoder and Decoder
2. Implementation of Arithmetic Circuits
    a. Adder
    b. Subtractor
    c. Multiplier
    d. Comparator
3. Implementation of code converters
    a. Gray code to Excess-3 code.
    b. BCD to Seven segment display
4. Implementation of sequential circuits
    a. Universal Shift register
    b. Counter

5. Implementation of Sequence generator in FSM approach.
6. Design and implement a final digital project of their choice, in areas such as games, music, digital filters, wireless communications, and graphics.

Learning Resources

1. John F Wakerly, **“**Digital Design Principles & Practices” 4th Edition, Prentice Hall, 2005.
2. M. Morris Mano and Michael D. Ciletti, “Digital Design: With an Introduction to the Verilog HDL”, 5th Edition, Prentice Hall 2012.
3. Stephen D. Brown, and Zvonko Vranesic, "Fundamentals of Digital Logic with Verilog Design, 2nd Edition," McGraw Hill, June, 2007.
4. Thomas L. Floyd, Digital Fundamentals, 10th ed. Prentice Hall, 2009
5. William I. Fletcher,” An Engineering Approach to Digital Design,1st Edition reprint 2015.
6. NPTEL course Digital Circuits: https://nptel.ac.in/courses/117106086/

Course Contents and Lecture Schedule

Module No.	Topic	No.of Lectures	CO
1	**Digital Information Processing**		
1.1	Basics of Digital Systems, Software and Electronic aspects of Digital Design, Digital ICs.	2	CO1
1.2	Number systems and Codes, Methods of base conversions	1	CO1
1.3	Code Converters and their Applications	1	CO1
2	**Boolean Algebra and Switching Functions**		
2.2	Basic postulates and fundamental theorems of Boolean algebra	1	CO2
2.3	Standard representation of logic functions - SOP and POS forms, NAND and NOR Implementation	1	CO2
2.4	Simplification of switching functions – Karnaugh Map	2	CO2
2.5	Quine-McCluskey Tabular methods	2	CO2
2.6	Practical – Simplification of Boolean functions	4	CO6
3	**Combinational logic Design**		
3.1	Adders/subtractors, fast adder, magnitude comparator	2	CO3
3.2	Multiplexer Demultiplexers, encoders, decoders	2	CO3
3.3	Multiplier, Parity generator.	2	CO3
3.4	Standard IC Data Sheets and its Descriptions	4	CO6
3.5	Practical - HDL implementation of combinational circuits	4	CO6
4	**Sequential Logic Design**		
4.1	Building blocks like S-R, JK and Master-Slave JK FF, Edge triggered FF	2	CO4
4.2	Universal Shift register	2	CO4
4.3	Ripple and Synchronous counters	2	CO4
4.4	Design of synchronous FSM	2	CO4
4.5	Practical – HDL Implementation of Sequential Circuits	8	CO6
5	**Memory and Programmable Logic Devices**		
5.1	Read Only Memory	1	CO5
5.2	Programmable ROM	2	CO5
5.3	Read Access Memory -SRAM, and DRAM.	1	CO5
	Total	48	

Course Designers:

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18EC270	CIRCUITS AND DEVICES LABORATORY	Category	L	T	P	Credit
		PC	0	0	1	1

Preamble

The goal is to supplement the theory courses '18EC230 Electronic Devices' and '18EC220 Network Theory' by giving a practical exposure of the operation of electric and electronic circuits to the students. The course also provides experience in analysing and testing of electric and electronic circuits using hardware implementation.

Prerequisite

NIL

Course Outcomes

On the successful completion of the course students will be able to

CO#	Course Outcome Statement	Weightage in %
CO1	Experimental verifications of Kirchhoff's Laws	10
CO2	Experimental verifications of Network theorems	20
CO3	Simulate to study the transient and steady-state response of first order RL and RC circuits	10
CO4	Experimental determination of Resonance frequency of Series and Parallel RLC Circuits.	10
CO5	Demonstrate the I-V characteristics, Static and Dynamic resistance of PN Junction Diode and Zener diode	10
CO6	Construction of Regulated DC power supply unit	20
CO7	Demonstrate the I-V characteristics of BJT and MOSFET. Also the characteristics of opto-coupler built using LED and LDR	20

CO Mapping with CDIO Curriculum Framework

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS3	Apply	Value	Mechanism	1.2.4, 2.1.1, 2.1.2, 2.2.2, 2.2.3, 2.4.2, 2.4.6, 2.5.1, 3.1.2, 3.2.3, 4.6.2
CO2	TPS3	Apply	Value	Mechanism	1.2.4, 2.1.1, 2.1.2, 2.2.2, 2.2.3, 2.4.2, 2.4.6, 2.5.1, 3.1.2, 3.2.3, 4.6.2
CO3	TPS3	Apply	Value	Mechanism	1.2.4, 2.1.1, 2.1.2, 2.2.2, 2.2.3, 2.4.2, 2.4.6, 2.5.1, 3.1.2, 3.2.3, 4.6.2
CO4	TPS3	Apply	Value	Mechanism	1.2.4, 2.1.1, 2.1.2, 2.2.2, 2.2.3, 2.4.2, 2.4.6, 2.5.1, 3.1.2, 3.2.3, 4.6.2
CO5	TPS3	Apply	Value	Mechanism	1.2.4, 2.1.1, 2.1.2, 2.2.2, 2.2.3, 2.4.2, 2.4.6, 2.5.1, 3.1.2, 3.2.3, 4.6.2
CO6	TPS3	Apply	Value	Mechanism	1.2.4, 2.1.1, 2.1.2, 2.2.2, 2.2.3, 2.4.2, 2.4.6, 2.5.1, 3.1.2, 3.2.3, 4.6.2
CO7	TPS3	Apply	Value	Mechanism	1.2.4, 2.1.1, 2.1.2, 2.2.2, 2.2.3, 2.4.2, 2.4.6, 2.5.1, 3.1.2, 3.2.3, 4.6.2

Mapping with Programme Outcomes and Programme Specific Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	S	M	L	-	S	-	-	L	S	S	L	-	S	-	L
CO2	S	M	L	-	S	-	-	L	S	S	L	-	S	-	L
CO3	S	M	L	-	S	-	-	L	S	S	L	-	S	-	L
CO4	S	M	L	-	S	-	-	L	S	S	L	-	S	-	L
CO5	S	M	L	-	S	-	-	L	S	S	L	-	S	-	L
CO6	S	M	L	-	S	-	-	L	S	S	L	-	S	-	L
CO7	S	M	L	-	S	-	-	L	S	S	L	-	S	-	L

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

Cognitive Levels	Model Examination	Terminal Examination
Remember		
Understand		
Apply	70	70
Analyse		
Evaluate		
Create		

Assessment Pattern: Psychomotor

Psychomotor Skill	Practical Component
Perception	
Set	
Guided Response	
Mechanism	30
Complex Overt Responses	
Adaptation	
Origination	

List of Experiments/Activities with CO Mapping

1. Verifications of Kirchhoff's Voltage Law and Kirchhoff's Current Law.
2. Demonstrate the I-V characteristics, Transient response of PN Junction Diode and Zener diode.
3. Verifications of Thevenin's theorem and Norton's theorem.
4. Construct constant DC power supply unit using bridge rectifier and Zener diode regulator.
5. Verifications of Maximum power transfer theorem and Superposition theorem.
6. Demonstrate the I-V characteristics of BJT and MOSFET.
7. Transient and steady-state analysis of first order RL and RC circuits.
8. Demonstrate the characteristics of opto-coupler built using LED and LDR.
9. Determination of Resonance frequency of series and parallel RLC circuits.

Learning Resources

1. NPTEL Video Lecture on "Basic Electronics and Lab" , weblink: https://nptel.ac.in/courses/122106025
2. MIT Video Lecture on "Circuits and Electronics" , weblink: https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-002-circuits-and-electronics-spring-2007/index.htm

Course Designers:

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18EC280	ELECTRONICS WORKSHOP	Category	L	T	P	Credit
		ES	0	0	1	1

Preamble

This workshop helps the students of electronic engineering and electronic professionals gain a full understanding of the basic of electronic components and instruments. The topics cover everything necessary as a prerequisite for their continued understanding in various circuits and systems in use in the coming courses. This course is for preparing students for engineering experience and practice through laboratory skill and experiments on PCB (Printed Circuit Board) designing is an integral part of each electronics products and this program is designed to make students capable to design their own projects PCB up to industrial grade In the laboratory, students learn by doing, by practicing engineering skills that they might perform in the future. After completion of the workshop for one semester, the course investigates the student's perception on the practical skills acquired. This course investigates students' perception on the practical skills acquired.

Prerequisite

Nil

Course Outcomes

On the successful completion of the course students will be able to

CO Number	Course Outcome Statement	Weightage*** in %
CO1	Identify various basic electronic components and packages and for understanding the operational principles of instruments, power supply and equipment	10
CO2	Experiment the connection of circuits in general board and specific Printed circuit board.	20
CO3	Develop a schematic circuit and acquire the knowledge for preparing necessary tools and customizing the tools for PCB design	20
CO4	Develop a PCB layout for the required specification, learn to use tools for layout preparation under various design constraints	30
CO5	Acquire the skills of soldering and desoldering in engineering practice and to learn the safety procedures	10
CO6	Test the assembled circuit in board with engineering IPC standards	10

*** Weightage depends on Bloom's Level, number of contact hours,

CO Mapping with CDIO Curriculum Framework

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS 2	Understand	Respond	Guided Response	1.1, 3.2.6
CO2	TPS 3	Apply	Value	Mechanism	1.1, 2.1.1, 3.2.6
CO3	TPS 3	Apply	Value	Mechanism	1.1, 2.2.3, 3.2.6
CO4	TPS 3	Apply	Value	Mechanism	1.1, 2.3.1, 2.3.2, 3.2.6
CO5	TPS 3	Apply	Value	Mechanism	1.1, 2.5.1, 3.1.1, 3.2.6, 4.1.5
CO6	TPS 4	Analyse	Organise	Complex Overt Responses	1.1, 3.2.1, 3.2.2, 3.2.6, 4.2.3

Mapping with Programme Outcomesand Programme Specific Outcomes

COs	PO1	PO2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2	PSO 3
CO1	M	L	-	-	-	-	-	L	L	L	-	-	M	-	-
CO2	M	L	-	-	-	-	-	L	L	L	-	-	M	-	-
CO3	M	L	-	-	-	-	-	L	L	L	-	-	M	-	-
CO4	S	M	L	-	M	-	-	M	M	M	-	L	S	-	M
CO5	S	M	L	-	L	-	-	M	M	M	-	L	S	-	M
CO6	S	M	L	-	L	-	-	M	M	M	-	L	S	-	M

S- Strong; M-Medium; L-Lowl

AssessmentPattern: Cognitive Domain

Cognitive Levels	Model Examination	Terminal Examination
Remember	0	0
Understand	10	10
Apply	10	10
Analyse	10	10
Evaluate	10	10
Create	15	15

AssessmentPattern: Psychomotor

Psychomotor Skill	Practical Component
Perception	-
Set	-
Guided Response	-
Mechanism	10
Complex Overt Responses	10
Adaptation	10
Origination	15

List of Experiments/Activities with CO Mapping

1. **Identification of components and packages**(CO1)
   Experimenting with -
   Active and passive components:
   Resistor with various power rating, capacitors and inductors
   Through Hole Packages:
   Axial lead, Radial Lead, Single Inline Package(SIP), Dual Inline Package(DIP),Transistor Outline(TO), Pin Grid Array(PGA)
   Surface mount Packages:
   Metal Electrode Face(MELF),Leadless Chip Carrier(LCC),Small Outline Integrated Circuit(SOIC),Quad Flat Pack(QPF) and Thin QFP (TQFP),Ball Grid Array(BGA),Plastic Leaded Chip Carrier(PLCC)
2. **Exploration of instruments, power supply and equipment (CO1)**
   Experimenting with analog (MI and MC types) and digital meters. Fixed power supply, various power supply, function generator and oscilloscope
3. **Experimenting with breadboard and dotted board connections (CO2)**
   Experimenting with circuit boardsand its internal connection such as bread board and dotted boards
4. **Practising soldering and desoldering procedures (CO3)**
   Experimenting withcircuit board connection by practising soldering and removing the components from the PCB by desoldering
5. **Development of schematic circuit (CO3)**

Experimenting with software tool for schematic capture and developing schematic by knowing the specification of the circuit and functionality of the tool. Practicing on available library of components and working through wiring and schematic designing and making new component symbols

6. **Investigation of Printed circuit Board (CO4)**
   Understanding and investigation of the following:
   Various PCB Substrates:Standard FR-4 Epoxy Glass, Multifuctional FR-4, Tetra Functional FR-4, Cyanate Aster, Plyimide Glass, Teflon
   Term and keyword:Footprint, Pad stacks, Vias, Tracks, Color of Layers, PCB Track Size Calculation Formula
   Track rules: Track Length, Track Angle, Rack Joints, Track Size
   PCB tool terms: Schematic Entry, Netlisting, PCB Layout Designing, Prototype Designing, Design Rule Check(DRC), Design For Manufacturing(DFM), PCB Making, Printing, Etching, Drilling
7. **Development of PCB Layout design(CO4)**
   Connecting the schematic from the software netlist, Selecting the Components Footprints as per design, Picking and placing the Component, Making New Footprints, assigning Footprint to components
8. **Practising PCB fabrication(CO5)**
   Printing the design, etching, drilling, interconnecting and packaging electronic circuits (IPC) standards, gerber Generation, soldering and desoldering, component mounting, PCB testing.
   IPC Standard for Schematic Design,Designing,Materials, PCB Fabrication
9. **Assembling components and packing procedures(CO5)**
   For the given PCB the components are fixed and assembled with safety measure in terms of human and components
10. **Practicing circuit in PCB testing procedures (CO6)**
    Continuity testing of PCB without components and output signal measurement procedures with components

Learning Resources

1. Teachers Soft copy manual for Electronic components and symbols
2. https://img.ozdisan.com/content/library/IC_Packages.pdf
3. CAD for Schematic and PCB Design Software.
4. Printed circuit board design techniques for EMC compliance, a handbook for designers 2nd edition. Mark I.Montrose, Wily publication 2016
5. http://www.ipc.org/4.0_Knowledge/4.1_Standards/OEM-Standards/IPC-OEM-Stds-A4-English-1111-ONLINE.pdf

Course Designer

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18EC231	ELECTRONIC DEVICES

Category	L	T	P	Credit
PC	3	0	0	3

Preamble

This is an introduction course to semiconductor electronic devices. In this course the principles and operations of essential semiconductor devices used in today's electronics: diodes, light detectors and emitters, bipolar junction transistors and MOSFETs are introduced. It includes the characterization, analysis and interpretation of model parameters from the corresponding datasheet of the devices which is the prerequisite for next level courses. The goal is to develop a solid understanding of the device concepts that will be needed in a broad range of areas from semiconductor to circuit (analog, digital and VLSI) design and engineering.

Prerequisite

Nil

Course Outcomes

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

CO#	Course Outcome Statement	Weightage in %
CO1	Understand the carrier concentration and recombination of semiconductors	25
CO2	Provide solution to numerical problems for diode, BJT and FET based application circuits.	30
CO3	Characterize the minority and majority carrier profile and parasitic in Bipolar Junction Transistor.	15
CO4	Demonstrate the working principle of Field Effect Transistor.	15
CO5	Explain the internal structure and principle of operation of special devices.	15

CO Mapping with CDIO Curriculum Framework

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS2	Understand	Respond	-	1.2., 2.1.1, 2.1.2, 2.4.1, 2.4.2, 2.4.5, 3.2.3, 3.2.5,
CO2	TPS3	Apply	Value	-	1.2.1, 2.1.1, 2.1.2, 2.1.4, 2.1.5, 2.4.1, 2.4.2, 2.4.5, 3.2.3, 3.2.5,
CO3	TPS3	Apply	Value	-	1.2.1, 2.1.1, 2.1.2, 2.1.4, 2.1.5, 2.4.1, 2.4.2, 2.4.5, 3.2.3, 3.2.5,
CO4	TPS4	Apply	Value	-	1.2.1, 2.1.1, 2.1.2, 2.1.3, 2.1.4, 2.1.5, 2.4.1, 2.4.2, 2.4.5, 3.2.3, 3.2.5,
CO5	TPS3	Apply	Value	-	1.2.1, 2.1.1, 2.1.2, 2.1.3, 2.1.4, 2.1.5, 2.4.1, 2.4.2, 2.4.5, 3.2.3, 3.2.5,

Mapping with Programme Outcomes and Programme Specific Outcomes

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO 3
CO1	M	L	-	-	-	-	-	-	-	-	-	-	L	-	-
CO2	S	M	L	-	-	-	-	-	-	-	-	-	M	-	-
CO3	S	M	L	-	-	-	-	-	-	-	-	-	M	-	-
CO4	S	M	L	-	-	-	-	-	-	-	-	-	M	-	-
CO5	S	M	L	-	-	-	-	-	-	-	-	-	M	-	-

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

Cognitive Levels	Continuous Assessment Tests			Assignment			End Semester Examination
	1	**2**	**3**	1	2	3	
Remember	20	10	0	0	0	0	0
Understand	30	30	30	0	0	0	40
Apply	50	60	70	100	100	100	60
Analyse	0	0	0	0	0	0	0
Evaluate	0	0	0	0	0	0	0
Create	0	0	0	0	0	0	0

Assessment Pattern: Psychomotor

Psychomotor Skill	Assignment 3
Perception	-
Set	-
Guided Response	-
Mechanism	-
Complex Overt Responses	-
Adaptation	-
Origination	-

Sample Questions for Course Outcome Assessment

Course Outcome 1(CO1):

1. Explain in detail about the intrinsic semiconductors
2. Derive an expression for Fermi level in p type semiconductor.
3. Draw the energy band diagram of a pn diode.

Course Outcome 2(CO2):

1. Calculate the built-in potential and depletion –region width for the given silicon diode. Given data: On p-type side: $N_a=10^{17}/cm^3$ on n-type side: $N_d=10^{20}/cm^3$. Assumptions: Room-temperature operations with V_T=0.025 V.
2. Consider an ideal pn junction diode at T=300K operating in the forward-bias region. Calculate the change in diode voltage that will cause a factor of 10 increases in current.
3. Explain in detail about transition and depletion capacitance.

Course Outcome 3(CO3):

1. In a common base connection, I_E = 2mA; I_C= 1.95 mA. Calculate the value of I_B.
2. Assuming the transistor is biased in the active region and the recombination factor is unity. Calculate the collector current for I_E=1.5mA.

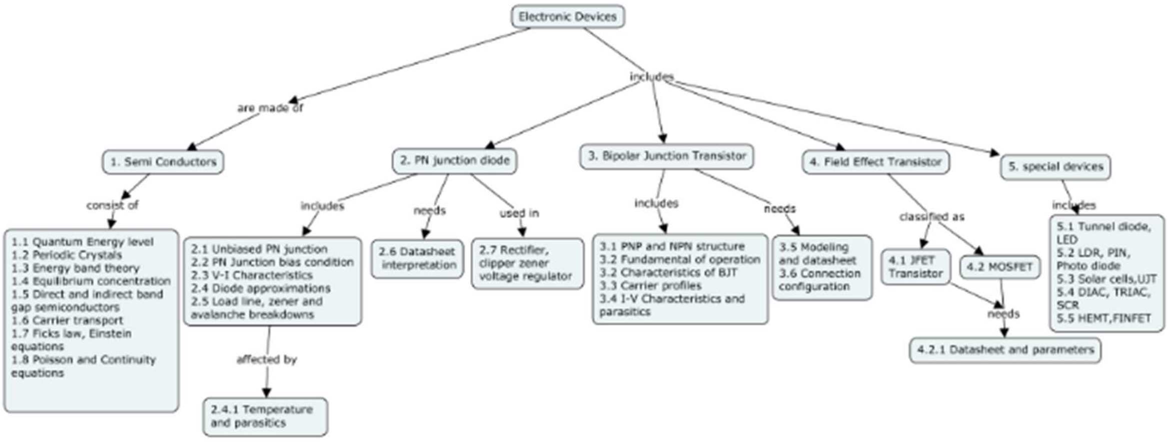
Course Outcome 4(CO4):

1. Consider an n-channel silicon JFET with the given function: Na=$3*10^{18}cm^{-3}$,Nd=$8*10^{16}$ cm and a=0.5µm.(a) Calculate the internal pinch off voltage.(b) Determine the gate voltage required such that the un-depleted channel is 0.20µm.
2. The datasheet for an E MOSFET gives I_{DSS} = 500 mA at V_{GS} and $V_{GS(th)}$ = 1 V. Determine the drain current V_{GS} = 5V.
3. An ideal n-channel MOSFET has an inversion carrier mobility µn=525 cm2/V-s a threshold voltage, V_T=+0.75V and an oxide thickness t_{ox}=400A.When biased in the saturation region, the required rated current is $I_{D(sat)=}$6mA when V_{GS}=5V.Determine the required W/L ratio (b) A p-channel MOSFET has the same requirements when V_{GS}=5V and has the same parameter as part(a) except μ_p=300cm2/V-s and V_T = -0.75V. Determine the W/L ratio.

Course Outcome 5 (CO5):

1. Compare the internal structure of SCR, DIAC and TRIAC
2. With the help of neat diagram, describe the operation of LED.
3. Describe the working principle of HEMT.

Concept Map



Syllabus

SEMICONDUCTORS: Quantum Energy Level, Periodic Crystals, Band Theory of Solids, Energy bands in intrinsic and extrinsic semiconductors, equilibrium carrier concentration, direct and indirect band-gap semiconductors. Carrier transport: diffusion current, drift current, mobility and resistivity, generation and recombination of carriers, Beer-Lambert law, Ficks' law, Einstein equations, Poisson and Continuity Equations. **PN JUNCTION DIODE**: Unbiased PN Junction diode, PN Junction Diode under forward and reverse bias, Current Components and V-I Characteristics, Temperature dependence, transition and diffusion capacitance, Reading Data Sheets, Diode Approximations, Load-line, Zener and avalanche breakdowns, Applications – Rectifier, Clipper, Zener voltage regulator. **BIPOLAR JUNCTION TRANSISTOR:** PNP and NPN structure, Fundamental of Operation and Characteristics of BJT, CB, CE and CC configurations, Early Effects, Load-line, Transistor Switching Times, Transistor Approximations, Reading Data Sheets. **FIELD EFFECT TRANSISTORS:** Junction Field Effect Transistor, MOSFET, Reading Data Sheets. **SPECIAL DEVICES:** Tunnel diode, LED, LDR, PIN diode, Photo diode, Solar Cells, UJT, DIAC, TRIAC, SCR, HEMT, FINFET.

Learning Resources

- Albert Paul Malvino and David J Bates," Electronic Principles", 8th Edition, Mc Graw Hill, 2020.
- Robert L.Boylestad, Louis Nashelsk, "Electronic Devices and Circuit Theory" , 11th Edition, Pearson, 2013
- Adel S. Sedra and Kenneth C. Smith, "Microelectronic Circuits: Theory and Application", 7th Edition, Oxford University Press, 2017.
- S.M. Sze and Ming-Kwei Lee," Semiconductor Devices: Physics and Technology", 3rd Edition, Wiley, 2012.
- Donald Neamen, "Semiconductor Physics and Devices: Basic Principles", 4th Edition, McGraw-Hill, 2012.
- S. O. Kasap, Principles of Electronic Materials and Devices, 4th Edition, McGraw-Hill, 2018.
- MIT Open Courseware: https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-012-microelectronic-devices-and-circuits-spring-2009/lecture-notes/

Course Contents and Lecture Schedule

No.	Topic	No. of Lectures	COs
1	**SEMICONDUCTORS**:		
1.1	Quantum Energy Level, Periodic Crystals, Band Theory of Solids	2	CO1
1.2	Energy bands in intrinsic and extrinsic semiconductors, equilibrium carrier concentration, direct and indirect band-gap semiconductors.	2	

1.3	Carrier transport: diffusion current, drift current, mobility and resistivity, generation and recombination of carriers	2	CO1
1.4	Beer-Lambert law, Ficks' law, Einstein equations, Poisson and Continuity Equations.	2	CO1
2	**PN JUNCTION DIODE**:		
2.1	Unbiased PN Junction diode, PN Junction Diode under forward and reverse bias Current Components and V-I Characteristics,	2	CO2
2.2	Temperature dependence, transition and diffusion capacitance, Data Sheet Interpretation	2	CO2
2.3	Diode Approximations, Load-line, Zener and avalanche	2	CO2
2.4	Applications – Rectifier, Clipper, Zener voltage regulator.	2	CO2
3	**BIPOLAR JUNCTION TRANSISTOR:**		
3.1	PNP and NPN structure, Fundamental of Operation and Characteristics of BJT	2	CO3
3.2	CB, CE and CC configurations, Early Effects, Load-line	2	CO3
3.3	Transistor Switching Times	2	CO3
3.4	Transistor Approximations, Data Sheet and parameters	2	CO3
4	**FIELD EFFECT TRANSISTORS:**		
4.1	Junction Field Effect Transistor	2	CO4
4.2	MOSFET, Data Sheet and parameters	2	CO4
5	**SPECIAL DEVICES:**		
5.1	LDR, PIN diode, Photo diode,	2	CO5
5.2	Photo diode, Solar Cells,	2	CO5
5.3	SCR, UJT, DIAC, TRIAC	2	CO5
5.4	HEMT, FINFET.	2	CO5
	Total	36	

Course Designers:

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21EC240	ELECTRONIC MATERIALS

Category	L	T	P	Credit
ES	3	0	0	3

Preamble

This course work aims in imparting fundamental knowledge of various classes of electronic materials which are essential in understanding and explaining engineering devices. Electronic materials exhibit the behaviour of new display devices and why they behave on its own. Materials science gives us the tailored made properties to design and develop any engineered product. You need the right materials to design your right engineering device.

Prerequisite

NIL

Course Outcomes

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

CO#	Course Outcome Statement	Weightage in %
CO1	Determine the temperatures and resistivities of various electronic materials using the classical free electron theory models.	25
CO2	Compute the energy band structure and optical transitions using the quantum free electron theory for some semiconductors.	25
CO3	Use the spintronics terminologies to compute the magnetic and semiconducting properties of few spin-based electronic systems.	20
CO4	Exhibit the technological importance of the Optoelectronic / Photonic devices.	15
CO5	Demonstrate few ultra-advanced technologies developed for the society out of these electronic materials.	15

CO Mapping with CDIO Curriculum Framework

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psycho-motor	
CO1	TPS3	Apply	Value	-	1.1, 2.1.1, 2.1.2, 2.4.2, 2.5.1
CO2	TPS3	Apply	Value	-	1.1, 2.1.1, 2.1.2, 2.5.1
CO3	TPS3	Apply	Value	-	1.1, 2.1.1, 2.1.2, 2.5.1
CO4	TPS4	Analyse	Organise	-	1.1, 2.1.1, 2.1.2, 2.1.3
CO5	TPS2	Understand	Respond	-	1.1, 2.5.4

Mapping with Programme Outcomes

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	S	M	L	L	-	-	-	-	L	L	-	-	M	-	-
CO2	S	M	L	-	-	-	-	-	L	L	-	-	M	-	-
CO3	S	M	L	L	-	-	-	-	L	L	-	-	M	-	-
CO4	S	S	M	L	-	-	-	-	L	L	-	-	S	-	-
CO5	M	L	L	-	-	-	-	-	L	L	-	-	L	-	-

S- Strong; M-Medium; L-Low

Cognitive Levels	Continuous Assessment Tests			Assignment			End Semester Examination
	1	2	3	1	2	3	
Remember	20	20	20	0	0	0	20
Understand	30	30	30	0	0	50	30
Apply	50	50	50	100	100	50	50
Analyse	0	0	0	0	0	0	0
Evaluate	0	0	0	0	0	0	0
Create	0	0	0	0	0	0	0

Assessment Pattern: Psychomotor

Psychomotor Skill	Assignment 3
Perception	-
Set	-
Guided Response	-
Mechanism	-
Complex Overt Responses	-
Adaptation	-
Origination	-

Sample Questions for Course Outcome Assessment

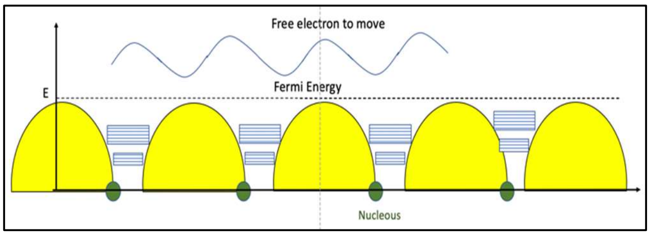
Course Outcome 1 (CO1)

1. Define Einstein temperature.
2. List out the shortcomings of free electron theory.
3. What is drift velocity?
4. Derive an expression for the Debye temperature. Obtain the high and low temperature limits of the heat capacity analytically.
5. When an electric field is applied to a metal conductor in the x-direction, it gives the x-component of the velocity in the i^{th} electron which is V_{ix}. What is the acceleration produced by the electron?
6. In a wire conductor, which one of the following is NOT true?
   a) the direction of the current and the direction of the electric field are opposite each other
   b) the direction of the current and direction of the drift velocity are opposite each other
   c) the direction of the current density and direction of the drift velocity are same.
   d) the direction of the current density and direction of the current are same.
7. Consider a piece of a metal wire heated to a temperature T which radiates energy in the form of electromagnetic waves. The power emitted per unit surface area is given by the Stefan's formula, $P_{stef} = \sigma T^4$ where the constant is 5.7 X 10^{-8} W/K^4. m^2. Our TCE two-wheeler shed/shelter is heated by a 1 m long metallic coil that is 1 mm in diameter. The temperature of the coil is 2000 K. If the resistivity of the coil material at that temperature is given by 5 X 10^{-7} Ω.m. Calculate the current flowing through the wire to maintain its temperature.
8. Both the Einstein model and the Debye model emphasis the impact of high temperature heat capacity. Determine the approximate ratio of Einstein temperature and Debye temperature. Compare your result with the values of silver and copper. Hint: Can we use this heat capacity equation given below to find out the ratio?
$$C = \frac{12NK_B\pi^4}{5}\left(\frac{T}{T_D}\right)^3$$
9. Nichrome is an alloy of nickel, chromium and iron often used as a heating element in electrical devices. A heating element in any electrical device uses a nichrome alloy. A nichrome wire of length 0.8 m in length is crisscrossed along the interior of a toaster that can carry a maximum current of 9 A when there is a 115 V potential difference from one end of this wire to the other. If the resistivity of nichrome is 1.0 X $10^{-6}\Omega$.m. what is the radius of the wire?
10. A rectangular solid block has a cross-sectional area 5.50 cm^2. Across its width, a front-to-rear length is 16.8 cm and has its own resistance. The block's material contains 5.33 X 10^{22} conduction electrons/ m^3. A potential difference of 35.8 V is maintained between its front and rear faces. Given the current density of the block; 109 Am^{-2}. What is the drift velocities of the conduction electrons and the magnitude of the electric field in the block?

Course Outcome 2 (CO2)

1. What are the salient features of the free electron model of a metal?
2. What are normal mode and phonon?

3. Why do metals held at room temperature feel cold to the touch even though their Fermi temperatures are much higher than room temperature?
4. What is a Bloch function?
5. If two or more atoms are brought close to each other the 1s and 2p levels are overlapped as shown in the figure. The electrons are free to move periodically and they form the Fermi energy levels. What is the name of the closely spaced 'blue lines' located between two atoms? Give reasons.

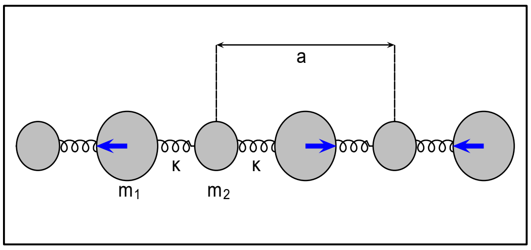


6. Explain what is meant by the Fermi energy, Fermi temperature and Fermi surface of a metal. Use this equation to explain your answers briefly

$$N = 2V \int_{K<K_F}^{1} \frac{dk}{(2\pi)^3}$$

7. Why phonons obey Bose statistics? Derive the dispersion relation for the longitudinal oscillations of a one-dimensional mass-and-spring crystal with N identical atoms of mass m, lattice spacing a, and spring constant κ (motion of the masses is restricted to be in one dimension).
8. Determine the probability current density for the Bloch wavefunction

   $\psi(x) = U(x)e^{ikx}e^{-i\omega t}$ where U is a time-independent periodic function having the period of the lattice U(x) = U (x + a).
9. Show that the mode with wavevector k has the same pattern of mass displacements as the mode with wavevector k + 2π/a. Hence show that the dispersion relation is periodic in reciprocal space (k-space).
10. Derive the dispersion relation for the longitudinal oscillations of a one-dimensional diatomic mass-and- spring crystal where the unit cell is of length a and each unit cell contains one atom of mass m1 and one atom of mass m2 connected together by springs with spring constant κ, as shown in the figure (all springs are the same, and motion of particles is in one dimension only).



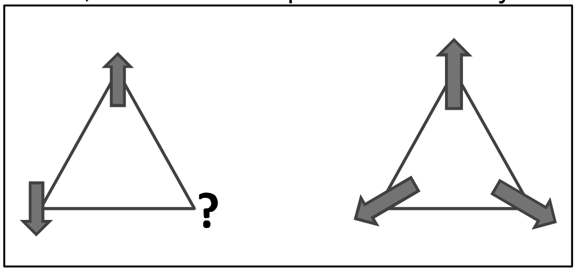
Course Outcome 3 (CO3)

1. What is a domain in ferromagnetic material?
2. State Hund's rule.
3. Define Curie-Weiss law. List out the properties of anisotropy energy?
4. The magnetization within a bar of some metal alloy is 1.2 X 10^6 A/m at an *H* field of 200 A/m. Compute the following: (a) the magnetic susceptibility, (b) the permeability, and (c) the magnetic flux density within this material. (d) What type(s) of magnetism would you suggest as being displayed by this material? Why?
5. Why spontaneous magnetic order is crucial in spintronics? Can we use Ising Model in magnetic materials? Explain.

6. List out the properties of Heisenberg's exchange interaction in ferromagnetism. Should we conclude about which samples in magnetic materials should have domain walls?
7. Suppose a ferromagnet is made up of a density ρ of spins each with moment μB. If a domain wall is introduced into the material, where might it go to minimize the magnetic energy in the two different geometries. Estimate how much magnetic energy is saved by the introduction of the domain wall.
8. Consider a Heisenberg model containing a chain of only two spins, so that

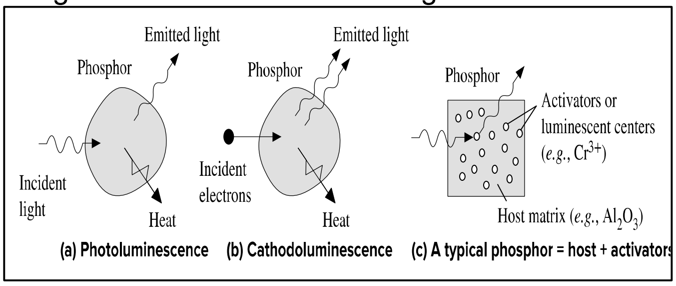
$$H = -J\,S_1.S_2 \text{ and } H = -\frac{1}{2}\sum_{(i,j)} J\,S_i.S_j$$

Supposing these spins have S = 1/2, calculate the energy spectrum of this system. Now consider three spins forming a triangle (as shown in Figure). Again assuming these spins are S = 1/2, calculate the spectrum of the system.



Course Outcome 4 (CO4)

1. What are optical transition and absorption?
2. What is the relation between relative permittivity and refractive index?
3. Define Complex refractive index, Group index, Snell's law and activator excitation.
4. How can different colors be obtained in an LED?
5. Consider the $GaAs_{1-x}P_x$ system. (*a*) For a mole fraction *x* = 0.2, determine the (*i*) bandgap energy and (*ii*) corresponding photon wavelength. (*b*) Repeat part (*a*) for a mole fraction *x* = 0.32.
6. Can we use this equation $E_x = E_0 Cos\,(\omega t - kz + \phi_0)$ to explain the behaviour of light waves in a homogeneous medium? see the figure.



7. Diamond, silicon, and germanium all have the same diamond unit cell. All three are covalently bonded solids. Their refractive indices (*n*) and energy bandgaps (*Eg*) are shown in the table. (*a*) Plot *n* versus *Eg* and (*b*) plot n^4 versus $1/Eg$. What is your conclusion? According to **Moss's rule,** very roughly, $n^4 Eg \approx K$ = Constant. What is the value of *K*?

	Diamond	Silicon	Germanium
Bandgap, Eg (eV)	5	1.1	0.66
n	2.4	3.46	4.0

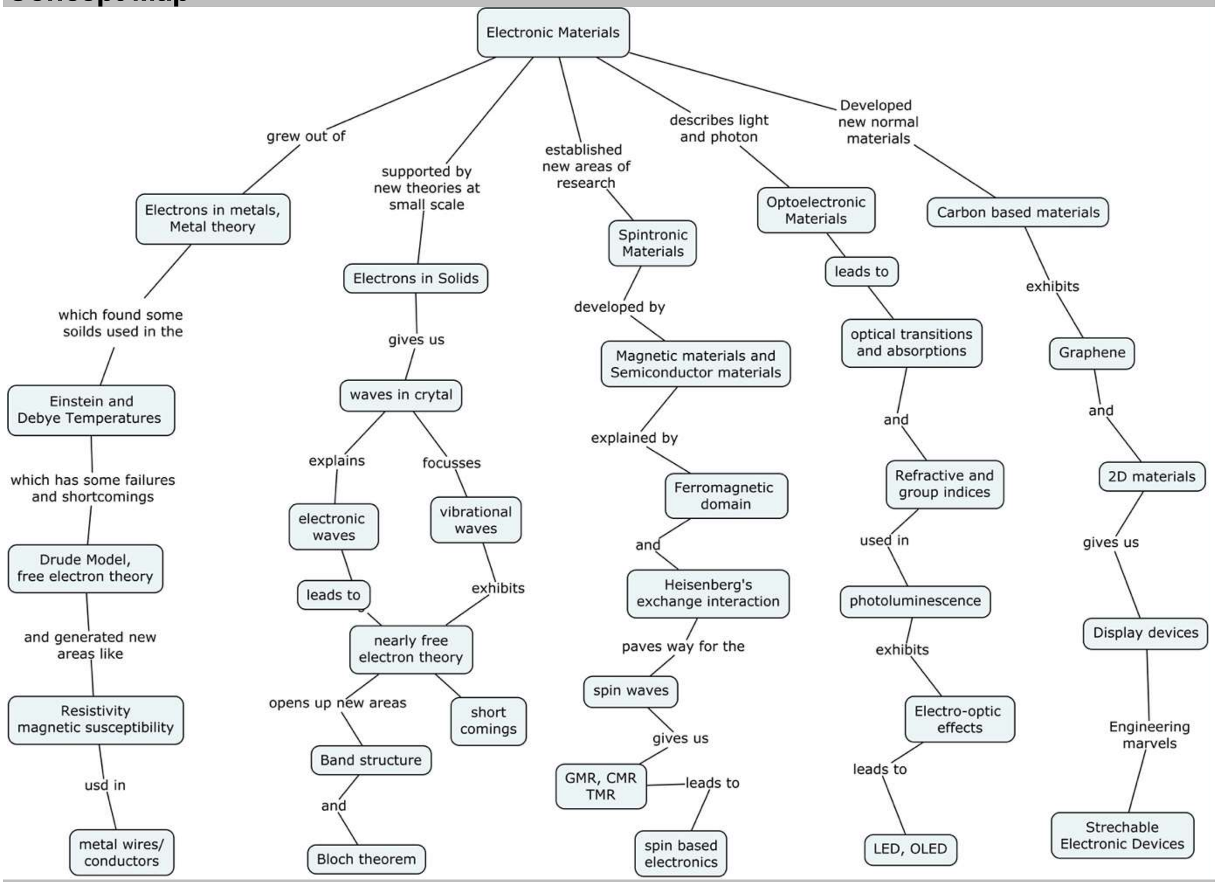
8. Suppose that λ is the free space wavelength and n is the refractive index of the medium at λ. Then, λ/n is the wavelength in the medium. Consider $\omega = \frac{2\pi c}{\lambda}$ and $K = \frac{2\pi n}{\lambda}$. By finding expressions for dω and dk in terms of dn and dλ derive equation $N_g = n - \lambda\frac{dn}{d\lambda}$ for the group index Ng.

Course Outcome 5 (CO5)

1. What is CNT?
2. List out the properties of carbon-based materials.

3. Why electronic materials are preferred in display devices?
4. Compare and contrast graphene and 2D materials?
5. Can we use quantum dots in electronic device?
6. How can we get a flexible and foldable laptop?
7. Write a report on “4K -HD” with special emphasis on materials science?

Concept Map



Syllabus

Electrons in Metals: History of Metal Theory -Specific heat of solids – Free electron Theory- Resistivity - Electronic heat capacity – Magnetic spin susceptibility. **Electrons in solids:** Electronic and vibrational waves in crystal- Nearly free electron model- Bloch’s theorem- Energy˜ bands - Failure of the Band structure- Mott Insulators. **Spintronics Materials:** Hund’s rule- Exchange energy– Spontaneous magnetic order- Spin based electronics- dynamics of anti-ferromagnet spins - Magnetoresistance -MTJ. **Optoelectronic Materials:** Light Waves in a Homogeneous Medium -Refractive Index - Light Absorption – Light Scattering in Materials - Photoluminescence – Phosphors- LED - OLED. **Advances in Electronic Materials:** Carbon Nano Tube – Graphene – 2D Materials – Quantum Dots - Stretchable and transparent electronic materials – Topological Electronic Materials.

Learning Resources

- Steven H. Simon, The Oxford Solid State Basics, The Oxford University Press, 2013.
- S. O. Kasap , Principles of Electronic Materials and Devices , 4th Edition, McGraw-Hill, 2018.
- William D. Callister, Materials Science and Engineering, Wiley, 2nd Edition, 2014.
- S. O. Pillai, Solid State Physics, New Age International Pvt Ltd, 8th Edition, 2018.
- M. A. Wahab, Solid State Physics, Narosa, 3rd Edition, 2019.
- Youtube Lectures: Prof. R. Sankar, Yale.
- Youtube Lectures: Prof. Jordan Edmund.
- Youtube Lectures: Prof. Michel Van Bienzen.

Course Contents and Lecture Schedule

S No.	Topic	No. of Hours	COs
1	**Electrons in Metals**	**7**	
1.1	History of Metal Theory	1	CO1
1.2	Specific heat of solids: Einstein, Debye calculations	2	CO1
1.3	shortcomings of Debye theory- Drude Model – Free electron Theory	2	CO1
1.4	Theory- Resistivity - Electronic heat capacity – Magnetic spin susceptibility.	2	CO1
	Assignment- I		
2	**Electrons in Solids**	**8**	
2.1	Electronic and vibrational waves in crystal	2	CO2
2.2	Free electron model	1	CO2
2.3	Periodic crystals - Bloch's theorem	2	CO2
	CAT-I after 12 contact hours		
2.4	Energy bands and Band theory of solids, Failure of the Band structure	2	CO2
2.5	Mott Insulators, intro optical materials	1	CO2
3	**Spintronics Materials**	**8**	
3.1	Pauli's exclusion principle, Hund's rule and Aufbau principle, Ferromagnetic materials	1	CO3
3.2	Heisenberg's exchange interaction, Magnetic ordering	2	CO3
	Assignment- II		
3.3	Domains, Spins and spin waves	2	CO3
3.4	Magnetoresistance – GMR, CMR, TMR	2	CO3
3.5	Magnetic Tunnel Junctions, spintronic device	1	CO3
4	**Optoelectronic Materials**	**7**	
4.1	Optical transition and absorption, Electro-optic effects	1	CO4
4.2	Light Waves in a Homogeneous Medium, photons, phonons	2	CO4
	CAT-II after 12 contact hours		
4.3	Complex refractive index, Group index, Activator excitation	2	CO4
4.4	Light Scattering in Materials, Photoluminescence, Phosphors	1	CO4
4.5	LED and OLED	1	CO4
	Assignment- III		
5	**Advances in Electronic Materials**	**6**	
5.1	Expert Lecture	1	CO5
5.2	Carbon based materials in Electronic devices	2	CO5
5.3	Graphene, 2D Materials, Quantum Dots	2	CO5
5.4	Stretchable and topological electronic materials, display devices	1	CO5
	CAT-III after 12 contact hours		
	Total contact hours	**36**	

Course Designers

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- Dr. A. L. Subramanian alsphy@tce.edu

18CHAA0	ENVIRONMENTAL SCIENCES	Category	L	T	P	Credit
		ES	1	0	1	-

Preamble

The objective of this course is intended to make the students to understand the basic concepts of environment, ecology and pollution of the current environmental issues and to participate in various activities on conserving and protecting the environment.

Prerequisite

NIL

Course Outcomes

On the successful completion of the course students will be able to

CO Number	Course Outcome	Weightage*** in %
CO1	Describe the importance and progression of ecological system	15%
CO2	Explain the significance of natural resources	10%
CO3	Demonstrate the effects of pollution on environment and human beings	15%
CO4	Practice the suitable management method during disaster episode	10%
CO5	Explain the ethics and values related to Environment	15%
CO6	Describe the Traditional values and Impact of modernization on Environment	10%
CO7	Carry out group activities	25%

*** Weightage depends on Bloom's Level, number of contact hours,

CO Mapping with CDIO Curriculum Framework

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS2	Understand	Respond	Guided Response	1.1,2.3.1,2.3.2,2.3.4
CO2	TPS2	Understand	Respond	Guided Response	1.1,2.3.1,2.3.2,2.3.4
CO3	TPS3	Apply	Value	Mechanism	1.1,2.1.1,2.1.5,2.4.1,4.1.2
CO4	TPS3	Apply	Value	Mechanism	1.1,2.4.1,2.4.7,4.1.1,4.1.2
CO5	TPS2	Understand	Respond	Guided Response	1.1,2.5.1,2.5.2,
CO6	TPS2	Understand	Respond	Guided Response	1.1,2.4.7,2.5.4,
CO7	TPS4	Analyse	Organise	Complex Overt Responses	3.1.1,3.1.2,3.1.3,3.1.4,4.1.1,4.1.2

Mapping with Programme Outcomes and Programme Specific Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	M	-	-	-	-	L	S	-	-	-	-	-
CO2	M	-	-	-	-	L	-	L	-	-	-	-
CO3	M	M	-	-	L	M	S	-	-	-	-	-
CO4	M	-	L	L	L	M	M	-	-	-	-	-
CO5	L	-	-	-	-	-	-	M	-	-	-	-
CO6	L	L	-	-	-	-	M	-	-	-	-	-
CO7	S	M	M	M	M	M	-	-	S	M	M	-

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

Cognitive Levels	Continuous Assessment Tests			Assignment#			Terminal Examination***
	1	2	3	1	2	3	
Remember	0	20	0	NA	NA	NA	Presentation on Case study report
Understand	0	40	0				
Apply	0	40	0				
Analyse	0	0	0				
Evaluate	0	0	0				
Create	0	0	0				

Assignment: Marks will be given for the review I, II & III of case study presentation.

*** Case study presentation and evaluation

- ❖ Each group comprises of maximum three students
- ❖ Students will submit the case study report similar to final year project report
- ❖ Evaluation of case study presentation is based on the approved rubrics

Method of Evaluation

a)Internal assessment

S.No	Description	Max.marks	Final conversion
1	CAT -II	50	40
2	Assignment marks (from Review I,II & III)	3 X 10 =30	10
		Total	50

b) End semester examination – Case study presentation

Performance Index	Marks per Individual
Originality of the work	20
Data collected	20
Suggestion to overcome for the identified issues	20
Final Presentation	40
Total	100

Model Titles for Case Study:

1. Environmental impacts of quarry industries in Melur Taluk.
2. A study on impacts of tanneries on ground water and soil quality in Dindigul district.
3. Effect of pharmaceutical industry on groundwater quality in poikaraipatty village, Alagar Kovil.
4. Solid waste and waste water management in TCE hostel.
5. Environmental effect of Kudankulam atomic power plant.
6. Case study on effect of Sterlite industry.
7. Effect on ground water and soil quality by dyeing industries in Tiruppur.
8. Effect of textile wastes in Karur District.
9. Segregation of waste and its recycling by Madurai Municipality at Vellakkal
10. Effect of fire work waste on atmosphere in Sivakasi region

Sample Questions for Course Outcome Assessment**

Course Outcome 1(CO1):

1. Describe the Universal Energy flow model in an Ecosystem.
2. Discuss the conversion of one ecosystem into another ecosystem with example.
3. Explain the multidisciplinary nature of the environment.

Course Outcome 2 (CO2):

1. Summarize the importance of Natural resources to animals and human beings.
2. Describe the role of an individual in the conservation of Natural resources.

Course Outcome 3(CO3):

1. Demonstrate the effects and control measures of air pollution
2. Investigate the sources and management methods of e-waste.

Course Outcome 4(CO4):

1. Dramatize the mitigation methods adopted in severe cyclone affected areas.
2. Suggest the precautionary steps to prevent life from flood.

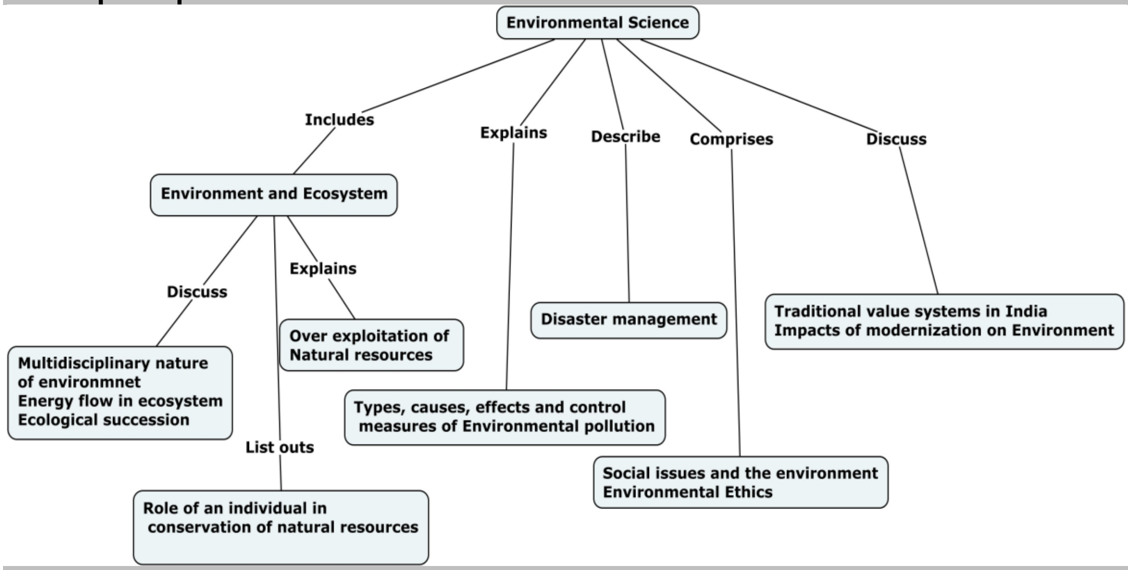
Course Outcome 5 (CO5):

1. Discuss the need for public awareness on environmental protection.
2. Identify the requirement for the equitable utilization of natural resources.

Course Outcome 6(CO6):

1. Describe the traditional value systems of India.
2. Recall the environmental related points discussed in our Indian Vedas.
3. List out the impacts of modernization on environment

Concept map:



Syllabus

Environment and Ecosystem - Multidisciplinary nature of environment- Ecosystem- Energy flow in ecosystem-Ecological succession-Over exploitation of Natural resources-Role of an individual in conservation of natural resources. **Environmental pollution and control -** Environmental pollution – types, causes, effects and control measures - Disaster management strategies. **Environmental Ethics and Values -** Social issues and the environment -need for public awareness, Environmental Ethics- need for equitable utilization of natural resources- Traditional value systems in India, Impacts of modernization on Environment

Awareness and actual activities:

- ✓ Group meeting on water management, promotion of recycle use, reduction of waste,
- ✓ Plantation
- ✓ Cleanliness drive
- ✓ Drive on segregation of waste
- ✓ Energy saving
- ✓ Lectures by Environmentalist
- ✓ Slogan and poster making event

Learning Resources

1. Kaushik,A & Kaushik.C.P, Environmental Science and Engineering, 6th Edition, New Age International, 2018.
2. Erach Bharucha, Text book of Environmental studies for Undergraduate courses, 2nd Edtion, UGC, 2013.

3. Gilbert M.Masters, Introduction to Environmental Engineering and Sciences, 2nd Edition, Pearson , 2004.
4. Garg S.K & Garg, Ecological and Environmental studies, Khanna Publishrers, 2006.
5. Wright &Nebel, Environmental science towards a sustainable future, 8th Editon,Prentice Hall of Indial Ltd, 2002.
6. Documentary titled “HOME” by Yves Bertrand, Video Link: https://www.youtube.com/watch?v=jqxENMKaeCU

Course Contents and Lecture Schedule

Module No.	Topic	No. of Hours	Course Outcome
1.0	**Environment and Ecosystem**		
1.1	Multidisciplinary nature of environment-Ecosystem	1	CO1
1.2	Energy flow in ecosystem – Universal energy flow model	1	CO1
1.3	Ecological succession	1	CO1
1.4	Over exploitation of Natural resources	1	CO2
1.5	Role of individual in conservation of natural resources	1	CO2
2.0	**Environmental pollution and control**		
2.1	Environmental pollution – types(Air, Water,soil,Marine),	2	CO3
2.2	causes (gaseous, liquid, solid, plastic, e-waste, biomedical waste and radiations),	2	CO3
2.3	**E**ffects and control measures of Pollution	2	CO3
2.4	Disaster managements during cyclone, Tsunami, flood, draught and earthquake	2	CO4
3.0	**Environmental Ethics and Values**		
3.1	Social issues and the environment -need for public awareness	1	CO5
3.2	Environmental Ethics- need for equitable utilization of natural resources	1	CO5
3.3	Traditional value systems in India,	1	CO6
3.4	Impacts of modernization on Environment	2	CO6
4.0	**Awareness and actual activities**		
4.1	Group meeting on water management, promotion of recycle use, reduction of waste	2	CO7
4.2	Plantation	1	CO7
4.3	Cleanliness drive	1	CO7
4.4	Drive on segregation of waste	1	CO7
4.5	Energy saving	1	CO7
4.6	Lectures by Environmentalist	1	CO7
4.7	Slogan and poster making event	Through online	CO7

Course Designers:

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CURRICULUM AND SYLLABI

FOR

B.E. DEGREE (ELECTRONICS AND COMMUNICATION ENGINEERING) PROGRAMME

THIRD SEMESTER

FOR THE STUDENTS ADMITTED FROM THE

ACADEMIC YEAR 2018-2019 ONWARDS

THIAGARAJAR COLLEGE OF ENGINEERING

(A Govt Aided Autonomous Institution Affiliated to Anna University)

MADURAI – 625 015, TAMILNADU

18EC310	COMPLEX ANALYSIS AND LINEAR ALGEBRA	Category	L	T	P	Credit
		BS	2	1	0	3

Preamble

An engineering UG student needs to have some basic mathematical tools and techniques to apply in diverse applications in Engineering. This emphasizes the development of rigorous logical thinking and analytical skills of the student and appraises him the complete procedure for solving different kinds of problems that occur in engineering. Based on this, the course aims to give a thorough knowledge on complex analysis and vector spaces, students get to know about analytic functions, complex integration and dimensions and linear independence and work on any dimensional spaces. It helps to work in complex domain in their required field.

Prerequisite

NIL

Course Outcomes

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

CO#	Course Outcome Statement	Weightage in %
CO1.	Discuss about differentiation and C-R equations	10%
CO2.	Predict an analytic function, when its real or Imaginary part is known. Calculate the Singularities and its corresponding Residues for the given function.	20%
CO3.	Predict the suitable method to evaluate the Contour integration.	20%
CO4.	Use visualization, spatial reasoning, as well as geometric properties and strategies to model, solve problems, and view solutions, especially in R^2 and R^3 , as well as conceptually extend these results to higher dimensions.	10%
CO5.	Use rank- nullity theorem to find where the object lies entirely.	20%
CO6.	Use orthogonal matrix to rotate objects in a two or three dimensional space.	20%

CO Mapping with CDIO Curriculum Framework

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X,Y,Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS2	Understand	Respond	-	1.1, 2.1.3, 2.1.5, 3.1.3, 4.1.1
CO2	TPS3	Apply	Value	-	1.1, 2.1.3, 2.1.5, 3.1.3, 4.1.1
CO3	TPS3	Apply	Value	-	1.1, 2.1.3, 2.1.5, 3.1.3, 4.1.1
CO4	TPS2	Understand	Respond	-	1.1, 2.1.3, 2.1.5, 3.1.3, 4.1.1
CO5	TPS3	Apply	Value	-	1.1, 2.1.3, 2.1.5, 3.1.3, 4.1.1
CO6	TPS3	Apply	Value	-	1.1, 2.1.3, 2.1.5, 3.1.3, 4.1.1

Mapping with Programme Outcomes

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	S	S	S	S	M	S	-	S	S	-	-	-	S	-	-
CO2	S	S	S	M	M	S	L	S	S	-	-	-	S	-	-
CO3	S	S	S	S	M	S	-	S	S	-	-	-	S	-	-
CO4	S	S	S	S	M	S	M	S	S	-	-	-	S	-	-
CO5	S	S	S	S	M	S	M	S	S	-	-	-	S	-	-
CO6	S	S	S	S	M	S	M	S	S	-	-	-	S	-	-

S- Strong; M-Medium; L-Low

Assesment Pattern: Cognitive Domain

Cognitive Levels	Continuous Assessment Tests			Assignment			End Semester Examination
	1	2	3	1	2	3	
Remember	10	10	10	-	-	-	0
Understand	20	20	20	-	-	-	30
Apply	70	70	70	100	100	100	70
Analyse	0	0	0	-	-	-	0
Evaluate	0	0	0	-	-	-	0
Create	0	0	0	-	-	-	0

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Identify whether $\bar{z}$ is analytic or not?
2. Examine whether the following function satisfies C-R equations or not: $u = x^2y - x$, $v = y^2x - y$.

Course Outcome 2 (CO2)

1. Find the analytic function $w = u + iv$ where $u = e^y \cos x$
2. Find the image of the rectangular region in the z-plane bounded by the lines x=0, y=0,
   a. x=2 & y=1 under the transformation w = z+2-i
3. Expand in Laurent's series about z=0 , f(z) = $(z-1)\sin(1/z)$
4. Find the singularities of $f(z) = \dfrac{z^2+4}{z^3+2z^2+2z}$ and the corresponding residues

Course Outcome 3 (CO3)

1. Evaluate $\int_0^\infty \dfrac{x \sin x dx}{x^2+a^2}$, by contour integration.
2. Evaluate $\int_{-\infty}^{\infty} \dfrac{x^2 \, dx}{(x^2+1)(x^2+4)}$.

Course Outcome 4 (CO4)

1. Show that $R^{m\times n}$, together with the usual addition and scalar multiplication of matrices, satisfies the eight axioms of a vector space.
2. Let $x_1, x_2,$ and x_3 be linearly independent vectors in R^n and let $y_1 = x_1 + x_2,\ y_2 = x_2 + x_3,\ y_3 = x_3 + x_1$. Are y_1, y_2, y_3 linearly independent? Prove your

answer.

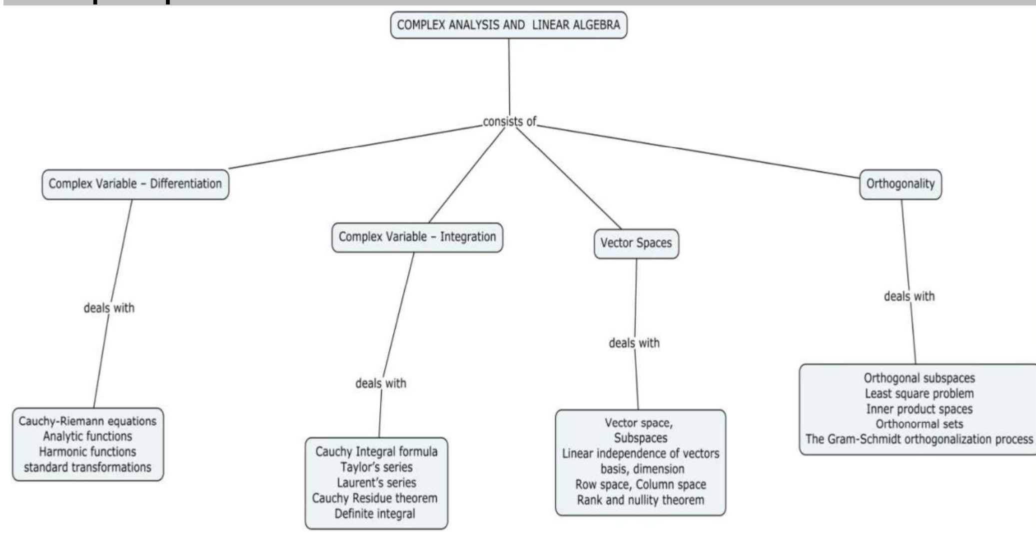
Course Outcome 5 (CO5)

1. Let S be the subspace of P_3 consisting of all polynomials of the form $ax^2+bx+2a+3b$. Find a basis for S.
2. Show that if U and V are subspaces of R^n and $U \cap V = \{0\}$, then $\dim(U+V)=\dim U+\dim V$.
3. Let A and B be $m \times n$ matrices. Show that $rank(A+B) \le rank(A)+rank(B)$

Course Outcome 6 (CO6)

1. Determine the distance from the point $(2,0,0)$ to the plane $x+2y+2z=0$.
2. Determine the least square solution of the system $x_1+x_2=3,\ \ -2x_1+3x_2=1,\ \ 2x_1-x_2=2$.
3. Show that the functions x and x^2 are orthogonal in P_5 with inner product defined by $\langle p,q\rangle=\sum_{i=1}^{n} p(x_i)q(x_i)$ where $x_i=\frac{(i-3)}{2}$ for $i=1,2,\ldots 5$.

Concept Map



Syllabus

Complex Variable – Differentiation: Differentiation, Cauchy-Riemann equations, Analytic functions, Harmonic functions, finding harmonic conjugate, Conformal mappings-standard transformations, Conformal transformations. **Complex Variable – Integration:** Cauchy theorem (without proof), Cauchy Integral formula (without proof), Taylor's series, zeros of analytic functions, singularities, Laurent's series; Residues, Cauchy Residue theorem (without proof), Evaluation of definite integral. **Vector Spaces**: Vector space, Subspaces, linear independence of vectors, basis, dimension, Row space, Column space, Rank and nullity theorem. **Orthogonality**: Orthogonal subspaces, Least square problem, Inner product spaces, Orthonormal sets, The Gram-Schmidt orthogonalization process.

Learning Resources

1. J. W. Brown and R. V. Churchill, Complex Variables and Applications, 7th Ed., McGraw Hill, 2004.
2. B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers, 36thEdition, 2010.
3. Steven.J.Leon, "Linear Algebra with Applications", 8th edition, Pearson, 2010.
4. David.C.Lay, "Linear Algebra and its applications", Pearson Addison – Addison Wesley, 3rd edition, 2006.

Course Contents and Lecture Schedule

Module No	Topic	No. of Lecture Hours	CO's
1	**Complex Variable – Differentiation**		
1.1	Differentiation, Cauchy-Riemann equations	1	CO1
1.2	Analytic functions	1	CO2
1.3	Harmonic functions, finding harmonic conjugate	2	CO2
1.4	Tutorial	1	
1.5	Conformal mappings-standard transformations	2	CO2
1.6	Conformal transformations	1	CO2
	Tutorial	1	
2	**Complex Variable – Integration**		
2.1	Cauchy theorem (without proof), Cauchy Integral formula (without proof)	1	CO3
2.2	Taylor's series, zeros of analytic functions, singularities	2	CO3
	Tutorial	1	
2.3	Laurent's series	2	CO3
2.4	Residues, Cauchy Residue theorem (without proof)	1	CO3
2.5	Evaluation of definite integral	2	CO3
	Tutorial	1	
3	**Vector Spaces**		
3.1	Vector space, Subspaces	2	CO4
3.2	Linear independence of vectors, basis, dimension	1	CO4
	Tutorial	1	
3.3	Row space, Column space	1	CO4
3.6	Rank and nullity theorem	2	CO5
	Tutorial	1	
4	**Orthogonality**		
4.1	Orthogonal subspaces	1	CO6
4.2	Least square problem	1	CO6
4.3	Inner product spaces	2	CO6
	Tutorial	1	
4.4	Orthonormal sets	1	CO6
4.5	The Gram-Schmidt orthogonalization process	2	CO6
	Tutorial	1	
Total		**36**	

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18EC320	RF PASSIVE DEVICES AND CIRCUITS	Category	L	T	P	Credit
		PC	2	1	0	3

Preamble

This course aims to provide students with the technological skills needed in understanding the behaviour of two wire line, planar transmission lines and the design of RF passive circuits.

Prerequisites

NIL

Course Outcomes

On the successful completion of the course students will be able to

CO#	Course Outcome Statement	Weightage in %
CO1	Understand the RF front end in a GSM cellular phone and the allied RF signal parameters	20
CO2	Understand and characterize transmission lines and calculate the transmission and reflection parameters	10
CO3	Design and Develop a microstrip transmission line and its variants and its feed mechanisms	10
CO4	Design and validate power divider and coupler	20
CO5	Design and validate filters for GSM frequencies	20
CO6	Apply the concepts of power divider, and filter to develop a duplexer for a GSM RF front end applications.	20

CO Mapping with CDIO Curriculum Framework

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS2	Understand	Respond	-	1.2, 2.1.1, 2.4.7, 4.1.4
CO2	TPS2	Understand	Respond	-	1.2, 2.1.1, 2.4.7, 4.1.4
CO3	TPS3	Apply	Value	Mechanism	1.2, 2.4.7, 2.5.1, 2.5.4, 3.1.1, 3.1.2, 3.1.4, 3.2.1, 3.2.6, 3.2.4, 3.2.5, 3.2.6, 3.3.1, 4.1.2 ,4.3.4, 4.4.3, 4.5.2, 4.5.3, 4.5.5
CO4	TPS3	Apply	Value	Mechanism	1.2, 2.4.7, 2.5.1, 2.5.4, 3.1.1, 3.1.2, 3.1.4, 3.2.1, 3.2.6, 3.2.4, 3.2.5, 3.2.6, 3.3.1, 4.1.2, 4.3.4, 4.4.3, 4.5.2, 4.5.3, 4.5.5
CO5	TPS3	Apply	Value	Mechanism	1.2, 2.4.7, 2.5.1, 2.5.4, 3.1.1, 3.1.2, 3.1.4, 3.2.1, 3.2.6, 3.2.4, 3.2.5, 3.2.6, 3.3.1, 4.1.2, 4.3.4, 4.4.3, 4.5.2, 4.5.3, 4.5.5
CO6	TPS3	Apply	Value	Mechanism	1.2, 2.4.7, 2.5.1, 2.5.4, 3.1.1, 3.1.2, 3.1.4, 3.2.1, 3.2.6, 3.2.4, 3.2.5, 3.2.6, 3.3.1, 4.1.2, 4.3.4, 4.4.3, 4.5.2, 4.5.3, 4.5.5

Mapping with Programme Outcomes and Programme Specific Outcomes

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	M	L	-	-	-	L	-	L	L	-	-	-	M	-	L
CO2	M	L	-	-	-	L	-	L	L	-	-	-	M	-	L
CO3	S	M	L	-	M	L	-	M	M	-	-	-	M	-	M
CO4	S	M	L	-	M	L	-	M	M	-	-	-	M	-	M
CO5	S	M	L	-	M	L	-	M	M	-	-	-	M	-	M
CO6	S	M	L	-	M	L	-	M	M	-	-	-	M	-	M

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

Cognitive Levels	Continuous Assessment Tests			Assignment			End Semester Examination
	1	2	3	1	2	3	
Remember	20	20	20	0	0	0	0
Understand	20	20	20	100	0	0	20
Apply	60	60	60	0	50	25	80
Analyse	0	0	0	0	0	0	0
Evaluate	0	0	0	0	0	0	0
Create	0	0	0	0	0	0	0

Assessment Pattern: Psychomotor

Psychomotor Skill	Assignment-1	Assignment-2	Assignment-3
Perception	-	-	-
Set	-	-	-
Guided Response	-	-	-
Mechanism	-	50	75
Complex Overt Responses	-	-	-
Adaptation	-	-	-
Origination	-	-	-

Course Level Assessment Questions

Course Outcome 1 (CO1)

1. Illustrate the behaviour of inductors and capacitors under high frequency circumstances
2. Calculate the following as desired: -20dBm to watts and 1nW to dBm
3. If the reflection coefficient is 0.4, calculate the VSWR.

Course Outcome 2 (CO2)

1. A radio transmitter is connected to an antenna having an impedance of 80+j40Ω with a 50Ω coaxial cable. If the 50Ω transmitter can deliver 30W when connected to a 50Ω load, how much power delivered to the antenna?
2. A 75Ω coaxial transmission line has a length of 2 cm and is terminated with a load impedance of 37.5+j75Ω. If the dielectric constant of the line is 2.56 and the frequency is 3.0 GHz, find the input impedance to the line, reflection coefficient at the load, the reflection coefficient at the input and the SWR on the line.
3. A lossless transmission line of electrical length $l = 0.3\lambda$ is terminated with a complex load impedance as shown below. Find the reflection coefficient at the load, the SWR on the line, the reflection coefficient at the input of the line and the input impedance to the line.

Course Outcome 3(CO3)

1. Justify, why microstrip lines cannot support pure TEM mode of propagation.
2. Classify planar transmission lines with their mode of propagation and field Variations.
3. Design a micro strip for a 75ohm characteristic impedance and a 90 degree phase shift at 3.5 GHz. The substrate thickness is d= 0.127cm with ε_r= 2.20.

Course Outcome 4(CO4)

1. A lossless T junction power divider has a source impedance of 50 ohms. Find the output characteristic impedances so that the input power is divided in a 2:1 ratio. Compute the reflection coefficients seen looking into the output ports.
2. A directional coupler has the scattering matrix given below. Find the return loss, coupling factor, directivity, insertion loss. Assume that the ports are terminated in matched loads.

$$[S] = \begin{bmatrix} 0.1\angle 40^\circ & 0.944\angle 90^\circ & 0.178\angle 180^\circ & 0.0056\angle 90^\circ \\ 0.944\angle 90^\circ & 0.1\angle 40^\circ & 0.0056\angle 90^\circ & 0.178\angle 180^\circ \\ 0.178\angle 180^\circ & 0.0056\angle 90^\circ & 0.1\angle 40^\circ & 0.944\angle 90^\circ \\ 0.0056\angle 90^\circ & 0.178\angle 180^\circ & 0.944\angle 90^\circ & 0.1\angle 40^\circ \end{bmatrix}$$

3. A 20 dBm power sorce is connected to the input of a directional coupler having a coupling factor of 20dB, a directivity of 35dB and an insertion of 0.5 dB. If all the ports are matched find the output powers (in dBm) at the through, coupled and isolated ports.

Course Outcome 5(CO5)

1. Design a maximally flat low pass filter with a cut-off frequency of 2 GHz, impedance 50 Ω, and at least 15 dB insertion loss at 3 GHz.
2. Design a stepped impedance low pass filter having a maximally flat response and a cut off frequency of 2.5 GHz. It is necessary to have more than 20 dB insertion loss at 4 GHz, the filter impedance is 50Ω, the highest impedance is 150Ω and the lowest is 10 Ω.
3. Design a high-pass lumped-element filter with a 3 dB equal-ripple response, a cutoff frequency of 3 GHz, and at least 30 dB insertion loss at 2.0 GHz. The characteristic impedance is 75 ohms. Use CAD to plot the insertion loss versus frequency

Course Outcome 6(CO6)

1. Design a bandpass filter having 0.5 dB equal ripple response with N=3.The Center frequency is 1GHz,the fractional bandwidth 10% and the impedance is 50 Ω.
2. Design a band pass filter with a single resonant circuit for a center frequency of 500MHz and a desired 3 dB bandwidth of 50 MHz. Use a 50Ω source and 50Ω load terminations. Also show the changes caused by finite component Q"s of 80 at 500MHz. Plot the response and show the changes from 450 MHz to 550 MHz.
3. Design a duplexer for GSM applications

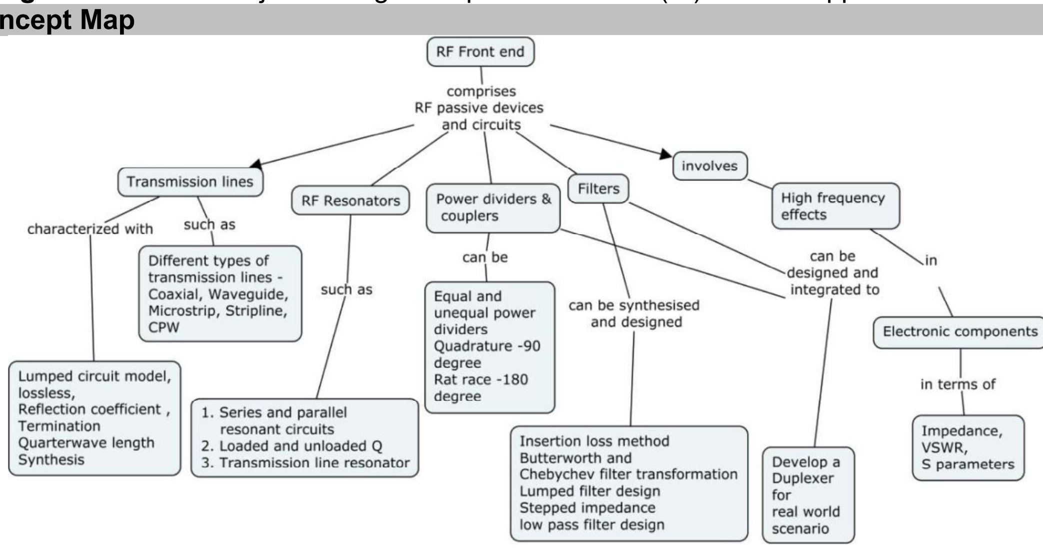
Sample Assignments:

Assignment 1: Design and simulation of Microstrip line for a given impedance.

Assignment 2: Design, simulate, & measure the power divider, coupler and filter for GSM (or) Cellular applications..

Assignment 3: Mini Project: Design a duplexer for GSM (or) Cellular applications

Concept Map



Syllabus:

Introduction: Cellular phone architecture – blocks and functionalities. **High frequency effects:** RF/Microwaves versus DC or Low AC signals, Wave concepts - Wavelength and Frequency, EM Spectrum-frequency allocation for various applications, Power units - dB and dBm, dBm – Watt conversions, high frequency behaviour of electronic Components– Wire, Resistor, Capacitor, Inductor. Equivalent voltage and current at RF frequency, Impedance and matching, VSWR, reflection and transmission coefficient, S parameters of a two port network, Cascaded networks – Practical examples. RF front end – Sub systems – transmission lines, active &, passive components, role of RF in communication with respect to modulation/demodulation – case study –GSM cellular application - air interface specifications - GSM, GSM upgrades to 4G – RF in 5G and IOT applications, Measurements using Spectrum analyser. **Transmission Lines:** Need for two wire Transmission Line, Lumped element circuit model for a transmission line- Wave propagation on a transmission line, Terminated lossless line & Quarter wave transformer, Types of transmission line – coaxial, waveguide, microstrip, stripline, coplanar waveguide, Synthesis of a transmission line for a given impedance. Synthesis of Microstrip transmission line for a given impedance. **RF Resonators:** Series and parallel resonant circuits, Loaded and unloaded Q, Transmission line resonators, Power dividers: Need for Power dividers, Basic properties of dividers, Equal and unequal power dividers. Couplers: Need for couplers, Basic properties of couplers, Principle and working of Quadrature 90º and Rat race 180º couplers. Design & Simulation of a power divider to split an incoming GSM signal from 930-960 MHz into two RF channels. **Filters:** Need for filters and practical applications, filter parameters, types of filters, Filter design by insertion loss method, finding the order of filter, Butterworth and Chebyshev filter transformations, Impedance and frequency scaling, lumped filters, Stepped impedance lowpass filter design. Design & Simulation of filters for GSM/5G wireless applications. **Duplexers:** Need for duplexers, specifications for a GSM front end, Layout, Design and simulation of a duplexer with power divider and filters for GSM. Identification of real world components and preparation of detailed schematics with loss and frequency Charts - Mini project.

Learning Resources:

1. Matthew M. Radmanesh, "Radio frequency and Microwave Electronics Illustrated", Pearson Education Asia, 2001
2. David M. Pozar," Microwave Engineering," John Wiley & Sons, Fourth Edition, 2015.
3. Les Besser and Rowan Gilmore, "Practical RF circuit Design for Modern Wireless Systems- Passive circuits and Systems", Vol.1, Artech House Publishers, Boston, London 2008.
4. G L Matthaei, L Young, and E M T Jones ," Microwave filters, impedance matching networks and coupling structures", Artech House, 1985.
5. Grish Kumar, microwave theory and techniques, NPTEL Video Lectures: https://www.youtube.com/watch?v=gH4bCRvBgBg&list=PLOzRYVm0a65dcxLJgO0uzQ0Sad-57w37u&index=3

Course Contents and Lecture Schedule

#	Topic	Lecture Hour	Practice Hour	CO Number
1	**Introduction:** Cellular phone architecture – blocks and functionalities	**1**	**1**	**CO1**
2	**High frequency effects:** RF/Microwaves versus DC or Low AC signals, Wave concepts - Wavelength and Frequency, EM Spectrum-frequency allocation for various applications	**1**	**1**	**CO1**
2.2	**Power units** - dB and dBm, dBm – Watt conversions	**1**		**CO1**
2.3	**High frequency behaviour** of electronic Components– Wire, Resistor, Capacitor, Inductor.	**1**		**CO1**

2.4	**Equivalent voltage and current** at RF frequency, Impedance and matching, VSWR, reflection and transmission coefficient	**1**		**CO2**
2.5	**S parameters** of a two port network, Cascaded networks – Practical examples. RF front end – Sub systems – transmission lines, active &, passive components, role of RF in communication with respect to modulation/demodulation	**1**		**CO1, CO2**
2.6	**Case study –**GSM cellular application - air interface specifications - GSM, GSM upgrades to 4G – RF in 5G and IOT applications, Measurements using Spectrum analyser.		**2**	**CO2**
3	**Transmission Lines:** Need for two wire Transmission Line, Lumped element circuit model for a transmission line- Wave propagation on a transmission line, Terminated lossless line & Quarter wave transformer,	**1**	**1**	**CO1, CO2, CO3**
3.2	Types of transmission line – coaxial, waveguide, microstrip, stripline, coplanar waveguide, **Synthesis of Microstrip transmission line for a given impedance – Assignment I**	**1**	**2**	**CO3**
4	**RF Resonators:** Series and parallel resonant circuits, Loaded and unloaded Q, Transmission line resonators,.	**1**		**CO1, CO2, CO3,**
4.2	Power dividers: Need for Power dividers, Basic properties of dividers, Equal and unequal power dividers.	**2**	**1**	**CO1, CO2, CO3, CO4**
4.3	Couplers: Need for couplers, Basic properties of couplers, Principle and working of Quadrature 90º and Rat race 180º couplers.	**1**	**1**	**CO1, CO2, CO3, CO4**
4.4	**Design & Simulation of a power divider to split an incoming GSM signal from 930-960 MHz into two RF channels – Assignment II**		**2**	**CO4**
5	**Filters:** Need for filters and practical applications, filter parameters, types of filters,	**1**		**CO1, CO2, CO3,**
5.2	Filter design by insertion loss method, finding the order of filter, Butterworth and Chebyshev filter transformations, Impedance and frequency scaling	**1**	**1**	**CO1, CO2, CO3,**
5.3	Design of lumped filter model,	**1**	**1**	**CO5**
5.4	Stepped impedance lowpass filter design.	**1**	**1**	**CO5**
5.5	Design & Simulation of filters for GSM/5G wireless applications.		**2**	**CO5**
6	**Duplexers:** Need for duplexers, specifications for a GSM front end, Layout model	**1**		**CO1, CO2, CO3,**
6.2	Design and simulation of a duplexer with power divider and filters for GSM	**1**	**1**	**CO6**
6.3	Identification of real world components and preparation of detailed schematics with loss and frequency Charts	**1**		**CO6**
6.4	**Mini project – Assignment III**		**2**	**CO6**

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18EC330	ELECTRONIC CIRCUITS	Category	L	T	P	Credit
		PC	3	0	0	3

Preamble

Having attained the basic knowledge about the principle of operation of semiconductor electronic devices like diodes, transistors and elementary circuits in the second semester, this course will enable the students to learn about the use of transistors in analog circuits like single and multi stage amplifier, feedback amplifier, Differential amplifier, power amplifier and oscillators. It also gives information about the current mirror circuits used for biasing in Integrated Circuits and their applications in the field of electronics industry.

Prerequisite

18EC230 Electronic Devices

Course Outcomes

On the successful completion of the course students will be able to

COs	Course Outcome Statement	Weightage*** in %
CO1	Analyze Input resistance, Output resistance, Voltage gain, and Current gain of the Single stage amplifiers and Multistage Amplifiers	20
CO2	Analyze the low frequency response and high frequency response of Single stage and Multi stage amplifiers.	15
CO3	Derive and analyze the expressions for voltage gain, input impedance of voltage series, voltage shunt, current series and current shunt negative feedback amplifiers ,RC and LC Oscillators	20
CO4	Derive the equation for power output and conversion efficiency of Class A ,Class B and Class C of large signal amplifiers.	15
CO5	Analyze the open loop and closed loop response of OP-AMP	10
CO6	Understand and explain the operation of Instrumentation amplifier, A/D –D/A converters, Active filters	10
CO7	Design of Multivibrators, ,Mixer circuits, VCO and PLL	10

*** Weightage depends on Bloom's Level, number of contact hours,

CO Mapping with CDIO Curriculum Framework

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS3	Apply	Value	Mechanism	1.2, 2.1.1, 2.1.2, 2.5.1, 3.1.1, 3.2.3, 4.5.5, 4.6.2
CO2	TPS3	Apply	Value	Mechanism	1.2, 2.1.1, 2.1.2, 2.5.1, 3.1.1, 3.2.3, 4.5.5, 4.6.2
CO3	TPS3	Apply	Value	Mechanism	1.2, 2.1.1, 2.1.2, 2.5.1, 3.1.1, 3.2.3, 4.5.5, 4.6.2
CO4	TPS4	Analyse	Organise	Complex Overt Responses	1.2, 2.1.1, 2.1.2, 2.1.3, 2.5.1, 3.1.1, 3.2.3, 4.5.5, 4.6.2
CO5	TPS4	Analyse	Organise	Complex Overt Responses	1.2, 2.1.1, 2.1.2, 2.1.3, 2.5.1, 3.1.1, 3.2.3, 4.5.5, 4.6.2
CO6	TPS4	Analyse	Organise	Complex Overt Responses	1.2, 2.1.1, 2.1.2, 2.1.3, 2.5.1, 3.1.1, 3.2.3, 4.5.5, 4.6.2
CO7	TPS3	Apply	Value	Mechanism	1.2, 2.1.1, 2.1.2, 2.1.3, 2.5.1, 3.1.1, 3.2.3, 4.5.5, 4.6.2

Mapping with Programme Outcomes and Programme Specific Outcomes

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	S	M	L	-	L	-	-	L	L	L	-	L	M	-	L
CO2	S	M	L	-	L	-	-	L	L	L	-	L	M	-	L
CO3	S	M	L	-	L	-	-	L	L	L	-	L	M	-	L
CO4	S	S	M	L	L	-	-	L	L	L	-	L	S	-	L
CO5	M	L	-	-	-	-	-	-	L	L	-	L	S	-	L
CO6	S	S	M	M	L	-	-	-	-	-	-	-	S	-	-
CO7	S	M	L	-	L	-	-	L	L	L	-	L	M	-	L

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

Cognitive Levels	Continuous Assessment Tests			Assignment			End Semester Examination
	1	2	3	1	2	3	
Remember	20	0	0	-	-	-	0
Understand	20	20	20	-	-	-	20
Apply	60	50	40	100	50	-	40
Analyse	0	30	40	0	50	50	40
Evaluate	0	0	0	0	0	20	0
Create	0	0	0	0	0	0	0

Assessment Pattern: Psychomotor

Psychomotor Skill	Assignment 3
Perception	
Set	
Guided Response	
Mechanism	30
Complex Overt Responses	
Adaptation	
Origination	

Sample Questions for Course Outcome Assessment

Course Outcome 1(CO1):

1. Design an common emitter amplifier with emitter degenerative resistance to operate between a 10K Ω source and a 2K Ω load with a gain of -8 V/V. the power supply available is 9V. Use an emitter current of 2 mA and a current of about one-tenth of that in the voltage divider that feeds the base, with the dc voltage at the base about one-third of the supply. The transistor β=100.
2. Design an audio amplifier (common emitter circuit) with an voltage gain of 10. The circuit uses a 12 V power supply. The input impedance of the amplifier should be about 15K, the same as the potentiometer from which the audio was taken. The impedance of the stereo amplifier's auxiliary input is about 50K.
3. Explain how h parameter can be obtained from the transistor characteristics.

Course Outcome 2(CO2):

1. Determine the critical frequency of the bypass RC circuit for the amplifier in figure.(r_e=12Ω)
2. Determine the high frequency response of the amplifier.
3. Determine the low frequency response of the amplifier.

Course Outcome 3(CO3):

1. In a bridge rectifier, the input is from 230V, 50HZ mains. Calculate the d.c., the output voltage. If a capacitor of 1000μF is used as a filter with this rectifier while supplying a load of 2kΩ. Calculate the ripple factor and the output voltage.
2. Explain how FET can be used as an amplifier.

3. Derive the expression of the output voltage and explain how it can be varied for the feedback type series regulator.

Course Outcome 4 (CO4):

1. Draw and explain the working of class C tuned amplifier
2. A certain B amplifier delivers 10W to the load. The output transform efficiency is 85% .A CRO connected across the load of 0,5 Ω in series with positive lead of the 24V power supply shows a peak voltage of 500mV. Determine the efficiency.
3. An ideal class B amplifier supplies power to a load of 4Ω connected through a step down transform with turns ratio 4:1 and efficiency of 90%.Calculate
   (a) Maximum power delivered to load
   (b) Power dissipation ratings of each transistor. Assume VCC=20V and gives turns ratio asN1/N2 .

Course Outcome 5 (CO5):

1. Determine the output voltage of an op-amp for the input voltages of V_1=150μV,V_2=140μV. The amplifier has a differential gain of 4000 and the value of CMRR is (i) 100 (ii)$10^{5.}$
2. For a differential amplifier, the two sets of input are applied. The first set is V1=50μV and V2= -50μV and the second set is V1=1050μV and V2=950μV. If the CMRR is 100, calculate the percentage difference in the output voltage obtained for the two sets of the input signals. If now CMRR is improved to 10000, Calculate the percentage difference in the output voltage obtained for the two sets of the input signal.

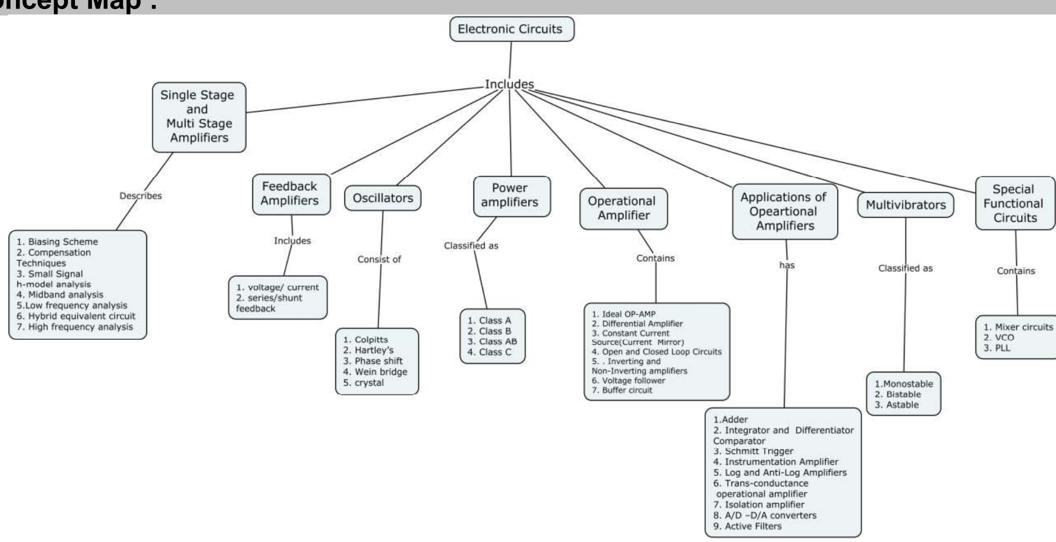
Course Outcome 6(CO6):

1. What is the main purpose of an instrumentation amplifier.
2. A certain op-amp has an open loop gain of 80,000.The maximum saturated output levels of this particular device are 12V. If a differential voltage of 0.15mV rms is applied between the input, what is the peak-to-peak value of the output?
3. How is the gain determined in a basic instrumentation amplifier? In a certain AD622 configuration, Rg=10KΩ.What is the voltage gain?

Course Outcome 7(CO7):

1. Construct a 555 timer configured to run in the astablemode(oscillator). Determine the frequency of the output and the duty cycle.
2. Discuss aastable operation of the 555timer and explain how to use the 555 timer as a VCO?

Concept Map :



Syllabus

Single Stage and Multistage Amplifiers: Biasing Scheme, Compensation Techniques, Small Signal h-model analysis, Midband analysis, Low frequency analysis, Hybrid π equivalent circuit , High frequency analysis, **Feedback Amplifiers and Oscillators:**voltage/ current, series/shunt feedback, Oscillators:Colpitts, Hartley's, Phase shift, Wein bridge and crystal oscillators.**Power amplifiers :** Class A, B, AB, C **Operational Amplifier:**Ideal OP-AMP, Differential Amplifier, Constant Current Source(Current Mirror), Open and Closed loop Circuits,Inverting and Non-Inverting amplifiers, Voltage follower, Buffer circuit, DC Imperfections, Transient and Frequency dependent performance, Applications:Adder, Integrator and Differentiator, Comparator, Schmitt Trigger, Instrumentation Amplifier, Log and Anti-Log Amplifiers, A/D –D/A converters, Active Filters.**Multivibrators and Special Functional Circuits:** Monostable,Bistable,Astable multi vibrators using 555 timer,Mixer circuits,VCO and PLL.

Text Books

1. Adel S. Sedra and Kenneth C. Smith, "Microelectronic Circuits: Theory and Application", 7th Edition, Oxford University Press, 2017.
2. SerigoFranco, "Design with Operational Amplifiers &Analog Integrated Circuits", 4th edition, McGraw Hill,2014.
3. Boylested&Nashelsky, "Electronic Devices and Circuit Theory", 11th edition, Pearson Education India, 2015.
4. BehzardRazavi, "Fundamentals of Microelectronics", 2nd Edition, Wiley, 2014.
5. https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-012-microelectronic-devices-and-circuits-fall-2009/readings/
6. NPTEL video lecture on "Analog Electronic Circuits" https://nptel.ac.in/courses/108102095/

Course Contents and Lecture Schedule

Module No.	Topic	No. of Hours	Course Outcome
1.	**SINGLE STAGE AND MULTISTAGE AMPLIFIERS**		
1.1	Biasing Scheme,	1	CO1
1.2	Compensation Techniques	2	CO1
1.3	Small Signal h-model analysis	2	CO1
1.4	Midband analysis,	2	CO2
1.5	Low frequency analysis	1	CO2
1.6	Hybrid π equivalent circuit	1	CO2
1.7	High frequency analysis	1	CO2
2.	**FEEDBACK AMPLIFIERS AND OSCILLATORS**		
2.1	voltage/ current feedback	2	CO3
2.2	series/shunt feedback	2	CO3
2.3	Oscillators: Colpitts, Hartley's	2	CO3
2.4	Phase shift, Wein bridge and crystal oscillators.	2	CO3
3.	**POWER AMPLIFIERS**		
3.1	Class A	1	CO4
3.2	Class B	1	CO4
3.3	Class AB	1	CO4
3.4	Class C	1	CO4
4.	**OPERATIONAL AMPLIFIER**		
4.1	Ideal OP-AMP, Differential Amplifier,Constant Current Source(Current Mirror)	2	CO5
4.2	Open and Closed Loop Circuits, Inverting and Non-Inverting amplifiers	1	CO5
4.3	Voltage follower, Buffer circuit, DC Imperfections	1	CO5
4.4	Transient and Frequency dependent performance	1	CO5

4.5	Adder, Integrator and Differentiator, Comparator	1	CO6
4.6	Schmitt Trigger, Instrumentation Amplifier,	2	CO6
4.7	Log and Anti-Log Amplifiers, A/D –D/A converters Active Filters	1	CO6
5.	**MULTIVIBRATORS AND SPECIAL FUNCTIONAL CIRCUITS**		
5.1	Monostable,Bistable,Astable multi vibrators using 555 timer	2	CO7
5.2	Mixer circuits	1	CO7
5.3	VCO and PLL	2	CO7
	Total Hours	**36**	

Course Designers:

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18EC340	SIGNALS AND SYSTEMS	Category	L	T	P	Credit
		PC	2	1	0	3

Preamble

Signals and Systems arise in a wide variety of fields, and the ideas and techniques associated with these concepts play an important role in areas of science and technology as communications, aeronautics and astronautics, acoustics, seismology, biomedical engineering and speech processing. Signals are functions of one or more independent variables, contain information about the behaviour or nature of some phenomenon. Signals vary continuously in time or it is described only at discrete points in time. Systems respond to particular signals by producing other signals or some desired behaviour. Systems that respond to or process these signals leads naturally to two parallel frameworks for signal and system analysis, one for phenomena and processes that are described in continuous in time and one for those that are described in discrete in time. It introduces the students to analyze signals and systems and to design systems to enhance or restore signals that have been degraded in some way.

Prerequisite

NIL

Course Outcomes

On the successful completion of the course students will be able to

CO#	Course Outcome Statement	Weightage in %
CO1	Classify the given deterministic signal as continuous or discrete periodic or aperiodic, even or odd, and energy or power.	10
CO2	Classify the given system in terms of continuous or discrete linearity, time invariance, causality and stability.	15
CO3	Determine the time domain response of a LTI System for a given continuous time or discrete time input signal	15
CO4	Determine the frequency domain representation of periodic and aperiodic continuous and discrete time signals	25
CO5	Convert a continuous time signal into discrete time signal and reconstruct the continuous time signal.	15
CO6	Characterize LTI system using pole-zero locations in z-plane	20

CO Mapping with CDIO Curriculum Framework

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS2	Understand	Respond	Perception and set	1.2., 2.1.1, 2.1.2, 2.4.1, 2.4.2, 2.4.5, 3.2.3, 3.2.5,
CO2	TPS2	Understand	Respond	Perception and set	1.2, 2.1.1, 2.1.2, 2.4.1, 2.4.2, 2.4.5, 3.2.3, 3.2.5,
CO3	TPS3	Apply	Value	Guided response	1.2, 2.1.1, 2.1.2, 2.1.4, 2.1.5, 2.4.1, 2.4.2, 2.4.5, 3.2.3, 3.2.5,
CO4	TPS3	Apply	Value	Guided response	1.2, 2.1.1, 2.1.2, 2.1.4, 2.1.5, 2.4.1, 2.4.2, 2.4.5, 3.2.3, 3.2.5,
CO5	TPS3	Apply	Value	Guided response	1.2, 2.1.1, 2.1.2, 2.1.4, 2.1.5, 2.4.1, 2.4.2, 2.4.5, 3.2.3, 3.2.5,
CO6	TPS3	Apply	Value	Guided response	1.2, 2.1.1, 2.1.2, 2.1.4, 2.1.5, 2.4.1, 2.4.2, 2.4.5, 3.2.3, 3.2.5,

Mapping with Programme Outcomes and Programme Specific Outcomes

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	M	L	-	-	L	-	-	L	L	L	-	L	L	-	L
CO2	M	L	-	-	L	-	-	L	L	L	-	L	L	-	L
CO3	S	M	L	-	L	-	-	L	L	L	-	L	L	-	L
CO4	S	M	L	-	L	-	-	L	L	L	-	L	L	-	L
CO5	S	M	L	-	L	-	-	L	L	L	-	L	L	-	L
CO6	S	M	L	-	L	-	-	L	L	L	-	L	L	-	L

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

Cognitive Levels	Continuous Assessment Tests			Assignment			End Semester Examination
	1	2	3	1	2	3	
Remember	0	0	0	0	0	0	0
Understand	20	20	20	50	30	30	20
Apply	80	80	80	50	40	40	80
Analyse	0	0	0	0	0	0	0
Evaluate	0	0	0	0	0	0	0
Create	0	0	0	0	0	0	0

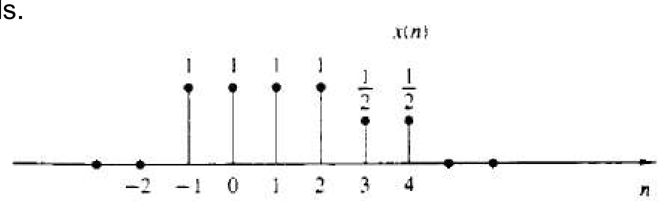
Assessment Pattern: Psychomotor

Psychomotor Skill	Assignment-1	Assignment-2	Assignment-3
Perception	-	-	-
Set	-	-	-
Guided Response	-	-	-
Mechanism	-	30	30
Complex Overt Responses	-	-	-
Adaptation	-	-	-
Origination	-	-	-

Sample Questions for Course Outcome Assessment

Course Outcome 1 (CO1):

1. Show that any signal can be decomposed in to an even and odd component. Is the decomposition unique? Illustrate your arguments using the signal $x[n] = e^{j\omega n}$
2. Show that $\delta(n) = u(n) - u(n-1)$
3. A discrete time signal $x(n)$ is shown in figure. Sketch and label carefully each of the following signals.



a. $x(2-n)$ b. $x(n)u(2-n)$ c. $x(n^2)$ d. even part of $x(n)$

e. $x(n-1)\delta(n-3)$

Course Outcome 2 (CO2):

1. For the each of the following systems, determine whether or not the system is 1. Linear and 2. Time invariant

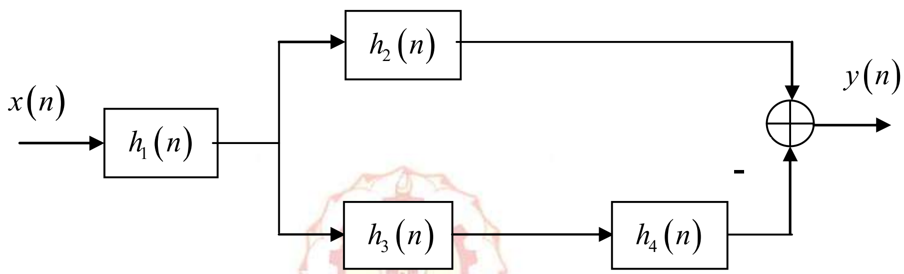
a. $y(n) = x(n)\cos(0.2\pi n)$

b. $y(n) = Ax(n) + B$, where A and B are constants.

2. Determine whether or not each of the following continuous time signals is periodic. If the signal is periodic, determine its fundamental period.
   a. $x(t)=3\cos\left(4t+\frac{\pi}{3}\right)$
   b. $x(t)=e^{j(\pi t-1)}$
3. For each of the following input-output relationships, determine whether the corresponding system is linear, time invariant or both.
   a. $y(t)=t^2x(t-1)$
   b. $y(n)=x(n+1)-x(n-1)$

Course Outcome 3 (CO3):

1. Consider the interconnection of LTI systems as shown in figure



   a. Express the overall impulse response in terms of $h_1(n)$, $h_2(n)$, $h_3(n)$ and $h_4(n)$.
   b. Determine $h(n)$ when $h_1(n)=\{1/2,1/4,1/2\}$, $h_2(n)=h_3(n)=\delta(n)+2\delta(n-2)+\delta(n-4)$ and $h_4(n)=\delta(n-2)$. Determine the response of the system in part (b) if $x(n)=\delta(n)+3\delta(n-3)-4\delta(n-5)$

2. Let $x(t)=u(t-3)-u(t-5)$ and $h(t)=e^{-3t}u(t)$.
   a. Compute $y(t)=x(t)*h(t)$
   b. Compute $g(t)=\left(\frac{dx(t)}{dt}\right)*h(t)$
   c. How is $g(t)$ is related to $y(t)$?
3. Let $x(n)=\delta(n)+2\delta(n-1)-\delta(n-3)$ and $h(n)=2\delta(n+1)+2\delta(n-1)$. Compute and plot each of the following convolutions:
   a. $y_1=(n)=x(n)*h(n)$
   b. $y_2=(n)=x(n+2)*h(n)$
   c. $y_3=(n)=x(n)*h(n+2)$

Course Outcome 4 (CO4):

1. A periodic signal $x(t)$ is given by $x(t)=1+2\cos\left(300\pi t+\pi/4\right)+\sin(500\pi t)$ a. What is the period of $x(t)$?
   b. Find the Fourier series coefficient of $x(t)$ for $-6\le k\le 6$.

2. Consider the square wave with 50 % duty cycle. Compute the exponential Fourier series and draw the spectrum for the square wave for 50 % duty cycle, having frequency of 25 Hz; then Synthesize the square wave from the Fourier coefficients for different harmonics and Describe Gibbs phenomenon
3. A periodic signal is represented by the Fourier Synthesis formula: $x(t)=\sum_{k=-\infty}^{\infty} a_k e^{j30\pi kt}$

   where $a_k = \begin{cases} \dfrac{1}{4+j2k} & k=-3,-2,-1,0,1,2,3 \\ 0 & |k|>3 \end{cases}$
   a. Sketch the two sided spectrum of the signal. Label all complex amplitudes in polar form.
   b. Determine the fundamental frequency and fundamental period of the signal.

Course Outcome 5 (CO5):

1. Consider the analog signal $x_a(t)=3\cos(2000\pi t)+5\sin(6000\pi t)+10\cos(12000\pi t)$
   a. What is the Nyquist rate for this signal?
   b. Assume now that we sample this sample using a sampling rate $F_s = 5000$ samples/sec. What is the discrete time signal obtained after sampling?
   c. What is the analog signal $y_a(t)$ we can reconstruct from the samples if we use ideal interpolation?
2. The frequency which, under the sampling theorem, must be exceeded by the sampling frequency is called the Nyquist rate. Determine the Nyquist rate corresponding to each of the following signals:
   a. $x(t)=1+\cos(2000\pi t)+\sin(4000\pi t)$
   b. $x(t)=\dfrac{\sin(4000\pi t)}{\pi t}$
   c. $x(t)=\left(\dfrac{\sin(4000\pi t)}{\pi t}\right)^2$
3. Show that $7\cos(8.4\pi n-0.2\pi)$ is an alias of $7\cos(0.4\pi n-0.2\pi)$

Course Outcome 6 (CO6):

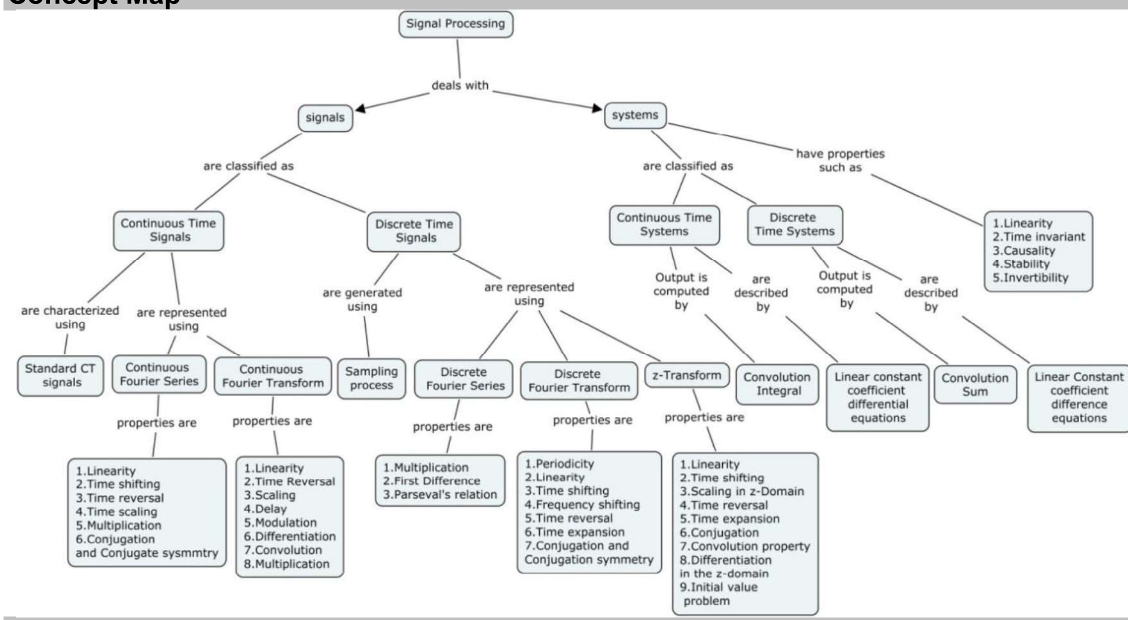
1. An LTI system is described by the difference equation $y[n]=\frac{1}{4}\left[x[n]+x[n-1]+x[n-2]+x[n-3]\right]$.
   a) What is $h[n]$, the impulse response of this system?
   b) Determine the system function $H(z)$ for this system.
   c) Plot the poles and zeros of $H(z)$ in the complex z-plane.
   d) From $H(z)$, obtain an expression for the frequency response $H(e^{j\hat{\omega}})$ of this system
2. Compute the convolution $x[n]$ of the signals

   $x_1[n]=\{1,-2,1\}$

   $x_2[n]=\begin{cases} 1, & 0\le n\le 5 \\ 0, & otherwise \end{cases}$ using the property of z-transform.

3. Find the region of convergence of z-transform of the sequence $\left(\frac{5}{6}\right)^n u(n)-\left(\frac{6}{5}\right)^n u(-n-1)$?

Concept Map



Syllabus

Introduction: Standard Signals: Unit impulse, unit step, unit ramp, exponential, and sinusoidal signals, Sampling Process, Mathematical Representation of Continuous and discrete time signals, Types of signals: power, energy, periodic, even and odd, **Basic System Properties: Linearity, Time Invariant, causality, stability and invertibility. Time Domain Characterisation of Continuous Time LTI system:** Convolution Integral, Properties of continuous time LTI system, Causal continuous time LTI system described by differential equations. **Frequency Domain Representation in Continuous Time Signals:** Fourier series representation of continuous time periodic signals, properties of continuous time Fourier series, Fourier transform of continuous time aperiodic signals and periodic signals, properties of continuous time Fourier transform. **Time Domain Characterisation of Discrete Time LTI system:** Convolution sum, properties of discrete time LTI system, Causal discrete time LTI system described by difference equations. **Frequency Domain Representation in Discrete Time Signals:** Fourier series representation of discrete time periodic signals, properties of discrete time Fourier series, Discrete time Fourier transform, properties.**z-Transform:** z-Transform and linear systems, properties of z-Transform, Analysis and characterization of LTI system using z-Transform

Learning Resources

1. Alan V.Oppenheim, Alan S.Willsky and S.Hamid Nawab, “Signals & Systems”, Prentice-Hall of India, Second Edition, 2011.
2. James H.McClellen, Ronald W.Schafer, Mark A.Yoder ,”Signal Processing First”, Pearson Education,2003
3. Rodger E.Ziemer, William H.Tranter and D.Ronald Fannain “Signals & Systems Continuous and Discrete”, Pearson Education, 2002.
4. Simon Haykin, Barry Van Veen,” Signals and Systems” ,Wiely,2nd Edition, 2002.
5. Sophocles J.Orfanidis “Introduction to Signal Processing”, Prentice Hall, 1996.
6. Ashok Ambardar, “ Digital Signal Processing: A Modern Introduction”, Nelson Engineering, 2007
7. https://ocw.mit.edu/resources/res-6-007-signals-and-systems-spring-2011/index.htm
8. http://signalsandsystems.wikidot.com/video-lectures

Course Contents and Lecture Schedule

No.	Topic	No. of Lectures	COs
1	**Introduction**		
1.1	Standard signals: Unit impulse, Unit step, Unit ramp, exponential and sinusoidal signals	1	CO1
1.2	Mathematical representation of continuous and discrete time signals	1	CO1
1.3	Types of signals: Power energy, periodic, even and odd	1	CO1
1.4	System properties: Linearity, time invariant, causality, stability and invertibility	2	CO2
1.5	Tutorial	1	CO2
2	**Time Domain Characterisation of Continuous time LTI system**		
2.1	Convolution Integral	2	CO3
2.2	Properties of continuous time LTI system	1	CO3
2.3	Causal continuous time LTI system described by differential equations	1	CO3
2.4	Tutorial	1	CO3
3	**Frequency Domain representation in continuous time signal**		
3.1	Fourier series representation of continuous time periodic signals	1	CO4
3.2	properties of continuous time Fourier series	1	CO4
3.3	Fourier transform of continuous time aperiodic signals	2	CO4
3.4	Fourier transform of continuous time periodic signals	2	CO4
3.5	properties of continuous time Fourier transform	1	CO4
3.6	Tutorial	1	CO4
4	**Sampling**		
4.1	Impulse Train Sampling	1	CO5
4.2	Reconstruction of a signal from its samples using Interpolation	1	CO5
5	**Time Domain Characterisation of Discrete time LTI system**		
5.1	Convolution sum	1	CO3
5.2	properties of discrete time LTI system	1	CO3
5.3	Casual discrete time LTI system described by difference equations	1	CO3
5.4	Tutorial	1	CO3
6	**Frequency Domain representation in discrete time signals**		
6.1	Fourier series representation of discrete time periodic signals	1	CO4
6.2	properties of discrete time Fourier series	1	CO4
6.3	Discrete time Fourier transform	2	CO4
6.4	Properties	1	CO4
6.5	Tutorial	1	CO4
7	**z-Transform**		
7.1	z-Transform and linear systems	1	CO6
7.2	properties of z-Transform	2	CO6
7.3	Analysis and characterization of LTI system using z-Transform	2	CO6
7.4	Tutorial	1	CO6
	Total	36	

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18EC350	MICROPROCESSORS AND MICROCONTROLLERS	Category	L	T	P	Credit
		PC	2	1	0	3

Preamble

The microprocessor has move out of giant air-conditioned rooms into closets, then onto desktops, and now into our laps and pockets. The rapid improvement in microprocessor architecture has come to both advances in the technology used to build computers and from innovation in computer design. The study of microprocessor architecture focuses on the structure and behaviour of the computer system and refers to the logical aspects of system implementation as seen by the engineer. The tremendous number of applications for embedded computing has given rise to high demand for engineers with experience in designing and implementing embedded systems with microcontroller. This course is also designed to provide an introduction to microcontroller architecture, internal and external peripherals, assembly language programming and embedded c programming. Students will be taught the basic use of a programming environment and how to develop the basic C programming for embedded application. This course highlights the general interfacing techniques and concepts through peripheral's data representation from input/output, and memory usage in the microcontroller in embedded C.

Prerequisite

18EC260-Digital System Design

Course Outcomes

On the successful completion of the course students will be able to

CO#	Course Outcome Statement	Weightage in %
CO1	Classify the features in the evolution of Intel architecture and show its computer components	20
CO2	Realize the need of the processor for computation by customizing the assembly level programming	15
CO3	Apply the knowledge on writing program for the system call in operating system	15
CO4	Apply the programming skill on accessing the timer and serial peripherals in ASM or in embedded C code	15
CO5	Apply the effective implementation of the algorithm for the given process control in embedded C code	15
CO6	Compute the number of machine cycles and T states taken by the program in ASM and embedded C code	20

CO Mapping with CDIO Curriculum Framework

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS3	Apply	Value	-	1.2, 2.1.1, 2.1.2, 2.4.2, 2.4.6, 2.5.1, 3.1.1, 3.2.3, 4.5.5, 4.6.2
CO2	TPS3	Apply	Value	-	1.2, 2.1.1, 2.1.2, 2.5.1, 3.1.1, 3.2.3, 4.5.5, 4.6.2
CO3	TPS3	Apply	Value	-	1.2,, 2.1.1, 2.1.2, 2.5.1, 3.1.1, 3.2.3, 4.5.5, 4.6.2
CO4	TPS4	Analyse	Organise	Complex Overt Responses	1.2, 2.1.1, 2.1.2, 2.1.3, 2.5.1
CO5	TPS4	Analyse	Organise	Complex Overt Responses	1.2, 2.1.1, 2.1.2, 2.1.3, 2.5.1
CO6	TPS3	Apply	Value	Mechanism	1.2, 2.1.1, 2.1.2, 2.5.1

Mapping with Programme Outcomes and Programme Specific Outcomes

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	S	M	L	-	L	-	-	L	L	L	-	L	M	-	L
CO2	S	M	L	-	L	-	-	L	L	L	-	L	M	-	L
CO3	S	M	L	-	L	-	-	L	L	L	-	L	M	-	L
CO4	S	S	M	L	L	-	-	L	L	L	-	L	S	-	L
CO5	S	S	M	L	L	-	-	L	L	L	-	L	S	-	L
CO6	S	M	L	-	L	-	-	L	L	L	-	L	M	-	L

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

Cognitive Levels	Continuous Assessment Tests			Assignment			End Semester Examination
	1	2	3	1	2	3	
Remember	0	0	0	0	0	0	0
Understand	20	20	20	0	0	0	20
Apply	80	60	60	100	70	70	60
Analyse	0	20	20	0	0	0	20
Evaluate	0	0	0	0	0	0	0
Create	0	0	0	0	0	0	0

Assessment Pattern: Psychomotor

Psychomotor Skill	Assignment-1	Assignment-2	Assignment-3
Perception	-	-	-
Set	-	-	-
Guided Response	-	-	-
Mechanism	-	30	30
Complex Overt Responses	-	-	-
Adaptation	-	-	-
Origination	-	-	-

Sample Questions for Course Outcome Assessment

Course Outcome 1 (CO1):

1. List the need of the microprocessor
2. How does 8086 generate physical address?
3. Compare logical and virtual address.

Course Outcome 2 (CO2):

1. How to write the ASM program for 8086? Show the template
2. Show the use of DB and DW assembler directive
3. List few of the assembler directive equivalent to compiler pre-processor like #define

Course Outcome 3 (CO3):

1. Develop an ASM code using "INT 10" interrupt with its various arguments
2. Show the ASM code for single loop delay program using interrupt
3. Exemplify the use of stack and stack pointer with the ASM code

Course Outcome 4 (CO4):

1. Develop embedded c code for accessing timer peripherals for the given time delay
2. Show the Embedded c code template for a cross compiler platform
3. Develop the embedded code to access the serial peripherals

Course Outcome 5 (CO5):

1. For the given flow chart of the process control system, develop a pseudo code
2. Develop an embedded c code for interfacing technique of external peripherals
3. How will you access the external peripherals with GPIO pins?

Course Outcome 6 (CO6):

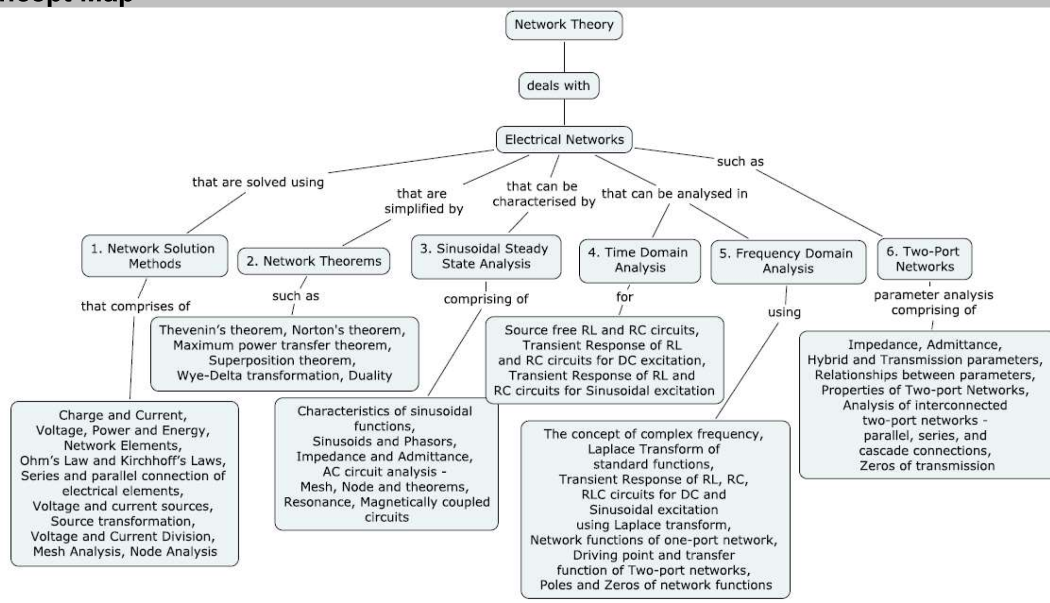
1. Evaluate the time latency for the embedded c code for accessing timer peripherals for the given time delay

2. Examine the number of machine cycles and T states taken for the given ASM program
3. Observe the comment the stack overflow for the nested function call in a given program

Sample Assignments:

1. Accessing input and output devices in x86 kit or computer using various BIOS interrupts. Develop the document for often used BIOS interrupts in printf and scanf function in C
2. In your own way of understating , create the document for 8085 architecture along with its instructions and develop ASM codes single precision and double precision arithmetic operations
3. Implement the unique idea of a given process control system in 8051 microcontroller hardware for the given requirement.(Additional hardware can be used).Developing hardware edge device for IoT framework for the given requirement

Concept Map



Syllabus

Computer organization and architecture: Architecture, Structure and Function, Computer components, function, and bus interconnection. Instruction sets and pipelines characteristics and functions. Evolution of the Intel x86 architecture. CISC and RISC Machines. Memory management: Cache and virtual memory paging.**8086 microprocessor:** architecture, instruction sets, addressing modes and assembler directives, stacks and interrupts. Assembly language programming for data transfer and arithmetic computations .**Microcontrollers:** 8051 architecture, programming model, instructions sets and addressing modes. Memory organization, stack structure and Interrupts. Assembly level program for arithmetic operations. **Internal-peripherals:** GPIO Timer architecture and modes of operation, Timer peripheral programming, UART and modes of operation. UART programming by polling and interrupt driven. **External peripherals interfacing:** Port expansion with 8255. ADC, DAC, Keyboard interfacing. Display interfacing LED 7 segment and LCD module. SPI and I2C protocols and devices. **Programming in C:** Cross compiler C -programming structure, Data types, memory models, infinite loops and handling interrupts in C. C-Programming for LED, LCD display, temperature sensor with ADC, Measuring pulse width and frequency.

Learning Resources

1. William Stallings "Computer Organization and architecture designing for performance" 8th Edition-Prentice hall -2017
2. K. Ray, K. M. Bhurchandi – "Advanced Microprocessors and Peripherals – Architecture, Programming and Interface" – Tata McGraw Hill – 2017
3. Kenneth J. Ayala,The 8051 Microcontroller. Architecture, Programming and Applns, West publishing company 2016

4. NPTEL video lecture by Dr.S.RAMAN IITMhttps://www.youtube.com/watch?v=leWKvuZVUE8
5. Teacher Handout

Course Contents and Lecture Schedule

No.	Topic	No. of Hours	Cos
1	**Computer organization and architecture**		
1.1	Introduction to organization and architecture	1	CO1
1.2	Architecture, Structure and Function, Computer components, function, and bus interconnection.	1	CO1
1.3	Instruction set: Formats and components	2	CO1
1.4	Pipelines characteristics and functions.	2	CO1
1.5	Evolution of the Intel x86 architecture CISC and RISC	1	CO1
1.6	Cache and virtual memory paging	1	CO1
2	**8086 microprocessor**		
2.1	Architecture and programming model, Memory Buses	1	CO2
2.2	Instruction sets formats and machine cycles	1	CO2
2.3	Instructions seta	1	CO2
2.4	Addressing modes &Assembler directives.	1	CO2
2.5	Stack and its operations & Interrupts.	1	CO2
2.6	Assembly language programming for data transfer	1	CO2
2.7	Assembly language programming arithmetic computations	1	CO2
3	**Microcontrollers**		
3.1	8051 architecture, programming model,	1	CO3
3.2	8051 Memory organization	1	CO3
3.3	Instructions sets: Data MOV groups	1	CO3
3.4	Instructions sets: Arithmetic and logical , branch	1	CO3
3.5	Machine cycle and delay computation	1	CO3
3.6	addressing modes	1	CO3
3.7	Stack structure and Interrupts.	1	CO3
3.8	ASM Program- Data transfer	1	CO3
3.9	ASM Program-Arithmetic and logical computation	1	CO3
4	**Internal-peripherals:**		
4.1	GPIO Pin outs and Timer architecture modes of operation	2	CO4
4.2	Timer peripheral programming	2	CO4
4.3	UART and modes of operation	1	CO4
4.4	UART programming by polling and interrupt driven	2	CO4
5.	**External peripherals interfacing:**.		
5.1	Port expansion with 8255	1	CO5
5.2	Interfacing with ADC and DAC	1	CO5
5.3	Keyboard interfacing, Lead per key and Matrix	2	CO5
5.4	Display interfacing: 7 segment and LCD module	2	CO5
5.5	SPI and I2C protocols and devices		
6	**Programming in Embedded C:**		
6.1	Cross compiler C-programming structure, memory models, infinite loops and handling interrupts in C.	2	CO6
6.2	C-Programming for LED, LCD display, temperature sensor with ADC, Measuring pulse width and frequency.	3	CO6
	Total Hours	48	

Course Designers:

1. Dr.K.Hariharan khh@tce.edu
2. Dr.E.Murugavalli murugavalli@tce.edu

18EC360	PROGRAMMING FOR PROBLEM SOLVING	Category	L	T	P	Credit
		BS	2	0	2	3

Preamble

This course aims to provide students with an understanding on the role of computation in problem solving. It focuses on problem analysis, algorithm development, top-down design, modular programming, debugging and testing. The students will learn the required background programming knowledge, including stream I/O, loops, functions, structures, arrays, pointers and memory management.

Prerequisite

NIL

Course Outcomes

On the successful completion of the course students will be able to

CO#	Course Outcome Statement	Weightage in %
CO1	Use various constructs of a programming language like decision making, looping, modularity and recursion in problem solving	30
CO2	Develop algorithms to perform sorting, searching and text processing.	25
CO3	Use pointers and derived data types like structures and union in solving complex problems.	20
CO4	Write programs to create text and database files.	10
CO5	Apply problem solving methodology in implementing mathematical and engineering problems.	15

CO Mapping with CDIO Curriculum Framework

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS3	Apply	Value	Mechanism	1.2, 2.1.1, 2.1.2, 2.3.1,
CO2	TPS3	Apply	Value	Mechanism	1.2, 2.1.1, 2.1.2, 2.3.1, 2.4.3, 2.4.4
CO3	TPS3	Apply	Value	Mechanism	1.2, 2.1.1, 2.1.2, 2.3.1, 2.4.3, 2.4.4
CO4	TPS3	Apply	Value	Mechanism	1.2, 2.1.1, 2.1.2, 2.3.1, 2.4.3, 2.4.4
CO5	TPS3	Apply	Value	Mechanism	1.2, 2.1.1, 2.1.2, 2.3.1, 2.4.3, 2.4.4, 2.5.1, 3.1.1, 3.1.2

Mapping with Programme Outcomes and Programme Specific Outcomes

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	S	M	M	-	S	-	-	-	S	M	-	-	M	-	L
CO2	S	M	M	-	S	-	-	-	S	M	-	-	M	-	L
CO3	S	M	M	-	S	-	-	-	S	M	-	-	M	-	L
CO4	S	M	M	-	S	-	-	-	S	M	-	-	M	-	L
CO5	S	M	M	-	S	-	-	-	S	M	-	-	M	-	L

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

Cognitive Levels	Continuous Assessment Tests			End Semester Examination
	1	2	3	
Remember	0	0	0	Lab Examination
Understand	30	30	30	
Apply	70	70	70	
Analyse	0	0	0	
Evaluate	0	0	0	
Create	0	0	0	

Assessment Pattern: Psychomotor

Psychomotor Skill	Practical
Perception	-
Set	-
Guided Response	-
Mechanism	80
Complex Overt Responses	20
Adaptation	-
Origination	-

Sample Questions for Course Outcome Assessment

Course Outcome 1 (CO1):

1. A manufacturer would like to have a device for a car that will turn on a light when the temperature is between 34 and 40 degrees Fahrenheit (F) and sound a warning signal when the outside temperature is 34 degrees F or below. The light and the sound are never going simultaneously. Write a solution to this problem.
2. Write a function for finding the power of a number using recursion and without using recursion.

Course Outcome 2 (CO2):

1. America and Britain are "two nations divided by a common language." The noticeable difference between American and British English is vocabulary. A blogger stared writing an article using American English and now he want to change it to British English. He found that the words {vacation, apartment} has to be changed to {holidays, flat}. Develop an algorithm and implement it, so that his problem is solved.
2. Given a list of temperature measured in Madurai city over a period of 15 days, develop an algorithm to print the minimum, maximum, median and average temperature over the given period. (median is the middle value in the sorted list)

Course Outcome 3 (CO3):

1. Write a program to dynamically allocate memory for a 1-D array and sort it.
2. Write a program that concatenates two linked lists of characters. The program should include function concatenate that takes pointers to both lists as arguments and concatenates the second list to the first list.

Course Outcome 4 (CO4):

1. A data file named 'employee.dat' to be created with the following details: employee ID, how many days (s)he worked, and how many hours (s)he worked in each day. a program to create a data file, read the above file and output the employee ID and average work hour per day.
2. Write a program to copy the content of file 'source.txt' into another file named 'dest.txt' in encrypted format. Open the destination file and print its content on screen. [use offset cipher for encryption. Offset each character with 3. E.g 'abc' is encrypted as 'def']

Course Outcome 5 (CO5):

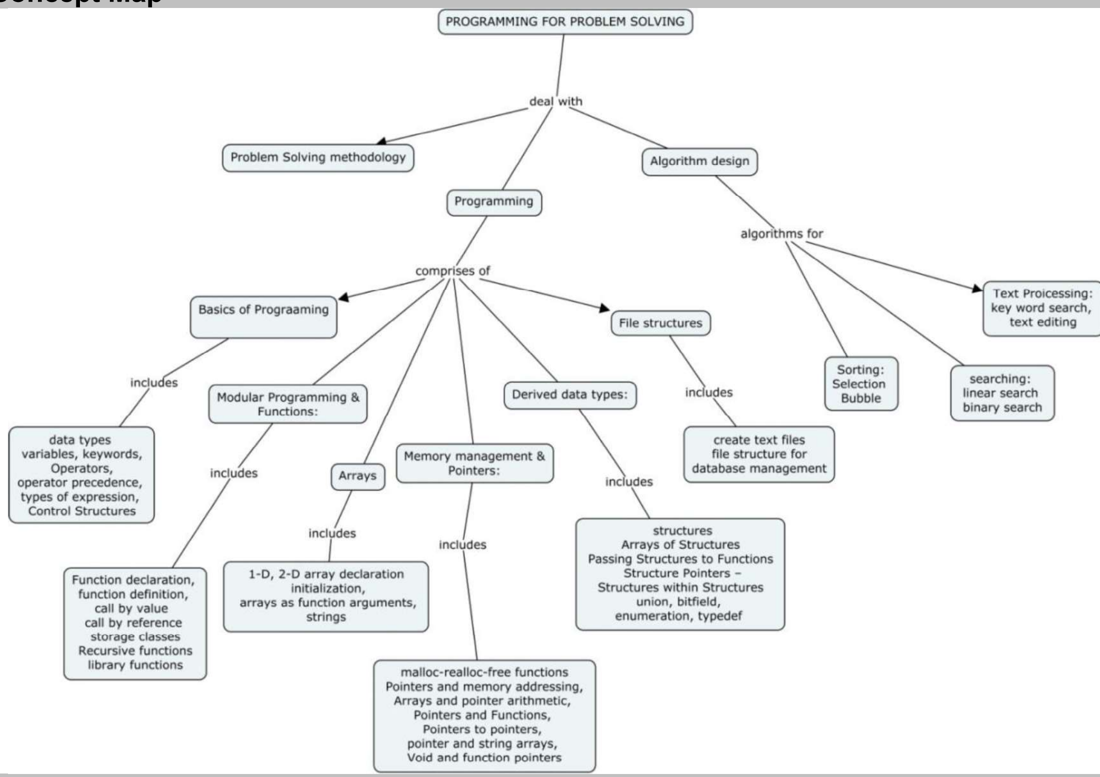
1. Consider a casual FIR filter of order M with impulse response h(n), n = 0,1,2,....M and input signal x(n) , n=0,1,2,....L-1. Write a program to calculate the convolution of the

length L input x with order M filter h using direct form. Let h=[1,2,-1,1] x=[1,1,2,1,2,2,1,1]

$$y(n) = \sum_{m=\max(0,n-L+1)}^{\min(n,M)} h(m)x(n-m)$$

2. Write a program to solve linear algebraic equation using Gauss elimination method.

Concept Map



Syllabus

Problem Solving Methodology: problem specification and analysis, algorithm design, flowchart, programs, program testing and verification **Basics of Programming:** data types and its representation, variables, keywords, Operators, operator precedence, types of expression, Control Structures: Selection structure, looping Structure **Modular Programming and Functions:** Function declaration, function definition, function call-call by value - call by reference, storage classes, variable scope, use of stacks in function call, Recursive functions, library functions **Array and string handling algorithms:** 1-D, 2-D array declaration, initialization, using arrays as function arguments, strings sorting: selection sort, bubble sort, searching: linear and binary search, text processing: key word search, text editing. **Memory management & Pointers:** use of malloc-realloc-free- heaps in memory management, Pointers and memory addressing, Arrays and pointer arithmetic, Pointers and Functions, Pointers to pointers, pointer and string arrays, Void and function pointers **Derived data types**: structures- Arrays of Structures – Passing Structures to Functions – Structure Pointers – Structures within Structures, union, bitfield, enumeration, typedef **File Handling:** read, write and update text files – file structure for database management

List of Experiments: **24 Hrs**

1. Programs to explore fundamental programming constructs
   a. Find the size of the processor, range of all primary data types.
   b. Use of different types of operators and expressions.
2. Programs using decision making, case control and looping statements.

   a. Print twin prime numbers in a given range
   b. Finding greatest common divisor using Euclid's method
   c. Trigonometric series generation
3. Programs using 1-D and 2-D arrays
   a. Bubble and insertion sort algorithms
   b. Matrix multiplication
4. Programs using strings
   a. Linear pattern search
   b. Text editing
5. Programs using recursive and non-recursive functions
   a. Binary search
   b. Finding nth Fibonacci number
6. Programs for dynamic memory management and pointer arithmetic
7. Programs to create database files using file structures
8. Solving numerical methods/engineering problems (sample) **CO5**
   a. Finding roots of a linear equation using bisection method
   b. Numerical integration by trapezoidal method
   c. Linear convolution
   d. Bitwise operations to set specific bit fields

Learning Resources

1. Kernighan, Brian, and Dennis Ritchie. "*The C Programming Language*", 2nd ed. Upper Saddle River, NJ: Prentice Hall, 1988.
2. Paul Deitel, Harvey Deitel, "C: How to program", 7th ed., ", Pearson Education, 2013
3. George S. Tselikis, Nikolaos D. Tselikas, "C: From Theory to Practice", 2nd Ed., CRC Press, 2017
4. R. G. Dromey, "How to Solve It By Computer", PearsonEducation, 1982
5. William H. Press, Saul A. Teukolsky, "Numerical Recipes in C:The Art of Scientific Computing", 2nd ed., Cambridge University Press, 2002
6. Adam Hoover, "System Programming *with C and Unix", 1 ed.,* Pearson Education, Inc., 2010
7. Randal E. Bryant and David R. O'Hallaron, *Computer Systems: A Programmer's Perspective, Third Edition*, Pearson, 2016
8. NPTEL course on problem solving through C , *https://nptel.ac.in/courses/106105171/*

Course Contents and Lecture Schedule

No.	Topic	No. of Hours	COs
1	**Problem Solving Methodology**		
1.1	problem specification and analysis, algorithm design, flowchart, programs, program testing and verification	1	CO1
2	**Basics of Programming**		
2.1	data types and its representation, variables, keywords,	1	CO1
2.2	Operators, operator precedence, types of expressions	1	CO1
2.3	Control Structures: Selection structure - looping Structure	2	CO1
3	**Modular Programming and Functions**		
3.1	Function declaration, function definition, function call-call by value - call by reference, storage classes, variable scope, use of stacks in function call	2	CO1
3.2	Recursive functions	1	CO1
3.3	library functions	1	CO1
4	**Arrays and Array handling algorithms**		
4.1	1-D, 2-D array declaration, initialization, using arrays as function arguments, strings	2	CO2
4.2	Sorting: selection sort, bubble sort	1	CO2

4.3	Searching: linear and binary search	1	CO2
4.4	text processing: key word search, text editing	1	CO2
5.	**Memory management & Pointers**		
5.1	Memory management functions: malloc, calloc, realloc, free - use of heap in memory management	1	CO3
5.2	Pointers and memory addressing, Arrays and pointer arithmetic	1	CO3
5.3	Pointers and Functions, Pointers to pointers	1	CO3
5.4	Pointer and string arrays, Void and function pointers	1	CO3
6	**Derived data types**		
6.1	Structures- Arrays of Structures - Passing Structures to Functions	1	CO3
6.2	Structure Pointers **–** Structures within Structures	1	CO3
6.3	Union, bitfield, enumeration, typedef	1	CO3
7.	**File Handling**		
7.1	read, write and modify text files	2	CO4
7.2	file structure for database management	1	CO4
	Theory	**24**	
	Practical	**24**	
	Total	**48**	

Course Designers:

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2. Dr.B.SathyaBama sbece@tce.edu

18EC370	MICROPROCESSOR AND MICROCONTROLLER LABORATORY	Category	L	T	P	Credit
		PC	0	0	2	1

Preamble

This course is designed to realize and to do practical experimentation on the theory course '18EC350 Microprocessors and Microcontrollers'. The purpose of this course is to give hands on training to the students in understanding and practicing the embedded C programming concepts and algorithms. This course will improve the embedded system design capability of the students. On successful completion with full involvement in the experimentation of the course, the knowledge will lead to the students to become entrepreneur in the start-up company.

Prerequisite

NIL

Course Outcomes

On the successful completion of the course students will be able to

CO#	Course Outcome Statement	Weightage in %
CO1	Write, assemble, debug, link and execute assembly program in the given 8086 simulator for transferring data from one space to another, arithmetic computation and accessing IOs using BIOS interrupts	10
CO2	Analyze the segment memory space, number of machine cycles and execution time taken for the given program or flow chart in the simulation tool	10
CO3	Use appropriate methods for accessing internal and external peripherals such as Timers, Serial peripheral and GPIO in assembly and C programming	20
CO4	Apply access methodologies to ADC and DAC in assembly and C programming	20
CO5	Design a flow chart and develop the code for processes control system	20
CO6	Analyze the memory requirements and number of clocks and delay for the system by implementing the application in 8051 target board	20

CO Mapping with CDIO Curriculum Framework

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS3	Apply	Value	Mechanism	1.2, 2.1.1, 2.1.2, 2.2.2, 2.2.3, 2.4.2, 2.4.6, 2.5.1, 3.1.2, 3.2.3, 4.6.2
CO2	TPS3	Apply	Value	Mechanism	1.2, 2.1.1, 2.1.2, 2.2.2, 2.2.3, 2.4.2, 2.4.6, 2.5.1, 3.1.2, 3.2.3, 4.6.2
CO3	TPS3	Apply	Value	Mechanism	1.2, 2.1.1, 2.1.2, 2.2.2, 2.2.3, 2.4.2, 2.4.6, 2.5.1, 3.1.2, 3.2.3, 4.6.2
CO4	TPS3	Apply	Value	Mechanism	1.2, 2.1.1, 2.1.2, 2.2.2, 2.2.3, 2.4.2, 2.4.6, 2.5.1, 3.1.2, 3.2.3, 4.6.2
CO5	TPS3	Apply	Value	Mechanism	1.2, 2.1.1, 2.1.2, 2.2.2, 2.2.3, 2.4.2, 2.4.6, 2.5.1, 3.1.2, 3.2.3, 4.6.2
CO6	TPS3	Apply	Value	Mechanism	1.2, 2.1.1, 2.1.2, 2.2.2, 2.2.3, 2.4.2, 2.4.6, 2.5.1, 3.1.2, 3.2.3, 4.6.2

Mapping with Programme Outcomes and Programme Specific Outcomes

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	S	M	L	-	S	-	-	L	S	S	L	-	S	-	L
CO2	S	M	L	-	S	-	-	L	S	S	L	-	S	-	L
CO3	S	M	L	-	S	-	-	L	S	S	L	-	S	-	L
CO4	S	M	L	-	S	-	-	L	S	S	L	-	S	-	L
CO5	S	M	L	-	S	-	-	L	S	S	L	-	S	-	L
CO6	S	M	L	-	S	-	-	L	S	S	L	-	S	-	L

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

Cognitive Levels	Model Examination	End Semester Examination
Remember		
Understand		
Apply	70	70
Analyse		
Evaluate		
Create		

Assessment Pattern: Psychomotor

Psychomotor Skill	Practical Component
Perception	
Set	
Guided Response	
Mechanism	30
Complex Overt Responses	
Adaptation	
Origination	

List of Experiments/Activities with CO Mapping

1. Develop an assembly program in 8086 simulator for copying data from one space to another space of the same or different segments (CO1)
    - Develop a user defined function for the given objective at the time of lab hour
    - Assembling and observing memory allocations for each segments used in the ASM code
    - Debugging the code in “step by step” and “GO” options
    - Inputting and showing the output in the simulator for the developed function
2. Develop and reverse an assembly level program in 8086 simulator BIOS interrupts (CO1)
    - Develop an ASM code for accessing IO devices such as display and keyboard using BIOS interrupts
    - Disassemble the c code with printf and scanf statement and list the BIOS interrupts used
    - List and tabulate other BIOS interrupts with its executives
3. Develop an assembly level program in 8086 simulator for performing given arithmetic computation (CO2)
    - Develop a user defined function for the given objective at the time of lab hour
    - Inputting and showing the output in the simulator for the developed function
    - Examine the memory space size of each segments used in the ASM code
    - List and tabulate the measured machine cycles, clock cycles and execution time
4. Programming in cross compiler Keil for 8051microcontroller (CO3)
    - Assembling and simulating an ASM code for accessing GPIO and external memory
    - Develop the user define function to a switches connected in PORT1 and outputting the data to the LEDs connected in PORT0 using appropriate argument and return type

- Methods to invoke break points and step by step execution of the code
- Calculating the delay for the given clock frequency

5. Embedded C programming in cross compiler Keil for 8051 microcontroller (CO3)
    - Compiling and simulating the embedded C code for performing the computation like root of the equation, and perform convolution operation.
    - an arithmetic computation
    - Methods to invoke break points and step by step execution of the C code
    - Calculating the delay for the given clock frequency
6. Developing the C program for accessing GPIO and Timer peripherals in 8051 boards (CO3)
    - Develop an user function for a software delay "**SoftDelay_ms(**no of milli-seconds**)**" and use this function for blinking the LEDs in Port 0
    - Plot the error in the delay function when the argument changes from 1 to 1000 in the order of 100
    - Develop an user function for a hardware delay "**HardDelay_ms(**no of milli-seconds**)**" and use this function for blinking the LEDs in Port 0
    - Plot the error in the delay function when the argument changes from 1 to 1000 in the order of 100
7. Invoking interrupt services in the Embedded C programming and to realize it in 8051 target board (CO4)
    - Control the LEDs in PORT-0 by the external interrupts INT0 and INT1
    - Blink the LEDs using Timer peripheral interrupt which runs periodic time of intervals
8. Establishing serial communication between target board and computer (CO3)
    - Develop an user function in the C code for serial transmission with defined baud rate to transmit a character and a string as an arguments. Use interrupt driven and polling methods
    - Develop an user function in the C code for serial reception with defined baud rate to transmit a character and a string as an arguments. Use interrupt driven method
9. Accessing analog signal into the 8051 system through ADC (CO4)
    - Develop the C code for accessing external ADC through parallel or serial communication and show the result in LEDs or in serial transmission
    - Access the ADC and display the send data to LEDs
    - Show the analog input data in CRO
10. Design a setup for a display system to display the data in 7 segment LED (CO5)
    - Develop the LUT for 7 segment pattern to display the list of characters including blank
    - The Number X is displayed and incremented up to 9 for every period of time and it is updated in a single display
    - The number X range from 0 to 9999 is displayed for every period of time and it is updated in a single display. BCD conversion is done before displaying
    - For all the above objective , user defined function is required
11. Design a setup for a display system to display the numbers and characters in LCD module (CO6)
    - Develop a function to display the array of stored alpha numeric string in LCD module
    - The arguments are needed to control the display position and clear the LCD
    - The text sent by PC is displayed in LCD module in 8051 target board

Case study implementation and prototyping:

1. **Implement a** on performing a simulation of a process control system
    a. Develop an ASM code for accessing simulation packages such as traffic control, temperature and motor control
    b. List and tabulate what are the BIOS interrupts used in this executives
2. **Implement a case study** on prototyping of access control system
    a. considering switches as discrete sensor switch are fixed in the door to detect the person entry and exit and LEDs are considered to be the actuators, develop the C code for accessing actuators by reading the sensor conditions
3. **Implement a case study** on prototyping of process control system

a. Use temperature sensor LM35/LDR/Thermistor/thermocouple/IR sensors and develop a process control with relay output
b. Servo motor/Brushless DC motor(BLDC) and stepper motor control
c. RGB LED control with climatic intensity condition

Learning Resources

1. NPTEL Video Lecture on "Microprocessor and Microcontroller", weblink: https://onlinecourses.nptel.ac.in/noc19_ee11/course
2. Virtual Lab on "Real Time Embedded System", weblink: https://nptel.ac.in/courses/108102045/24

Course Designers:

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2. Dr.E.Murugavalli murugavalli@tce.edu

18EC380	ELECTRONIC CIRCUITS LABORATORY	Category	L	T	P	Credit
		PC	0	0	2	1

Preamble

The goal is to supplement the theory courses ‘18EC330 Electronic Circuits’ by giving a practical exposure of the operation of linear and non linear electronic circuits to the students. The linear mode of operation of the active devices was demonstrated with the amplifier, oscillator and filter circuits. The non linear mode of operation is demonstrated with switching applications. The course also provides experience in analysing and testing of electronic circuits using simulation software and hardware implementation.

Prerequisite

18EC230: Electron Devices, 18EC280: Circuits and Devices Laboratory

Course Outcomes

On the successful completion of the course students will be able to

CO#	Course Outcome Statement	Weightage in %
CO1	Design a single stage and two stage transistor amplifier for the given specification.	20
CO2	Analyse the frequency response of the amplifier with and without feedback based on gain and bandwidth.	20
CO3	Identify the parameters given in the datasheet of operational amplifier IC.	10
CO4	Demonstrate the inverting and non-inverting mode of operation of the operational amplifer.	10
CO5	Create low frequency and high frequency sinusoidal oscillations using operational amplifier.	10
CO6	Analyse the frequency response of analog filters (LPF, HPF and BPF) using the TI ASLKv analog kit.	10
CO7	Demonstrate the nonlinear mode operation of active devices.	10
CO8	Explain the power amplification and efficiency calculation of class B power amplifier.	10

CO Mapping with CDIO Curriculum Framework

CO #	TCE Profi. Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS3	Apply	Value	Mechanism	1.2, 2.1.1, 2.1.2, 2.2.2, 2.2.3, 2.4.2, 2.4.6, 2.5.1, 3.1.2, 3.2.3, 4.6.2
CO2	TPS3	Apply	Value	Mechanism	1.2, 2.1.1, 2.1.2, 2.2.2, 2.2.3, 2.4.2, 2.4.6, 2.5.1, 3.1.2, 3.2.3, 4.6.2
CO3	TPS3	Apply	Value	Mechanism	1.2, 2.1.1, 2.1.2, 2.2.2, 2.2.3, 2.4.2, 2.4.6, 2.5.1, 3.1.2, 3.2.3, 4.6.2
CO4	TPS3	Apply	Value	Mechanism	1.2, 2.1.1, 2.1.2, 2.2.2, 2.2.3, 2.4.2, 2.4.6, 2.5.1, 3.1.2, 3.2.3, 4.6.2
CO5	TPS3	Apply	Value	Mechanism	1.2, 2.1.1, 2.1.2, 2.2.2, 2.2.3, 2.4.2, 2.4.6, 2.5.1, 3.1.2, 3.2.3, 4.6.2
CO6	TPS3	Apply	Value	Mechanism	1.2, 2.1.1, 2.1.2, 2.2.2, 2.2.3, 2.4.2, 2.4.6, 2.5.1, 3.1.2, 3.2.3, 4.6.2
CO7	TPS3	Apply	Value	Mechanism	1.2, 2.1.1, 2.1.2, 2.2.2, 2.2.3, 2.4.2, 2.4.6, 2.5.1, 3.1.2, 3.2.3, 4.6.2
CO8	TPS3	Apply	Value	Mechanism	1.2, 2.1.1, 2.1.2, 2.2.2, 2.2.3, 2.4.2, 2.4.6, 2.5.1, 3.1.2, 3.2.3, 4.6.2

Mapping\ with Programme Outcomes and Programme Specific Outcomes

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	S	M	L	-	S	-	-	L	S	S	L	-	S	-	L
CO2	S	M	L	-	S	-	-	L	S	S	L	-	S	-	L
CO3	S	M	L	-	S	-	-	L	S	S	L	-	S	-	L
CO4	S	M	L	-	S	-	-	L	S	S	L	-	S	-	L
CO5	S	M	L	-	S	-	-	L	S	S	L	-	S	-	L
CO6	S	M	L	-	S	-	-	L	S	S	L	-	S	-	L
CO7	S	M	L	-	S	-	-	L	S	S	L	-	S	-	L
CO8	S	M	L	-	S	-	-	L	S	S	L	-	S	-	L

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

Cognitive Levels	Model Examination	End Semester Examination
Remember		
Understand		
Apply	100	100
Analyse		
Evaluate		
Create		

Assessment Pattern: Psychomotor

Psychomotor Skill	Practical Component
Perception	
Set	
Guided Response	
Mechanism	100
Complex Overt Responses	
Adaptation	
Origination	

List of Experiments/Activities with CO Mapping

1. Design, simulation and hardware realization of Single Stage amplifier for given specification and its frequency analysis. (using BJT)
2. Design and hardware realization of Multistage Amplifier for given specification and its frequency analysis. (using BJT)
3. Hardware realization of different types of feedback amplifiers and infer the effect of feedback on gain and frequency of the amplifier.(using BJT)
4. Study the AC and DC characteristics of Operational amplifier and implement the inverting and non-inverting mode of operation. (using TL082)
5. Design, Simulation and Hardware realisation of sinusoidal waveform generators.
   RC Oscillators – RC phase shift and wien bridge. (using IC741)
6. Design, Simulation and Hardware realisation of sinusoidal waveform generators.
   LC Oscillators – Hartley and Colpitts. (using IC741)
7. Design and hardware implementation of Low pass, High pass and Band pass filter using operational amplifier. (using TI - ASLKV kit)
8. Design and implementation of Non linear analog circuit, Astable and Monostable multivibrator using NE555 timer IC.
9. Simulation and hardware realization of Class – B power amplifier and calculation of its efficiency
10. Mini project

Learning Resources

3. NPTEL Video Lecture on "Basic Electronics and Lab" , weblink: https://nptel.ac.in/courses/122106025

4. MIT Video Lecture on "Circuits and Electronics" , weblink: https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-002-circuits-and-electronics-spring-2007/index.htm

Course Designers:

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18ES390	DESIGN THINKING

Category	L	T	P	Credit
ES	1	-	2	2

Preamble

Design has been defined as a “systematic, intelligent process in which designers generate, evaluate, and specify concepts for devices, systems, or processes whose form and function achieve clients’ objectives or users’ needs while satisfying a specified set of constraints”. Human-centered design is defined as a process and a set of techniques used to create new solutions for the world. Solutions include products, services, environments, organizations, and modes of interaction. The reason this process is called “human-centered” is because it starts with the people we are designing for. This course facilitates the development of students’ professional skills through their team engagement in developing conceptual design for a local community problem.

Prerequisite

Nil

Course Outcomes

On the successful completion of the course students will be able to

CO Number	Course Outcome Statement	Weightage in %
CO1	Identify a specific social need to be addressed	20
CO2	Identify stakeholder’s requirements for the societal project	20
CO3	Develop measurable criteria in which design concepts can be evaluated	10
CO4	Develop prototypes of multiple concepts using user’s feedback	30
CO5	Select the best design solution among the potential solutions with its functional decomposition	20

CO Mapping with CDIO Curriculum Framework

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS3	Apply	Value	Mechanism	1.1, 1.2, 2.1.1, 3.1.2, 3.2.3, 3.2.6, 4.1.2
CO2	TPS3	Apply	Value	Mechanism	1.1, 1.2, 2.1.2, 2.5.1, 2.5.2, 3.1.2, 3.2.3, 3.2.6, 4.1.2
CO3	TPS3	Apply	Value	Mechanism	1.1, 1.2, 2.1.3, 3.1.2, 3.2.3, 3.2.6, 4.1.2, 4.3.1
CO4	TPS3	Apply	Value	Mechanism	1.1, 1.2, 2.1.4, 3.1.2, 3.2.3, 3.2.6, 4.1.2, 4.4.1
CO5	TPS5	Evaluate	Organise	Adaptation	1.1, 1.2, 2.1.5, 3.1.2, 3.2.3, 3.2.6, 4.1.2, 4.4.1

Mapping with Programme Outcomes and Programme Specific Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S	M	L	-	-	M	M	M	L	M	M	S
CO2	S	M	L	-	-	M	M	M	L	M	M	S
CO3	S	M	L	-	-	M	M	M	L	M	M	S
CO4	S	M	L	-	M	M	M	M	L	M	M	S
CO5	S	S	M	L	M	M	M	M	L	M	M	S

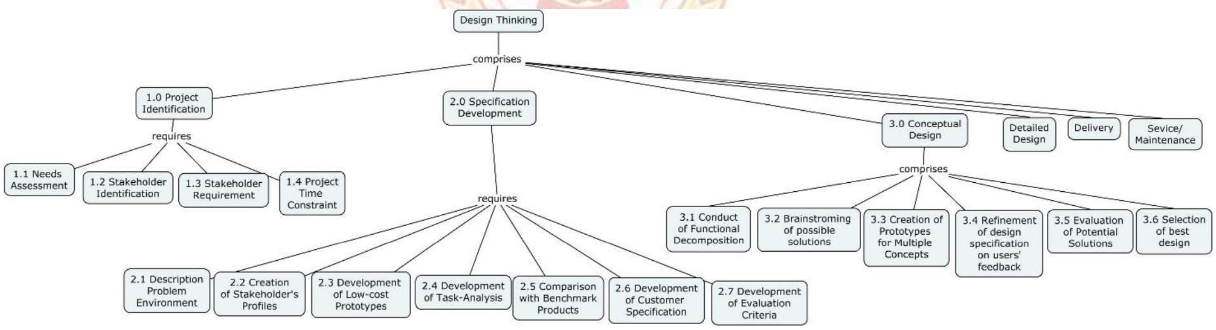
S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

Phases	Deliverables	Marks	Course Outcomes
Continuous Assessment			
Review 1 – Problem Identification	Technical Report	10	CO1 and CO2
Review 2 – Specification Development	Technical Report	20	CO3
Review 3 -Conceptual Design	Technical Report	20	CO4 and CO5
End-Semester Examination			
Demonstration	Prototype	60	CO1, CO2, CO3, CO4 and CO5
Poster Presentation	Poster	40	

- Reports are to be submitted at each review. The report and presentation will be evaluated based on Rubrics
- Demonstration and Poster presentation will be evaluated by two faculty members nominated by their respective Head of the Department.

Concept Map



Syllabus

1.0 Project Identification: Needs Assessment, Stakeholder Identification, Stakeholder Requirement Project Time Constraint.
2.0 Specification Development: Description Problem Environment, Creation of Stakeholder's Profiles Development of Low-cost Prototypes, Development of Task-Analysis, Comparison with Benchmark Products, Development of Customer Specification, Development of Evaluation Criteria,
3.0 Conceptual Design: Conduct of Functional Decomposition, Brainstroming of possible solutions, Creation of Prototypes for Multiple Concepts, Refinement of Design Specification on users' feedback, Evaluation of Potential Solutions, Selection of best design.

Learning Resources

1. Learning Material prepared by TCE faculty members
2. https://www.ideo.com/
3. https://engineering.purdue.edu/EPICS

Course Contents and Lecture Schedule

Module No.	Topic	No. of Hours		Course Outcome
		In-Class	Hands-on	
1.	**Project Identification**: Introduction to Human-Centered Design	1	-	CO1
1.1	Needs Assessment	1	2	CO1
1.2	Identification of Stakeholders	1	2	CO2
1.3	Identification of Stakeholder Requirements		2	CO2
1.4	Project Time Constraint	1	2	CO2
2.	**Specification Development**			
2.1	Description Problem Environment	1	2	CO3
2.2	Creation of Stakeholder's Profiles		2	CO3
2.3	Development of Low-cost Prototypes	1	2	CO3
2.4	Development of Task-Analysis	1	2	CO3
2.5	Comparison with Benchmark Products	1	2	CO3
2.6	Development of Customer Specification		2	CO3
2.7	Development of Evaluation Criteria	1	2	CO3
3.	**Conceptual Design**			
3.1	Conduct of Functional Decomposition	1	2	CO4
3.2	Brainstroming of possible solutions	1	2	CO5
3.3	Creation of Prototypes for Multiple Concepts	1	2	CO5
3.4	Refinement of design Specification on users' feedback		2	CO6
3.5	Evaluation of Potential Solutions	1	2	CO6
3.6	Selection of best design		2	CO6
	Total	12	34	

Course Designers:

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CURRICULUM AND SYLLABI

FOR

B.E. DEGREE (ELECTRONICS AND COMMUNICATION ENGINEERING) PROGRAMME

FOURTH SEMESTER

FOR THE STUDENTS ADMITTED FROM THE

ACADEMIC YEAR 2018-2019 ONWARDS

THIAGARAJAR COLLEGE OF ENGINEERING

(A Govt Aided Autonomous Institution Affiliated to Anna University)

MADURAI – 625 015, TAMILNADU

18EC410	OPTIMIZATION AND NUMERICAL METHODS	Category	L	T	P	Credit
		BS	2	1	0	3

Preamble

An engineering UG student needs to have some basic mathematical tools and techniques to apply in diverse applications in Engineering. This emphasizes the development of rigorous logical thinking and analytical skills of the student and appraises him the complete procedure for solving different kinds of problems that occur in engineering. Optimization is a scientific approach to decision making that seeks to best design and operate a system, usually under conditions requiring the allocation of scarce resources. Various techniques of optimization have been dealt on the title "Operations Research". Because of the complexity of most real-world optimization problems, it has been necessary to reduce the complexity of the problem by either simplifying the problem or constraining it by making reasonable assumptions. Students will get exposure to such knowledge on operations research and numerical methods.

Prerequisite

NIL

Course Outcomes

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

CO#	Course Outcome Statement	Weightage in %
CO1	Compute the solution for the IVPs in ODE using single step methods.	10%
CO2	Compute the solution for the IVPs in ODE using multistep methods and the solution for the Boundary value problems in ODE.	20%
CO3	Solving partial differential equation using Numerical methods.	20%
CO4	Formulate mathematical models of Linear Programming (LP)	10%
CO5	Solve Linear Programming Problems (LPP) by appropriate techniques (i.e. Graphical, Simplex method) and evaluate the behaviour under different range of parameters.	20%
CO6	Examine the performance characteristics such as time and cost in solving shortest route, flow, transportation and assignment problems with an appropriate model	20%

CO Mapping with CDIO Curriculum Framework

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X,Y,Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS2	Understand	Respond	-	1.1.1, 2.1.3, 2.1.5, 3.1.3, 4.1.1
CO2	TPS3	Apply	Value	-	1.1.1, 2.1.3, 2.1.5, 3.1.3, 4.1.1
CO3	TPS3	Apply	Value	-	1.1.1, 2.1.3, 2.1.5, 3.1.3, 4.1.1
CO4	TPS2	Understand	Respond	-	1.1.1, 2.1.3, 2.1.5, 3.1.3, 4.1.1
CO5	TPS3	Apply	Value	-	1.1.1, 2.1.3, 2.1.5, 3.1.3, 4.1.1
CO6	TPS3	Apply	Value	-	1.1.1, 2.1.3, 2.1.5, 3.1.3, 4.1.1

Mapping with Programme Outcomes

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	S	S	S	S	M	S		S	S	-	-	-	S	-	-
CO2	S	S	S	M	M	S	L	S	S	-	-	-	S	-	-
CO3	S	S	S	S	M	S		S	S	-	-	-	S	-	-
CO4	S	S	S	S	M	S	M	S	S	-	-	-	S	-	-
CO5	S	S	S	S	M	S	M	S	S	-	-	-	S	-	-
CO6	S	S	S	S	M	S	M	S	S	-	-	-	S	-	-

S- Strong; M-Medium; L-Low

Assesment Pattern: Cognitive Domain

Cognitive Levels	Continuous Assessment Tests			Assignment			End Semester Examination
	1	2	3	1	2	3	
Remember	10	10	10	-	-	-	0
Understand	20	20	20	-	-	-	30
Apply	70	70	70	100	100	100	70
Analyse	0	0	0	-	-	-	0
Evaluate	0	0	0	-	-	-	0
Create	0	0	0	-	-	-	0

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. A company produces two types of goods A and B that require gold and silver. Each unit of type A requires 3 grams of silver and 1 gram of gold while B requires 1 grams of silver and 2 grams of gold. The company can produce 9 grams of silver and 8 grams of gold. If each unit of type A brings a profit of Rs.40 and that of type B Rs.50, determine the number of units of each type that should be produced to maximize the profit. Formulate the LP Model and find the optimal product mix and the corresponding profit of the company using simplex method.
2. A firm produces two products A and B on which the profits earned per unit are Rs.3 and Rs.4, respectively. They are processed on two machines M1 and M2. Product A requires one minute of processing time on M1 and two minutes on M2, while B requires one minute on M1 and one minute on M2. Machine, M1 is available for not more than 7 hours 30 minutes, while machine M2 available for 10 hours during any working day. Formulate the problem as LPP to find the number of units of products A and B to be manufactured to get maximum profit and solve this LPP using the result of the its dual problem.

Course Outcome 2 (CO2):

1. Solve the following problem graphically
   Maximize $Z = 60\,x_1 + 40x_2$ subject to $2\,x_1 + x_2 \leq 60$; $X_1 \leq 25$; $X_2 \leq 35$; $X_1 \geq 0; x_2 \geq 0$
2. Solve by simplex method: Maximize $Z = x_1 - x_2 + 3x_3$ subject to $2x_1 + x_2 + x_3 \leq 10$; $2x_1 - x_3 \leq 2$; $2x_1 - 2x_2 + 3x_3 \geq 0$; x_1, x_2, x_3 all ≥ 0

Course Outcome 3 (CO3):

1. The owner of a small machine shop has four mechanics available to assign jobs for the day. Five jobs are offered with expected profit for each mechanic on each job as follows.

$$\begin{array}{cc} & \textit{Jobs} \\ & \begin{array}{ccccc} A & B & C & D & E \end{array} \\ \textit{Machines} & \begin{array}{c} 1 \\ 2 \\ 3 \\ 4 \end{array} \begin{bmatrix} 62 & 78 & 50 & 111 & 82 \\ 71 & 84 & 61 & 73 & 59 \\ 87 & 92 & 111 & 71 & 81 \\ 48 & 64 & 87 & 77 & 80 \end{bmatrix} \end{array}$$

Find by using the assignment method the assignment of mechanics of the job that will recent in a maximum profit. Which job should be declined.

2. Solve the following transportation problem.

	To			Available
From	A	B	C	
I	50	30	220	1
II	90	45	170	3
III	250	200	50	4
Requirement	4	2	2	

Course Outcome 4 (CO4):

1. Using Euler's method, solve numerically the equation $y' = x + y$, y(0) = 1, for x = 0.0 (0.2) (0.1). Check your answer with the exact solution.
2. By means of Taylor series expansion find y at x = 0.1 & 0.2, given $\frac{dy}{dx} - 2y = 3e^x$, y(0) = 0.

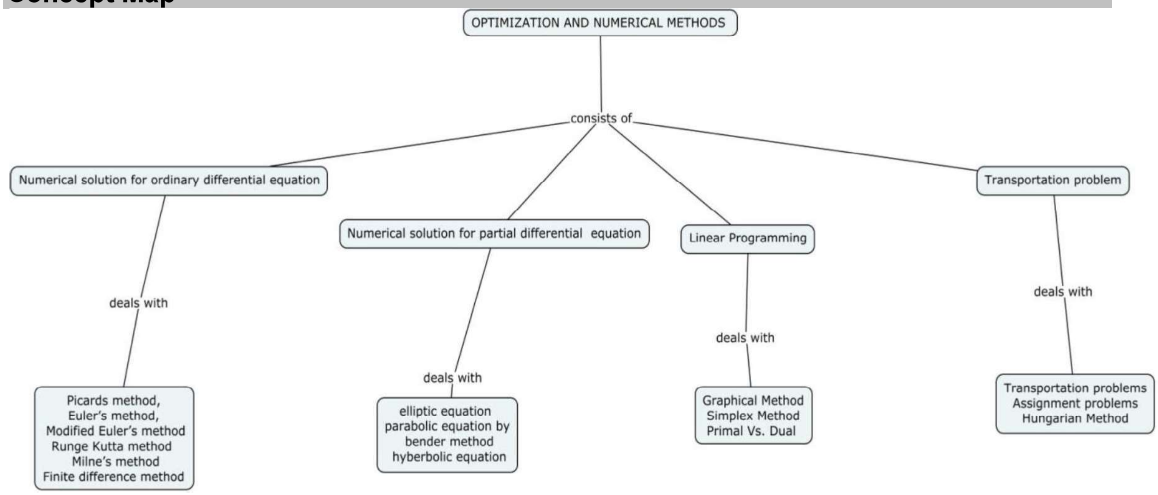
Course Outcome 5 (CO5):

1. Given $y' + xy^2 + y = 0$, y(0) = 1, find the value of y(0.2) by using Runge-Kutta method of fourth order.
2. Using Milne's method find y(4.4) given $5xy' + y^2 - 2 = 0$ given y(4) =1; y(4.1) =1.0049; y(4.2) = 1.0097 and y(4.3) = 1.0143.

Course Outcome 6 (CO6):

1. Solve $u_{xx} + u_{yy} = 0$ over the square mesh of side 4 units; satisfying the following conditions.u(x, 0) = 3x for $0 \le x \le 4$; u(x, 4) = $x^2$for $0 \le x \le 4$; u(0, y) = 0 for $0 \le y \le 4$; u(4, y) = 12 + y for $0 \le y \le 4$.
2. Solve $\frac{\partial^2 u}{\partial x^2} - 2.\frac{\partial u}{\partial t} = 0$ given u(0, t) = 0, u(4, t) = 0, u(x, 0) = x(4 – x). Assume h = 1. Find the values of u upto t = 5.
3. Solve $y_{tt} = 4y_{xx}$ subject to the conditions y(0, t) = 0, y(2, t) =, y(x, 0) = x(2 – x), $\frac{\partial y}{\partial x}(x,0) = 0$. Do 4 steps. Find values upto 2 decimal accuracy.

Concept Map



Syllabus

Numerical Solution for Ordinary Differential Equation: Picards method, Eulers method, modified Eulers method, Runge Kutta method of fourth order - Predictor- corrector method: Milne's method. Solving simultaneous first order differential equation. Solving boundary value problems : finite difference method. **Numerical Solution for Partial Differential Equation**: Classification of second order partial differential equation-Solution of elliptic equation, - Solution of parabolic equation by bender method and Solution of hyberbolic equation. **Linear Programming:** Formulation - Graphical Method and Simplex Method – Primal Vs. Dual relationships. **Transportation problems**: Transportation problems and solutions - Assignment problems – Solution using Hungarian Method.

Learning Resources

1. S.S. Sastry, Introductory methods of numerical analysis, PHI, 4th Edition, 2005.
2. P.Kandasamy, K.Thilagavathy, K.Gunavathi, Numerical Methods, S. Chand & Company, 2nd Edition, Reprint 2012.
3. Hamdy A. Taha, "Operations Research - An Introduction", 7th Edition, MacMillan Co., 2010.
4. Frederick Hillier, Gerald Lieberman, "Introduction to Operations Research" Tenth Edition, Tata McGraw Hill, 2015.

Course Contents and Lecture Schedule

Module No	Topic	Lecture Hours	CO's
1	**Numerical solution for ordinary differential equation**		
1.1	Picards method, Euler's method, Modified Euler's method	2	CO1
1.2	Runge Kutta method of fourth order	2	CO1
	Tutorial	1	
1.3	Predictor- corrector method: Milne's method	2	CO2
1.4	Finite difference method	1	CO2
	Tutorial	1	
2	**Numerical solution for partial differential equation**		
2.1	Classification of second order partial differential equation	1	CO3
2.2	Solution of elliptic equation	2	CO3
	Tutorial	1	
2.3	Solution of parabolic equation by bender method	2	CO3
2.4	Solution of hyberbolic equation	2	CO3
	Tutorial	1	
3	**Linear Programming:**		
3.1	Formulation	1	CO4
3.2	Graphical Method	2	CO5
3.3	Simplex Method	2	CO5
	Tutorial	1	
3.4	Primal Vs. Dual relationships.	2	CO5
	Tutorial	1	
4	**Transportation problems**		
4.1	Transportation problems and solutions	3	CO6
	Tutorial	1	
4.2	Assignment problems	2	CO6
4.3	Solution using Hungarian Method	2	CO6
	Tutorial	1	
Total		**36**	

Course Designers:

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3. Mr.R.Sivakumar rsrmat@tce.edu

18EC420	RF ACTIVE CIRCUITS	Category	L	T	P	Credit
		PC	2	1	0	3

Preamble

This course aims to provide students with the technological skills needed in understanding the behaviour of active circuits and analyze the system level parameters of the RF front end.

Prerequisite

18EC320 RF Passive Devices and Circuits

Course Outcomes

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

CO#	Course Outcome Statement	Weightage in %
CO1	Understand the fundamentals of maximum power transfer, stability criteria, Oscillation criteria, heterodyning criteria.	20
CO2	Design and implementation of Matching network in different platforms for maximum power transfer between two microwave circuits.	20
CO3	Design and develop linear amplifier for the GSM applications	20
CO4	Design an oscillator for the given specifications.	15
CO5	Design a mixer for the given specifications.	15
CO6	Calculate the RF System level power budget for the given receiver architecture.	10

Mapping with Programme Outcomes

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	M	L	-	-	L	-	-	-	L	-	-	L	L	-	L
CO2	S	M	L	-	M	L	-	M	M	M	L	L	M	M	L
CO3	S	M	L	-	M	L	-	M	M	M	L	L	M	M	L
CO4	S	M	L	-	M	L	-	M	M	M	L	L	M	M	L
CO5	M	L	-	-	M	L	-	M	M	M	-	L	M	-	L
CO6	M	L	-	-	L	-	-	-	L	-	-	L	L	-	L

S- Strong; M-Medium; L-Low

CO Mapping with CDIO Curriculum Framework

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS2	Understand	Respond	-	1.2, 2.1.1, 2.4.7, 4.1.4
CO2	TPS3	Apply	Value	Mechanism	1.2, 2.4.7, 2.5.1, 2.5.4, 3.1.1, 3.1.2, 3.1.4, 3.2.1, 3.2.6, 3.2.4, 3.2.5, 3.2.6, 3.3.1, 4.1.2, 4.3.4, 4.4.3, 4.5.2, 4.5.3, 4.5.5
CO3	TPS3	Apply	Value	Mechanism	1.2, 2.4.7, 2.5.1, 2.5.4, 3.1.1, 3.1.2, 3.1.4, 3.2.1, 3.2.6, 3.2.4, 3.2.5, 3.2.6, 3.3.1, 4.1.2, 4.3.4, 4.4.3, 4.5.2, 4.5.3, 4.5.5
CO4	TPS3	Apply	Value	Mechanism	1.2, 2.4.7, 2.5.1, 2.5.4, 3.1.1, 3.1.2, 3.1.4, 3.2.1, 3.2.6, 3.2.4, 3.2.5, 3.2.6, 3.3.1, 4.1.2, 4.3.4, 4.4.3, 4.5.2, 4.5.3, 4.5.5

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO5	TPS3	Apply	Value	Mechanism	1.2, 2.4.7, 2.5.1, 2.5.4, 3.1.1, 3.1.2, 3.1.4, 3.2.1, 3.2.6, 3.2.4, 3.2.5, 3.2.6, 3.3.1, 4.1.2, 4.3.4, 4.4.3, 4.5.2, 4.5.3, 4.5.5
CO6	TPS2	Understand	Respond	-	1.2, 2.1.1, 2.4.7, 4.1.4

Assessment Pattern: Cognitive Domain

Cognitive Levels	Continuous Assessment Tests			Assignment			End Semester Examination
	1	2	3	1	2	3	
Remember	20	0	20	0	0	0	0
Understand	20	20	20	100	0	0	20
Apply	60	80	60	0	50	50	80
Analyse	0	0	0	0	0	0	0
Evaluate	0	0	0	0	0	0	0
Create	0	0	0	0	0	0	0

Assessment Pattern: Psychomotor

Psychomotor Skill	Assignment-1	Assignment-2	Assignment-3
Perception	-	-	-
Set	-	-	-
Guided Response	-	-	-
Mechanism	-	50	50
Complex Overt Responses	-	-	-
Adaptation	-	-	-
Origination	-	-	-

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. What are the factors needed to develop a matching network? What is a stub?
2. What are the drawbacks of L section matching? Why double stubs are preferred?
3. An amplifier uses a transistor having the following S parameters (Z_0=50 Ω) S_{11}=0.61$\angle -170^\circ$,S_{12}=0.06$\angle 70^\circ$,S_{21}=2.3$\angle 80^\circ$,S_{22}=0.72$\angle -25^\circ$.The input of the transistor is connected to a source with V_s=2 V(peak) and Z_s=25 Ω. and the output of the transistor is connected to a load of Z_L=100 Ω. What is the power gain, the available power gain, the transducer power gain and the unilateral transducer power gain.

Course Outcome 2 (CO2):

1. For a load impedance ZL= 15+j10 Ω, design two single stub shunt tuning networks to match this load to a 50 Ω line. Assume the load is matched at 2 GHz and the load consists of a resistor and inductor in series.
2. Design a single stub shunt tuner to match a load impedance ZL=60-j80 Ω to a 50Ω line. The stubs are to be short circuited stubs. Assume that this load consists of a series resistor and capacitor and the match frequency is 2 GHz.
3. Design a lumped element matching network at 1 GHz that would transform ZL= 0.2+j0.2 Ω into a 50 Ω transmission line.

Course Outcome 3 (CO3):

1. The S parameters for the HP HFET-102 GaAS FET at 2 GHz with the bias voltage Vgs=0 are given as follows: S11=0.894$\angle$60.6° ,S21=3.122$\angle$123.6° ,S12=0.020$\angle$62.4° ,S22=0.781$\angle$ 27.6° .Determine the stability of this transistor by calculating K and $|\Delta|$and plot the stability circles.

2. A GaAs FET has the following scattering and noise parameters at 6 GHz (Z0=50 Ω): S11=0.6 ∠60° ,S12=0,S21=2.0∠81° ,S22=0.7∠60° , Fmin= 2. dB, Γopt=0.62∠100° and RN=20 Ω. Design an amplifier to have a gain of 6 dB, and the minimum noise figure possible with this gain. Use open circuited shunt stubs in the matching sections.
3. Design an amplifier for maximum gain at 4 Ghz using single stub matching sections. The GaAs FET has the following specifications: S11=0.72∠116° ,S21=2.60 ∠76° ,S12=0.03∠57° ,S22=0.73 ∠54° ,Ts= 0.872 ∠123° , TL= 0.876∠61° ,Z0= 50 ohms.

Course Outcome 4 (CO4):

1. One oscillator has a Q of 5, another a Q of 50. Which oscillator reaches steady-state conditions first ? Which oscillator can be quenched more quickly ? Are these results intuitive ? Can you think a mechanical system that behaves the same way ?
2. Design a transistor oscillator at 4 GHz using a GaAs MESFET in a common gate configuration, with a 5 nH inductor in series with the gate to increase the instability. Choose a load network to match to a 50 _ load, and an appropriate terminating network at the input to the transistor. The scattering parameters of the transistor in a common source configuration are: S11=0.72∠116 °,,S21=2.60∠76° ,S12=0.03∠57° ,S22=0.73∠54°,Ts=0.872∠123°,TL= 0.876∠61° ,Z0= 50 ohms.
3. Design a transistor oscillator at 1.9 GHz using a silicon BJT in a common emitter configuration driving a 50 ohms load on the drain side. The scattering parameters are as follows: : S11=0.72∠116° ,S21=2.60∠76° ,S12=0.03 ∠57° ,S22=0.73∠ 54° ,Ts= 0.872 ∠123° , TL= 0.876∠61° ,Z0= 50 ohms. Choose Γ_L for Γ_{in} >> 1, design appropriate load and terminating networks.

Course Outcome 5 (CO5):

1. An RF input signal at 900MHz is down- converted in a mixer to an IF frequency of 80MHz. What are the two possible LO frequencies, and the corresponding image frequencies?
2. An input level signal composed of two closely spaced frequencies (ω_1, ω_2) is applied to a mixer along with an LO frequency at ω_0. Calculate and sketch the resulting output spectrum due to the v^2 term of the mixer response equation.
3. Consider a single ended mixer having the following port VSWR values at 15GHz: $(VSWR)_{RF}$ = 2.5; $(VSWR)_{IF}$ = 3.5; L_h = 3 dB. The diode used in the mixer has: R_j = 100 Ω, R_s = 2 Ω and C_j = 0.2 pF. What is the conversion loss of the mixer?

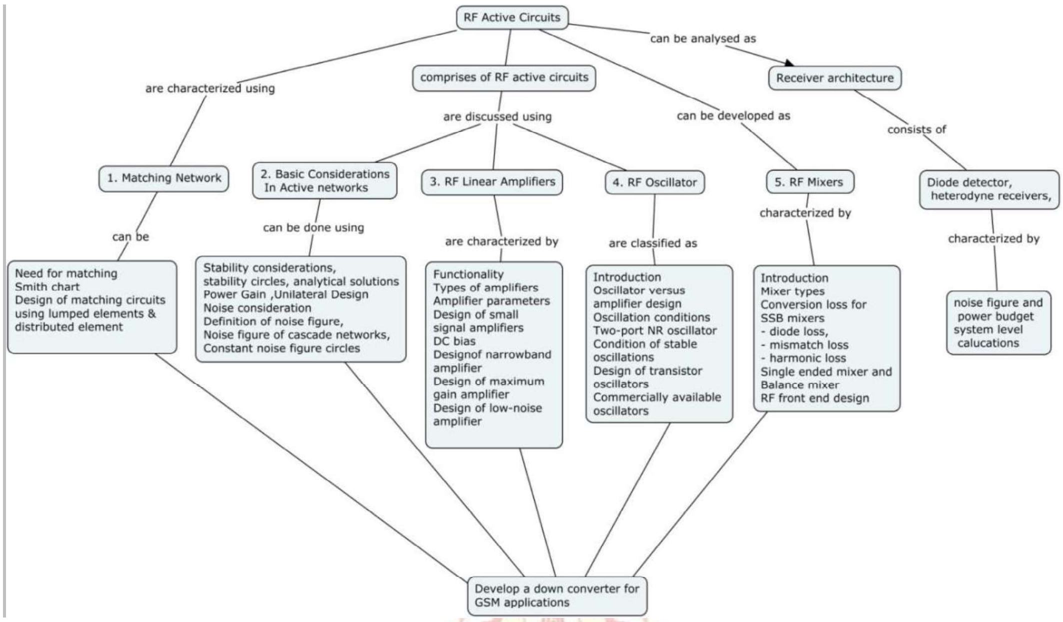
Course Outcome 6 (CO6):

1. Consider a 50Ω cable, LNA and another amplifier are cascaded together. Their gain and Noise figures are G_1= -3dB, NF_1= 3dB; G_2= -20dB, NF_2= 1.5dB; G_3=13dB, NF_3= 4dB. Compute the overall noise figure.
2. An amplifier with a bandwidth of 1GHz has a gain of 15d dB and a noise temperature of 250°K . If it is used as a preamplifier in a cascade , preceding a microwave amplifier of 20 dB gain and 5 dB noise figure, determine the overall noise temperature.
3. For a wideband amplifier operating over 3-5GHz with gain 10dB, output power 10dbm and noise figure 4 dB at room temperature, find the output noise power
4. An amplifier with a gain of 12dB, a bandwidth of 150 MHz and a noise figure of 4 dB feeds a receiver with a noise temperature of 900K.Find the noise figure and equivalent noise temperature of the overall system.

Sample Assignments

1. **Assignment-1:** Presentation of linear amplifiers for the GSM applications
2. **Assignment-2:** Commercially available oscillator for GSM Transceiver applications
3. **Assignment-3:** Design a down converter for GSM application

Concept map



Syllabus

Introduction- Review of Cellular phone architecture, Transmitter/Receiver System, Operation mechanisms, UP/ down Conversion: Frequency translation and harmonics. RF front end, Role of Amplifiers, Mixers and oscillators.
Consideration in Active networks: Introduction to diodes and Transistors – PIN Diodes, Schottky diodes, BJT and FET.
Matching Network – Need for Impedance matching, Smith chart, Design of matching circuits using lumped elements, Matching network design using distributed element, Choice of short- or open circuited stubs, Design steps for single stub matching.
Stability considerations - stability circles, K- Δ Test, μ test, Gain considerations - power gain concepts, A special case: unilateral transistor, Unilateral case (maximum gain and constant gain circles)
Noise consideration-Definition and sources, Definition of noise figure, Noise figure of cascade networks, Constant noise figure circles.
RF/Microwave Linear Amplifiers: Functionality, Types of amplifiers Amplifier parameters- Gain, Noise figure, Compression, Third order Intercept. Small-signal amplifiers- DC-bias circuit design and amplifiers DC-bias RF/MW circuit design, GSM receiver LNA Specifications Design of narrowband amplifier (NBA) design, Design of maximum gain amplifier (MGA) design, Design of low-noise amplifier (LNA) design
RF/Microwave Oscillator: Introduction-Oscillator versus amplifier design, Oscillation conditions, Two-port NR oscillator, Condition of stable oscillations, Design of transistor oscillators, Commercially available oscillator for GSM wireless Transceiver Applications
RF/Microwave Mixers: Introduction, Mixer types-up converter, Mixer parameters: Conversion loss for SSB mixers-diode loss, mismatch loss and harmonic loss - conversion loss and noise figure, Single ended mixer, Balanced mixer.
Receiver architecture and System level power budgeting - Receiver Architecture: Diode detectors and heterodyne, Noise Figure and power budgets for a GSM Down convertor
Mini project: Design of a down converter for GSM application – System level calculation and simulations.

Learning Resources:

1. Matthew M. Radmanesh, "Radio frequency and Microwave Electronics Illustrated", Pearson Education Asia, 2001.

2. David M Pozar: Microwave and RF design of wireless systems, John Wiley & Sons, 2001.
3. David M. Pozar," Microwave Engineering," John Wiley & Sons, Fourth Edition, 2015
4. Les Besser and Rowan Gilmore, "Practical RF circuit Design for Modern Wireless Systems- Passive circuits and Systems", Vol.1, Artech House Publishers, Boston, London 2008.
5. Joy Laskar, Babak Matinpour, Sudipto Chakraborty, "Modern Receiver Front- Ends Systems, Circuits, and Integration", Wiley- Interscience, 2004.
6. https://onlinecourses.nptel.ac.in/noc18_ee22
7. https://www.udemy.com/courses

Course Contents and Lecture Schedule

Sl.No	Topic	Lecture Hours	Practice Hours	COs
1	**Introduction- Review of Cellular phone architecture**	1	1	CO1
1.1	Transmitter/Receiver System, Operation mechanisms, UP/ down Conversion: Frequency translation and harmonics	1	1	CO1
1.2	RF front end, Role of Amplifiers, Mixers and oscillators	1		CO1
2	Consideration in Active networks: Introduction to diodes and Transistors – PIN Diodes, Schottky diodes, BJT and FET.	1		CO1
3	Matching Network – Need for Impedance matching, Smith chart	1	1	CO2
3.2	Design of matching circuits using lumped elements	1	1	CO2
3.3	Matching network design using distributed element - Choice of short- or open circuited stubs	1		CO2
3.4	Design steps for single stub matching	1	1	CO2
4	**Stability considerations** - stability circles, Gain considerations - K- Δ Test, μ test	1	1	CO1
4.2	power gain concepts, A special case: unilateral transistor, Unilateral case (maximum gain and constant gain circles)	1		CO1
5	**Noise consideration**-Definition and sources, Definition of noise figure, Noise figure of cascade networks.	1		CO1
5.2	Constant noise figure circles	1		CO1
6	**RF/Microwave Linear Amplifiers:** Functionality, Types of amplifiers Amplifier parameters- Gain, Noise figure, Compression, Third order Intercept.	1	1	CO1, CO3
6.2	Small-signal amplifiers- DC-bias circuit design and amplifiers DC-bias RF/MW circuit design, GSM receiver LNA Specifications	1		CO1, CO3
6.3	Design of narrowband amplifier (NBA) design,	1	1	CO3
6.4	Design of maximum gain amplifier (MGA) design,		1	CO3
6.5	Design of low-noise amplifier (LNA) design		1	CO3
	Assignment 1: Presentation of linear amplifiers for the GSM applications		1	CO3
7	**RF/Microwave Oscillator:** Introduction-Oscillator versus amplifier design, Oscillation conditions, Two-port NR oscillator, Condition of stable oscillations,	1		CO1, CO4
7.2	Design of transistor oscillators	2	1	CO4
	Assignment 2:Commercially available oscillator for		1	CO4

Sl.No	Topic	Lecture Hours	Practice Hours	COs
	GSM wireless Transceiver Applications			
8	**RF/Microwave Mixers:** Introduction, Mixer types-up converter, Mixer parameters: Conversion loss for SSB mixers-diode loss, mismatch loss and harmonic loss - conversion loss and noise figure,	1		CO1, CO5
8.2	Single ended mixer, Balanced mixer.	1		CO5
9	**Receiver architecture and System level power budgeting -** Receiver Architecture: Diode detectors and heterodyne, Noise Figure and power budgets for a GSM Down convertor	1	1	CO6
9.2	**Mini project – Design of a down converter for GSM application –** System level calculation and simulations. **Assignment III**		2	CO6

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18EC430	CMOS VLSI SYSTEMS	Category	L	T	P	Credit
		PC	3	0	0	3

Preamble

The course aims at understanding the basic concepts of Digital CMOS VLSI circuit by studying logic design, physical structure and fabrication of MOS devices and how they are combined to build systems for efficient data processing.

Prerequisite

18EC330 : Electronics Circuits

Course Outcomes

On the successful completion of the course students will be able to

CO#	Course Outcome Statement	Weightage in %
CO1	Construct CMOS logic circuits and Layouts.	20
CO2	Examine the electrical characteristics of CMOS logic circuits.	15
CO3	Examine the electronic aspects of CMOS logic circuits.	20
CO4	Understand VLSI design flow and fabrication of CMOS integrated circuits	15
CO5	Combinational Circuit Design using Advanced CMOS logic design techniques	15
CO6	Construct CMOS VLSI system components	15

CO Mapping with CDIO Curriculum Framework

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS3	Apply	Value	Mechanism	1.2, 2.1.1, 2.4.2, 3.1.1, 4.5.1, 4.6.1
CO2	TPS3	Apply	Value	-	1.2, 2.1.1, 2.1.2, 3.1.1, 4.5.1, 4.6.1
CO3	TPS3	Apply	Value	-	1.2,, 2.1.1, 2.1.2, 3.1.1, 3.2.3, 4.5.1, 4.6.1
CO4	TPS4	Understand	Respond	-	1.2, 2.1.1, 2.1.2, 4.5.1, 4.6.1
CO5	TPS4	Apply	Value	Mechanism	1.2, 2.1.1, 2.5.1, 4.5.1, 4.6.1
CO6	TPS3	Apply	Value	Mechanism	1.2, 2.1.1, 2.5.1, 4.5.1, 4.6.1

Mapping with Programme Outcomes and Programme Specific Outcomes

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	S	S	M	L	L	-	-	-	-	-	-	-	M	-	-
CO2	S	S	M	L	-	-	-	-	-	-	-	-	M	-	-
CO3	S	S	M	L	-	-	-	-	-	-	-	-	M	-	-
CO4	S	M	L	-	-	-	-	-	-	-	-	-	L	-	-
CO5	S	S	M	M	L	-	-	-	-	-	-	-	M	-	-
CO6	S	S	M	M	L	-	-	-	-	-	-	-	M	-	-

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

Cognitive Levels	Continuous Assessment Tests			Assignment			End Semester Examination
	1	2	3	1	2	3	
Remember	0	0	0	0	0	0	0
Understand	20	20	20	0	0	0	20
Apply	80	80	80	100	100	0	80
Analyse	0	0	0	0	0	0	0
Evaluate	0	0	0	0	0	0	0
Create	0	0	0	0	0	0	0

Assessment Pattern: Psychomotor

Psychomotor Skill	Assignment-1	Assignment-2	Assignment-3
Perception	-	-	-
Set	-	-	-
Guided Response	-	-	-
Mechanism	-	-	100
Complex Overt Responses	-	-	-
Adaptation	-	-	-
Origination	-	-	-

Sample Questions for Course Outcome Assessment

Course Outcome 1 (CO1):

1. Design a CMOS logic circuit that implements the function F = (a+b.c+a.b.c)' using series-parallel logic. The objective is to minimize the transistor count.
2. Using transmission gates, design a 2:1 MUX circuit.
3. Draw the CMOS Gates to realize the function: F = $\overline{a+b.c+a.b.c}$. Find a Common Euler Path for both PUN and PDN. Use the Common Euler Path to draw Stick Diagram.

Course Outcome 2 (CO2):

1. Construct the RC switch Model for the FET layout specifications. Assume a power supply voltage of 3 V.

   L'= 0.5 µm   Lo = 0.05 µm
   V_{ton} = 0.6 v   k'n = 150µA/V^2
   C_{ox} = 2.70 x 10^{-15} F/µm^2 C_j = 0.86 x 10^{-15} F/µm^2
   C_{jsw} = 0.24 x 10^{-15} F/µm^2 X= 2 microns, W= 6 microns
2. Derive the Expression for MOS threshold voltage and MOS Drain current.
3. Construct the voltage transfer characteristics of an electrically symmetric CMOS inverter that is build in a process where

   V_{Tn} = +0.5 V, W_n=4µm, L_n=0.25µm, k'_n = 130 µA/V^2
   V_{Tp}= -0.6 V, W_p=4µm, L_p=0.25µm, k'_p = 65 µA/V^2
   and a power supply of V_{DD}=3V is used.

Course Outcome 3(CO3):

1. An inverter uses FETs with b_n = 2.1mA/v^2 and b_p = 1.8mA/v^2. The threshold voltages are given as V_{tn} = 0.6 V and V_{tp} = -0.7V and the power supply has a value of 5V.The parasitic capacitance at the output node is C_{out}= 74 x 10^{-15} F.
   a. Find the mid-point Voltage V_m and values of R_n and R_p.
   b. Calculate the rise time and fall time when C_L = 0
   c. Calculate the rise time and fall time when C_L = 115 x 10^{-15} F
   d. Plot rise time and fall time as functions of C_L.
2. A interconnect has the geometry with T_{ox} = 0.9µm, w = 0.35µm and t = 1.10µm. The interconnect line has a sheet resistance of Rs = 0.04 ohms.
   a. Find the value of 'c' predicted by the empirical expression that includes fringing.
   b. Find the values of R_{line} and C_{line} if the line is 48um long.

3. Construct an m=7 RC ladder equivalent for the line, then use the model to determine time constant.

Course Outcome 4 (CO4):

1. List the steps in CMOS fabrication?
2. Explain the process of photolithography.
3. What do you understand by synthesis in VLSI Design process?

Course Outcome 5 (CO5):

1. Consider the OAI Logic Function g = (a+b).(c+d).e. Design the Clocked CMOS Logic circuit and then construct a basic layout for the circuit.
2. Draw the Pseudo-nmos circuit for the functions
   i) F= (a+(c.[x+(y.z)]))' ii) h=((a+b+c).x + y.z)'
3. Design a 2/4 active high decoder using only transmission gates in the main logic paths.

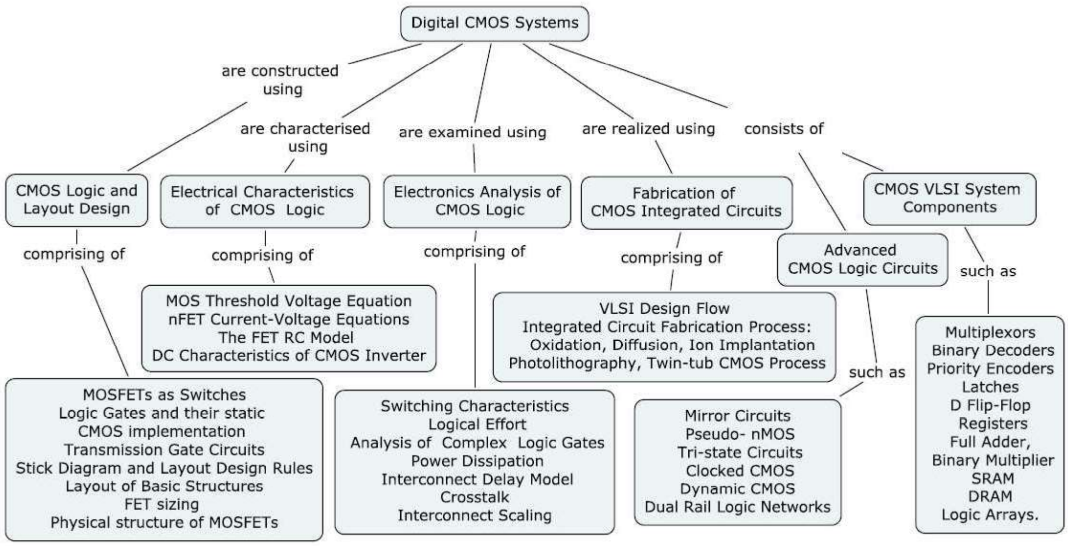
Course Outcome 6 (CO6):

1. Design a NAND3 gate using an 8:1 MUX.
2. Design a CMOS logic gate circuit the implements the function F = (a+b.c+a.b.c)' using series-parallel logic. The objective is to minimize the transistor count.
3. Design a 6T SRAM memory cell

Sample Assignments

Assignment 1	Complex CMOS logic circuit Layout Design
Assignment 2	Drain current, Midpoint voltages, Rise time, Fall time calculations and FET-RC model
Assignment 3	Spice simulation for the given CMOS logic circuit

Concept Map



Syllabus

CMOS Logic and Layout Design: MOSFETs as Switches, Logic Gates and their static CMOS implementation, Transmission Gate Circuits, Stick Diagram and Layout Design Rules, Layout of Basic Structures, FET sizing, Physical structure of MOSFETs,. **Electrical Characteristicsof CMOS Logic:** MOS Threshold Voltage Equation, nFET Current-Voltage Equations, The FET RC Model, DC Characteristics of CMOS Inverter. **Electronics Analysis of CMOS Logic:**Switching Characteristics, Logical Effort, Analysis of Complex Logic Gates, Power Dissipation, Interconnect Delay Model, Crosstalk and Interconnect Scaling. **Fabrication of CMOS Integrated Circuits:** VLSI Design Flow, Integrated Circuit Fabrication Process: Oxidation, Diffusion, Ion Implantation, Photolithography and Twin-tub CMOS Process.**Advanced CMOS Logic Circuits:** Mirror Circuits, Pseudo- nMOS, Tri-state Circuits, Clocked CMOS, Dynamic CMOS and Dual Rail Logic Networks.**CMOSVLSI**

System Components: Multiplexors, Binary Decoders, Priority Encoders, Latches, D Flip-Flop, Registers, Full Adder, Binary Multiplier, SRAM, DRAM and Logic Arrays.

Learning Resources

1. N. Weste and David Harris," CMOS VLSI Design : A circuits and systems perspective" 4th Edition, Pearson, 2015.
2. N. Weste and K. Eshraghian, "Principles of CMOS VLSI Design", Second Edition, Addison-Wesley, 1993.
3. Uyemura, John P, "Introduction to VLSI Circuits and Systems". Wiley & Sons, 8th Reprint 2009.
4. Jan M. Rabaey, "Digital Integrated Circuits: A Design Perspective", Prentice Hall, Second Edition, 2006.
5. R. Jacob Baker, "CMOS: Circuit Design, Layout, and Simulation", Wiley-IEEE, Revised Second Edition, 2008.
6. Pucknell, "Basic VLSI Design", Prentice Hall, 1995.
7. Wayne Wolf, "Modern VLSI Design: System on Chip", Pearson Education, 2002.
8. MIT Open courseware: http://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-374-analysis-and-design-of-digital-integrated-circuits/.
9. Dr.Nandita Dasgupta, VLSI Design, NPTEL Video Lectures: http://www.nptelvideos.in/2012/12/vlsi-design.html

Course Contents and Lecture Schedule

No.	Topic	No.of Hours	COs
1	**CMOS Logic and Layout Design**		
1.1	MOSFETs as Switches	1	CO1
1.2	Logic Gates and their static CMOS implementation	1	CO1
1.3	Transmission Gate Circuits	1	CO1
1.4	Stick Diagram and Layout Design Rules	2	CO1
1.5	Layout of Basic Structures	1	CO1
1.6	FET sizing	1	CO1
1.7	Physical structure of MOSFETs	1	CO1
2	**Electrical Characteristics of CMOS logic:**		
2.1	MOS Threshold Voltage Equation	1	CO2
2.2	nFET Current-Voltage Equations	1	CO2
2.3	The FET RC Model	2	CO2
2.4	DC Characteristics of the CMOS Inverter.	2	CO2
3	**Electronic Analysis of CMOS Logic:**		
3.1	Switching Characteristics	2	CO3
3.2	Logical Effort	1	CO3
3.3	Analysis of Complex Logic Gates	1	CO3
3.4	Power Dissipation	1	CO3
3.5	Interconnect Delay Model	1	CO3
3.6	Crosstalk and Interconnect Scaling	1	CO3
4	**Fabrication of CMOS Integrated Circuits:**		
4.1	VLSI Design Flow	0.5	CO4
4.2	Integrated Circuit Fabrication Process	0.5	CO4
4.3	Oxidation	0.5	CO4
4.4	Diffusion	0.5	CO4
4.5	Ion Implantation	0.5	CO4
4.6	Photolithography and Twin-tub CMOS Process	1	CO4
5	**Advanced CMOS Logic Circuits**		
5.1	Mirror Circuits	0.5	CO5

5.2	Pseudo-nMOS	0.5	CO5
5.3	Tri - State Circuits	0.5	CO5
5.4	Clocked CMOS	1	CO5
5.5	Dynamic CMOS	1	CO5
5.6	Dual - Rail Logic Networks	1	CO5
6	**CMOSVLSI System Components**		
6.1	Multiplexors	0.5	CO6
6.2	Binary Decoders	0.5	CO6
6.3	Priority Encoders	0.5	CO6
6.4	Latches	0.5	CO6
6.5	D Flip-Flop	0.5	CO6
6.6	Registers	0.5	CO6
6.7	Full adder	1	CO6
6.8	Binary Multiplier	1	CO6
6.9	SRAM, DRAM and logic arrays	2	CO6
TOTAL		**36**	

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18EC440	SIGNAL PROCESSING	Category	L	T	P	Credit
		PC	2	1	0	3

Preamble

Signal processing is concerned with the representation, transformation and manipulation of signals and the information they contain. It is an area of science and engineering that has developed rapidly over the past few decades. The novel algorithms by Cooley and Tukey (1965) for efficient computation of Fourier transform provided a new point of view towards a discrete time signal processing. This course aims at the analysis and design of signal processing systems and computational techniques.

Prerequisite

18EC340 Signals and Systems

Course Outcomes

On the successful completion of the course students will be able to

CO#	Course Outcome Statement	Weightage in %
CO1	Compute DFT and IDFT coefficients of a given discrete time sequence using Fast Fourier Transform algorithms	15
CO2	Design Linear phase FIR digital filters using windowing and frequency sampling methods	15
CO3	Design IIR digital filters from analog filters namely Butterworth, and Chebyshev for a given specification	20
CO4	Draw the implementation structure of FIR and IIR discrete time systems using block diagram and signal flow graph representation.	10
CO5	Compute statistical parameters like mean, correlation and power spectral density of a given random variable or random processes at the output of a LTI system	20
CO6	Design LTI systems for noise reduction & signal enhancement, linear prediction and analyzing the effects of finite precision representation of system coefficients and truncation/rounding of intermediate computation.	20

CO Mapping with CDIO Curriculum Framework

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS3	Apply	Value	Guided response	1.2, 2.1.1, 2.1.2, 2.1.4, 2.1.5, 2.4.1, 2.4.2, 2.4.5, 3.2.3, 3.2.5,
CO2	TPS3	Apply	Value	Guided response	1.2, 2.1.1, 2.1.2, 2.1.4, 2.1.5, 2.4.1, 2.4.2, 2.4.5, 3.2.3, 3.2.5,
CO3	TPS3	Apply	Value	Guided response	1.2, 2.1.1, 2.1.2, 2.1.4, 2.1.5, 2.4.1, 2.4.2, 2.4.5, 3.2.3, 3.2.5,
CO4	TPS3	Apply	Value	Guided response	1.2, 2.1.1, 2.1.2, 2.1.4, 2.1.5, 2.4.1, 2.4.2, 2.4.5, 3.2.3, 3.2.5,
CO5	TPS3	Apply	Value	Mechanism	1.2, 2.1.1, 2.1.2, 2.1.3, 2.1.4, 2.1.5, 2.4.1, 2.4.2, 2.4.5, 3.2.3, 3.2.5,
CO6	TPS3	Apply	Value	Mechanism	1.2, 2.1.1, 2.1.2, 2.1.3, 2.1.4, 2.1.5, 2.4.1, 2.4.2, 2.4.5, 3.2.3, 3.2.5,

Mapping with Programme Outcomes and Programme Specific Outcomes

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	S	M	L	-	L	-	-	M	M	M	-	L	M	-	M
CO2	S	M	L	-	L	-	-	M	M	M	-	L	M	-	M
CO3	S	M	L	-	L	-	-	M	M	M	-	L	M	-	M
CO4	S	M	L	-	L	-	-	M	M	M	-	L	M	-	M
CO5	S	M	L	-	L	-	-	M	M	M	-	L	M	M	M
CO6	S	M	L	-	L	-	-	M	M	M	-	L	M	M	M

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

Cognitive Levels	Continuous Assessment Tests			Assignment			End Semester Examination
	1	2	3	1	2	3	
Remember	0	0	0	0	0	0	0
Understand	20	20	20	50	30	30	20
Apply	80	80	80	50	40	40	80
Analyse	0	0	0	0	0	0	0
Evaluate	0	0	0	0	0	0	0
Create	0	0	0	0	0	0	0

Assessment Pattern: Psychomotor

Psychomotor Skill	Assignment-1	Assignment-2	Assignment-3
Perception	-	-	-
Set	-	-	-
Guided Response	-	-	-
Mechanism	-	30	30
Complex Overt Responses	-	-	-
Adaptation	-	-	-
Origination	-	-	-

Sample Questions for Course Outcome Assessment

Course Outcome 1 (CO1):

1. a. Determine the Fourier transform $X(\omega)$ of the signal $x(n)=\{1,2,\underset{\uparrow}{3},2,1,0\}$

   b. Compute the 6 point DFT $V(k)$ of the signal $v(n)=\{3,2,1,0,1,2\}$

   c. Is there any relation between $X(\omega)$ and $V(k)$?

2. Consider the sequences

$$x_1(n)=\{0,1,2,3,4\},\quad x_2(n)=\{0,1,0,0,0\}, s(n)=\{1,0,0,0,0\}$$

   a. Determine a sequence $y(n)$ so that $Y(k)=X_1(k)X_2(k)$.

   b. Is there a sequence $x_3(n)$ such that $S(k)=X_1(k)X_3(k)$?

3. Determine the eight point DFT of the signal $x(n)=\{1,1,1,1,1,1,0,0\}$ using DIF and DIT algorithms.

Course Outcome 2 (CO2):

1. A FIR linear phase, digital low pass filter is to be designed with a cutoff frequency of $\frac{\pi}{4}$ rad.
   i) Determine the coefficients of a 7-tap filter based on the windowing technique with a Hamming window
   ii) Determine and plot the magnitude and phase response of the filter.
   iii) What will happen to the magnitude response if the taps of the filter increases to 11.

2. Design an FIR low pass filter satisfying the specifications
$0.95 < H\left(e^{j\omega}\right) < 1.05, \quad 0 \le |\omega| \le 0.25\pi$

$-0.1 < H\left(e^{j\omega}\right) < 0.1, \quad 0.35\pi \le |\omega| \le \pi$

By applying a window $w[n]$ to the impulse response $h_d[n]$ for the ideal discrete time low pass filter with cutoff $\omega_c = 0.3\pi$. Which of the window can be used to meet the specification? For each window that you claim will satisfy this specification, give the minimum length M+1 required for the filter.

3. Determine the unit sample response $h[n]$ of a linear phase FIR filter of length $M = 4$ for which the frequency response at $\omega = 0$ and $\omega = \pi/2$ is specified as $H_r(0) = 1$, $H_r\left(\frac{\pi}{2}\right) = \frac{1}{2}$

Course Outcome 3 (CO3):

1. For the analog transfer function $H_a(s) = \frac{2}{(s+1)(s+2)}$, Determine $H(z)$ if T=1 Sec, by means of the impulse invariant method.
2. Convert the analog filter with system transfer function $H_a(s) = \frac{(s+0.1)}{(s+0.1)^2 + 9}$ in to digital IIR bilinear transformation.
3. Determine the order and poles of a type I Chebyshev lowpass filter that has a 1dB ripple in the passband, a cutoff frequency of 1000π, a stopband frequency of $\Omega_s = 2000\pi$ and attenuation of 40dB or more for $\Omega > \Omega_s$

Course Outcome 4 (CO4):

1. Determine a direct form realization for the following linear phase filters:
   a. $h[n] = \left\{\underset{\uparrow}{1}, 2, 3, 4, 3, 2, 1\right\}$
   b. $h[n] = \left\{\underset{\uparrow}{1}, 2, 3, 3, 2, 1\right\}$
2. Consider an FIR filter with system function $H(z) = 1 + 2.88z^{-1} + 3.4048z^{-2} + 1.74z^{-3} + 0.4z^{-4}$. Sketch the direct form and lattice realizations of the filter and determine in detail the corresponding input-output equations. Is the system minimum phase?
3. Determine all the FIR filters which are specified by the lattice parameters $K_1 = \frac{1}{2}$, $K_2 = 0.6$, $K_3 = -0.7$ and $K_4 = \frac{1}{3}$

Course Outcome 5 (CO5):

1. Consider the sinusoidal process $X(t) = A\cos(2\pi f_c t)$ where the frequency f_c is constant and the amplitude A is uniformly distributed: $f_A(a) = \begin{cases} 1, & 0 \le a \le 1 \\ 0, & otherwise \end{cases}$. Determine whether or not this process is strictly stationary.
2. Prove the following two properties of the autocorrelation function $R_X(\tau)$ of a random process $X(t)$:
   a. If $X(t)$ contains a DC component equal to A, then $R_X(\tau)$ will contain a constant component equal to A^2.

b. If $X(t)$ contains a sinusoidal component, then $R_X(\tau)$ will also contain a sinusoidal component of the same frequency

3. Consider two linear filters connected in cascade as shown in Figure. Let $X(t)$ be a stationary process with autocorrelation function $R_X(\tau)$. The random process appearing at the first filter output is $V(t)$ and the second filter output $Y(t)$.

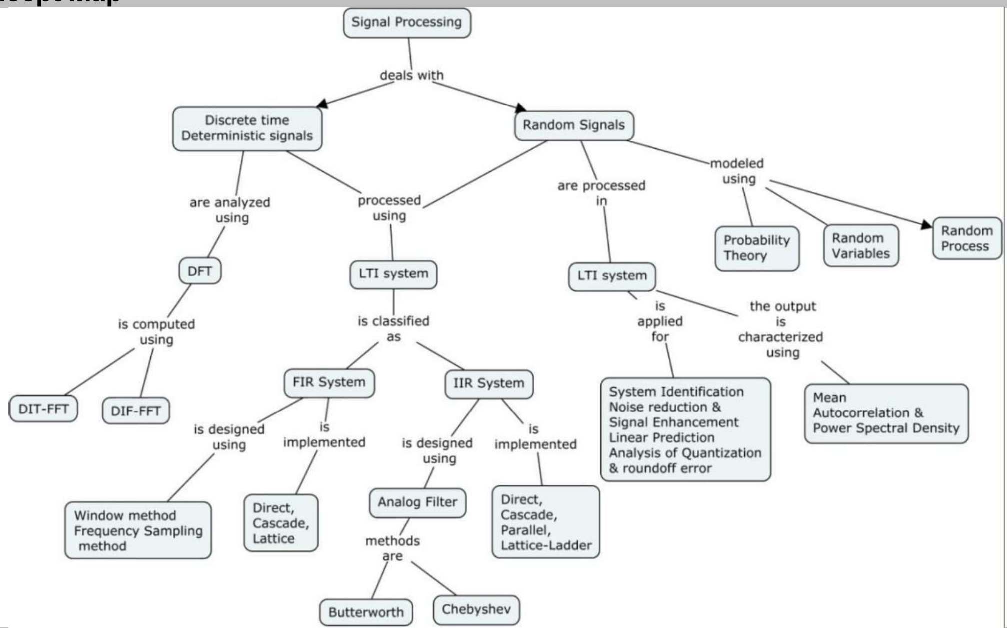
   d. Find the autocorrelation function of $Y(t)$.

   e. Find the cross correlation function $R_{VY}(\tau)$ of $V(t)$ and $Y(t)$.

Course Outcome 6 (CO6):

1. Design a 2-pole resonator with peak $f_0 = 500Hz$ and width $\Delta f = 32Hz$ operating at a sampling rate of $f_s = 10kHz$. Draw its magnitude response and Impulse response.
2. Design a peaking digital IIR filter operating at a rate of $10kHz$ that has a peak at 1.75kHz and 3dB width of 500Hz. Then redesign it such that 500Hz represents its 10 dB width. For the 3 dB width care, determine also the corresponding complementary notch filter.
3. Consider the four comb filters: $y(n) = x(n) + x(n-8)$, $y(n) = x(n) - x(n-8)$, $y(n) = x(n) + x(n-8) + x(n-16)$, $y(n) = x(n) - x(n-8) + x(n-16)$. Determine their transfer functions and their impulse responses. Place their zeros on the z-plane relative to the unit circle. Sketch their magnitude responses. How are they similar or different? Draw their canonical realization forms using 8-fold delays z^{-8}. Write the corresponding sample processing algorithms both in their linear and circular buffer versions.

Concept Map



Syllabus

Discrete Fourier Transform (DFT): Fourier representation of Finite duration sequences, Properties of DFT, Linear Convolution using DFT, Direct computation of the DFT, Decimation-in Time and Decimation in frequency FFT algorithms.

FIR Filter Design Techniques: Filter specifications, Design of FIR filters by Windowing, Frequency sampling method, Basic network structures for FIR filters: Direct, cascade, lattice and Linear phase FIR form

IIR Filter Design Techniques: Filter specifications, Design of Discrete time IIR filters from continuous time filters: Impulse invariance, Bilinear transformation techniques, Discrete time Butterworth and Chebyshev filters, Basic structures for IIR filters: Direct, cascade, parallel, lattice and lattice-ladder.

Random signals: Probabilistic concept, random variables, statistical averages, random process: definition, stationary process, mean, correlation and covariance functions, ergodic process, transmission of random process through LTI systems, power spectral density, Gaussian process, noise, narrow band noise.

Applications: Filter design based on Pole/zero: First order filters, Parametric resonators and equalizers, Notch and Comb filters, Effects of coefficient quantization, effects of roundoff noise in digital filters, noise reduction and signal enhancement, linear prediction

Learning Resources

1. Alan V.Oppenheim, Ronald W. Schafer, “Discrete time signal processing”, Prentice Hall, Third Edition, 2009.
2. John G.Proakis and Dimitris G.Manolakis, “Digital Signal Processing Principles, Algorithms and Applications”, Prentice-Hall of India, Fourth Edition, 2006.
3. Sophocles J.Orfanidis “Introduction to Signal Processing”, Prentice Hall, 1996.
4. Sanjit K.Mitra “Digital Signal Processing: A computer based approach” McGraw Hill Education; 4 edition – 2013.
5. Richard G. Lyons, “Understanding Digital Signal Processing” Third Edition, Pearson Education India, 2011.
6. https://ocw.mit.edu/resources/res-6-008-digital-signal-processing-spring-2011/study-materials/
7. https://freevideolectures.com/course/2317/digital-signal-processing-iit-delhi

Course Contents and Lecture Schedule

No.	Topic	No. of Lectures	COs
1	**Discrete Fourier Transform (DFT)**		
1.1	Fourier representation of Finite duration sequences	1	CO1
1.2	Properties of DFT	1	CO1
1.3	Linear Convolution using DFT,	1	CO1
1.4	Direct computation of the DFT: Decimation-in Time and	2	CO1
1.5	Decimation in frequency FFT algorithms.	2	CO1
2	**FIR Filter Design Techniques**		
2.1	Filter specifications	1	CO2
2.2	Design of FIR filters by Windowing	1	CO2
2.3	Frequency sampling method	1	CO2
3	**IIR Filter Design Techniques**		
3.1	Filter specifications	1	CO3
3.2	Design of Discrete time IIR filters from continuous time filters: Impulse invariance,	2	CO3
3.3	Bilinear transformation techniques,	1	CO3
3.4	Butterworth filter design	1	CO3
3.5	Chebyshev Filter design	2	CO3
4	**Filter Structures**		
4.1	Basic structures for IIR filters: Direct, cascade, parallel,	1	CO4
4.2	lattice and lattice-ladder	1	CO4
4.3	Basic network structures for FIR filters: Direct, cascade,	1	CO4
4.4	Lattice and Linear phase FIR form	1	CO4

5	**Random signals**		
5.1	Probabilistic concept, random variables, statistical averages**,**	1	CO5
5.2	Random process: definition, stationary process, mean, correlation and covariance functions,	2	CO5
5.3	Ergodic process,	1	CO5
5.4	Transmission of random process through LTI systems,	2	CO5
5.5	Power spectral density, Gaussian process, noise, narrow band noise.	2	CO5
6	**Applications**		
6.1	Filter design based on Pole/zero: First order filters	1	CO6
6.2	Parametric resonators and equalizers	1	CO6
6.3	Notch and Comb filters	1	CO6
6.4	transmission of random process through LTI systems	1	CO6
6.5	noise reduction and signal enhancement	1	CO6
6.6	linear prediction	2	CO6
	Total	36	

Course Designers:

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18EG460	PROFESSIONAL COMMUNICATION	Category	L	T	P	Credit
		HSS	0	1	2	2

Preamble

This course helps the students to achieve effective language proficiency for their professional, social and interpersonal communication skills, hence increasing their employability and career skills.

Prerequisite

Basic English Knowledge

Course Outcomes

On the successful completion of the course students will be able to

CO#	Course Outcome Statement	Weightage*** in %
CO1	Listen, watch, understand and respond to talks, conversations, etc by native and neutral speakers on science, general context, and from ETS test samples with confidence.	22%
CO2	Present ideas, express opinions/comments, practice presentation, and converse in discussions on a variety of technical and non-technical domains without fear	39%
CO3	Read and comprehend passages/texts from various topics – general and reasoning, to respond precisely through reading techniques, besides getting awareness on competitive exam lexicon/verbal exercises for career prospects	17%
CO4	Write journal abstracts/projects and business correspondences with clarity, accuracy, intelligibility, and precision.	22%

*** Weightage depends on Bloom's Level, number of contact hours

CO Mapping with CDIO Curriculum Framework

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS2	Understand	Respond	Guided Response	2.4.2, 2.4.6, 3.2.1, 3.2.2,
CO2	TPS3	Apply	Value	Mechanism	3.1.3, 3.1.2, 3.2.4, 3.2.5,3.2.6
CO3	TPS2	Understand	Respond	Guided Response	2.4.6, 2.4.5, 3.2.1,
CO4	TPS3	Apply	Value	Mechanism	2.4.3, 3.2.1, 3.2.3, 3.2.5

Mapping with Programme Outcomes and Programme Specific Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	-	-	-	-	-	-	-	-	L	S	-	M	-	-	-
CO2	-	-	-	-	-	-	-	-	S	S	-	M	-	-	-
CO3	-	-	-	-	-	-	-	-	M	S	-	M	-	-	-
CO4	-	-	-	-	-	-	-	-	M	S	-	M	-	-	-

S- Strong; M-Medium; L-Low

Assessment Pattern:

Internal: No Continuous Assessment Test CAT) will be conducted. Students' performance will be continuously assessed in various classroom activities in Listening, Speaking, Reading and Writing for 50 marks as detailed below:

Listening Test	- 10
Speaking Test (Group Discussion and Technical Presentation)	- 20
Written Test(Objective/Descriptive to be tested for 40 marks and converted to 20 marks)	- 20

External (Practical):

Group Discussion - 20

Personal Interview / Situational Conversation (BEC speaking based) - 20

Listening Test ` - 20

Reading/Writing –Computerised or Paper-based Test /General Aptitude Test – Objective type - 40

List of Experiments/Activities with CO Mapping

S.No	Activities	Hours T	Hours P	CO Mapping			
1	Listening, Reading and Writing based on Extensive Reading	2		CO1		**CO3**	CO4
2	Listening exercises at lab - online resources		2	**CO1**			
3	Developing Listening skills (BEC / IELTS / TOEIC / TOEFL)		2	**CO1**			
4	GD/Mock interview/Presentation Intro at lab through online		2	**CO1**			
5	GD Practice at classroom in groups		4	CO1	**CO2**		
6	Presentation on Technical / general topics – from dailies &	1	4		**CO2**		
7	Mock interview practice at classroom	1	4	CO1	**CO2**		
8	Comprehension Descriptive and Reasoning	2	2			**CO3**	
9	General Aptitude Practice – Vocabulary Development / Sentence completion / Error spotting /Analogy / Reasoning	3	2			CO3	**CO4**
10	Business Correspondence - BEC Writing Task II	2					**CO4**
11	Basics of Technical Writing/ Project Reports		2		**CO2**		
12	Preparation of Resume	1					**CO4**

Learning Resources

Reference Books:

1. Cappel, Annette and Sharp, Wendy, Cambridge English: Objective First, 4th Ed., CUP,
2. New Delhi, 2013.
3. Cusack, Barry. Improve Your IELTS Listening and Speaking Skills (With CD)
4. Paperback, Mcmillan, 2007.
5. Bates, Susan TOEFL iBT Exam Paperback – Oxford, 2012.
6. Hart, Guy Brook. Cambridge English Business Benchmark: 2 Ed., CUP 2014

Websites:

1. https://ielts-up.com (IELTS – LSRW – Practice Tests)
2. www.cambridgeenglish.org (BEC - LSRW)
3. www.etsglobal.org (TOEIC Preparation)
4. www.examenglish.com (Online Exams for international ESL Exams)
5. www.testpreppractice.net (GRE Tests -Vocabulary /Analogy / Sentence Completion / Reading)
6. https://www.freshersworld.com (Placement Papers)

Extensive Reading:

Coelho, Paulo. The Alchemist, Harper Publication, 2018.

Course Designers:

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3. Mr.R.Vinoth
4. Dr.G.Jeya Jeevakani
5. Ms.R.Manibala

18EC470	RF CIRCUITS LABORATORY

Category	L	T	P	Credit
PC	0	0	2	1

Preamble

The objective of this course is to design, simulate and validate the characteristics of RF active, passive circuits and wireless boards.

Prerequisite

18EC320 RF Passive devices and circuits, 18EC420 RF Active Circuits

Course Outcomes

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

CO#	Course Outcome Statement	Weightage in %
CO1	Design and validate a matching network	20
CO2	Design, simulate and test the characteristics of microwave passive devices such as coupler, filter	10
CO3	Design and validate linear amplifier for GSM frequencies	10
CO4	Analyze the mixer parameters	20
CO5	Perform the RF signal measurements	20
CO6	Understand the usage of spectrum and network analyzer	20

CO Mapping with CDIO Curriculum Framework

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS3	Apply	Value	Mechanism	1.2, 2.1.1, 2.1.2, 2.1.5, 2.3.4, 2.4.2, 2.4.3, 2.4.4. 2.4.5, 2.4.6, 2.4.7, 2.5.1, 2.5.2, 3.1.2, 3.1.4, 3.2.3, 3.2.4, 4.1.7,4.2.3,4.4.1,4.4.3,4.4.6
CO2	TPS3	Apply	Value	Mechanism	1.2, 2.1.1, 2.1.2, 2.1.5, 2.3.4, 2.4.2, 2.4.3, 2.4.4. 2.4.5, 2.4.6, 2.4.7, 2.5.1,2.5.2, 3.1.2, 3.1.4, 3.2.3, 3.2.4, 4.1.7,4.2.3,4.4.1,4.4.3,4.4.6
CO3	TPS3	Apply	Value	Mechanism	1.2, 2.1.1, 2.1.2, 2.1.5, 2.3.4, 2.4.2, 2.4.3, 2.4.4. 2.4.5, 2.4.6, 2.4.7, 2.5.1,2.5.2, 3.1.2, 3.1.4, 3.2.3, 3.2.4, 4.1.7,4.2.3,4.4.1,4.4.3,4.4.6
CO4	TPS4	Analyse	Oraganize	Complex overt responses	1.2, 2.1.1, 2.1.2, 2.1.5, 2.3.4, 2.4.2, 2.4.3, 2.4.4. 2.4.5, 2.4.6, 2.4.7, 2.5.1,2.5.2, 3.1.2, 3.1.4, 3.2.3, 3.2.4, 4.1.7,4.2.3,4.4.1,4.4.3,4.4.6
CO5	TPS2	Understand	Respond	Guided response	1.2, 2.1.1, 2.1.2, 2.1.5, 2.3.4, 2.4.2, 2.4.3, 2.4.4. 2.4.5, 2.4.6, 2.4.7, 2.5.1,2.5.2, 3.1.2, 3.1.4, 3.2.3, 3.2.4, 4.1.7,4.2.3,
CO6	TPS2	Understand	Respond	Guided response	1.2, 2.1.1, 2.1.2, 2.1.5, 2.3.4, 2.4.2, 2.4.3, 2.4.4. 2.4.5, 2.4.6, 2.4.7, 2.5.1,2.5.2, 3.1.2, 3.1.4, 3.2.3, 3.2.4, 4.1.7,4.2.3,

Mapping with Programme Outcomes and Programme Specific Outcomes

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	S	M	L	-	S	-	-	L	S	S	L	-	S	M	M
CO2	S	M	L	-	S	-	-	L	S	S	L	-	S	M	M
CO3	S	M	L	-	S	-	-	L	S	S	L	-	S	M	M
CO4	S	M	L	L	S	-	-	L	S	S	L	-	M	M	M
CO5	M	L	-	-	M	-	-	L	M	M	L	-	L	L	M
CO6	M	L	-	-	M	-	-	L	M	M	L	-	L	L	M

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

Cognitive Levels	Model Examination	End Semester Examination
Remember		
Understand		
Apply	60	60
Analyse	10	10
Evaluate		
Create		

Assessment Pattern: Psychomotor

Psychomotor Skill	Practical Component
Perception	
Set	
Guided Response	
Mechanism	20
Complex Overt Responses	10
Adaptation	
Origination	

List of Experiments:

1. Study of Spectrum and Network analyzers
2. Design and Validation of a matching network.
3. Design, development and validation of a Low pass filter.
4. Design and Simulation of a coupler.
5. Design and Simulation of a linear amplifier.
   (Gain, RL,1dB compression, II^{nd} and III^{rd} order harmonics)
6. Harmonic balance simulation of a linear amplifier.
7. Measurement of mixer parameters.
8. RF parameter measurement of a WLAN board

Learning Resources

1. https://www.coursehero.com/file/32950114/ADS-cookbookpdf/
2. David M. Pozar," Microwave Engineering," John Wiley & Sons, Fourth Edition, 2015
3. Les Besser and Rowan Gilmore, "Practical RF circuit Design for Modern Wireless Systems- Passive circuits and Systems", Vol.1, Artech House Publishers, Boston, London 2008.
4. https://www.udemy.com/courses

Course Designers:

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3. Dr.A.Thenmozhi thenmozhi@tce.edu

18EC480	SIGNAL PROCESSING LABORATORY	Category	L	T	P	Credit
		PC	0	0	2	1

Preamble

This course is designed to complement the course 18EC340 Signals and Systems and 18EC440 Signal Processing. The purpose of this course is to give hands on training to the students in understanding the theory of signals and systems and practicing the algorithms used in digital signal processing. This will improve the understanding capability of the signal and system theory and simulation capability of the signal processing algorithms.

Prerequisite

18EC340 Signals and Systems

Course Outcomes

On the successful completion of the course students will be able to

CO#	Course Outcome Statement	Weightage in %
CO1	Analyze time and frequency domain response of discrete time LTI systems	10
CO2	Analyze the effects of sampling theorem through DFT and FFT	20
CO3	Analyze the filter concepts through pole zero placement and the effects of quantization error in the filter coefficients	20
CO4	Design FIR and IIR filter for the given specification and simulate the frequency response	10
CO5	Analyze the upsampling and downsampling process through simulation	10
CO6	Simulate a random sequence for the given distribution	10
CO7	Apply signal processing principle for removing noise in speech and image	20

CO Mapping with CDIO Curriculum Framework

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS3	Apply	Value	Mechanism	1.2.4, 2.1.1, 2.1.2, 2.2.2, 2.2.3, 2.4.2, 2.4.6, 2.5.1, 3.1.2, 3.2.3, 4.6.2
CO2	TPS3	Apply	Value	Mechanism	1.2.4, 2.1.1, 2.1.2, 2.2.2, 2.2.3, 2.4.2, 2.4.6, 2.5.1, 3.1.2, 3.2.3, 4.6.2
CO3	TPS3	Apply	Value	Mechanism	1.2.4, 2.1.1, 2.1.2, 2.2.2, 2.2.3, 2.4.2, 2.4.6, 2.5.1, 3.1.2, 3.2.3, 4.6.2
CO4	TPS3	Apply	Value	Mechanism	1.2.4, 2.1.1, 2.1.2, 2.2.2, 2.2.3, 2.4.2, 2.4.6, 2.5.1, 3.1.2, 3.2.3, 4.6.2
CO5	TPS3	Apply	Value	Mechanism	1.2.4, 2.1.1, 2.1.2, 2.2.2, 2.2.3, 2.4.2, 2.4.6, 2.5.1, 3.1.2, 3.2.3, 4.6.2
CO6	TPS3	Apply	Value	Mechanism	1.2.4, 2.1.1, 2.1.2, 2.2.2, 2.2.3, 2.4.2, 2.4.6, 2.5.1, 3.1.2, 3.2.3, 4.6.2
CO7	TPS3	Apply	Value	Mechanism	1.2.4, 2.1.1, 2.1.2, 2.2.2, 2.2.3, 2.4.2, 2.4.6, 2.5.1, 3.1.2, 3.2.3, 4.6.2

Mapping with Programme Outcomes and Programme Specific Outcomes

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	S	M	L	-	S	-	-	L	S	S	L	-	S	-	L
CO2	S	M	L	-	S	-	-	L	S	S	L	-	S	-	L
CO3	S	M	L	-	S	-	-	L	S	S	L	-	S	-	L
CO4	S	M	L	-	S	-	-	L	S	S	L	-	S	-	L
CO5	S	M	L	-	S	-	-	L	S	S	L	-	S	-	L
CO6	S	M	L	-	S	-	-	L	S	S	L	-	S	-	L
CO7	S	M	L	-	S	-	-	L	S	S	L	-	S	-	L

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

Cognitive Levels	Model Examination	End Semester Examination
Remember		
Understand		
Apply	70	70
Analyse		
Evaluate		
Create		

Assessment Pattern: Psychomotor

Psychomotor Skill	Practical Component
Perception	
Set	
Guided Response	
Mechanism	30
Complex Overt Responses	
Adaptation	
Origination	

List of Experiments/Activities with CO Mapping

1. Introduction to MATLAB
2. Time and Frequency response of Discrete Time LTI systems
3. Fourier Series Analysis and Synthesis
4. Sampling and DFT Spectral Analysis.
5. Z-transforms, Pole-Zero Diagrams, BIBO Stability
6. FIR Filter Design
7. IIR Filter Design
8. Multi rate signal processing
9. Random variable and Random process
10. Signal Processing Applications

Learning Resources

1. Buck, Daniel, Singer, “Computer Explorations in Signals and Systems Using MATLAB”, Prentice Hall, 2nd Ed., 2001.
2. Vinay K. Ingle, John G.Proakis, “Digital Signal Processing using MATLAB” Cengage Learning, Third Edition, 2012.

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18EC490	PROJECT MANAGEMENT	Category	L	T	P	Credit
		HSS	3	0	0	3

Preamble

Project management has been proven to be the most effective method of delivering products within cost, schedule, and resource constraints. It provides the skills to ensure that the projects are completed on time and on budget while giving the user the product, they expect. This course gives strong working knowledge of the basics of project management and be able to immediately use that knowledge to effectively manage work projects.

Prerequisite

Nil

Course Outcomes

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

COs	Course outcomes	Weightage (%)
CO1	Explain the importance of project management and methodologies	15%
CO2	Prepare a project proposal and apply methods for project planning and analysis	20%
CO3	Apply methods to examine the risk and social cost benefit while implementing a project	15%
CO4	Identify the critical path and time in scheduling a set of project-activities	20%
CO5	Explain resource allocation and levelling and the use of PM software	15%
CO6	Outline the importance and various activities during project closure and prepare a project report	15%

CO Mapping with CDIO Curriculum Framework

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS2	Understand	Respond	-	2.3.1, 2.5.2, 4.2.1,4.3.4
CO2	TPS3	Apply	Value	-	2.3.2, 2.4.3, 2.5.4, 3.2.3, 3.2.4,4.3.4
CO3	TPS3	Apply	Value	-	2.1.4, 2.4.4, 4.1.5,4.3.4
CO4	TPS3	Apply	Value	-	2.4.3, 2.4.4,4.3.4
CO5	TPS2	Understand	Respond	-	3.2.4,4.3.4
CO6	TPS3	Understand	Respond	-	2.1.5, 3.2.3, 3.2.4, 4.3.4

Mapping with Programme Outcomes

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	-	-	-	-	-	-	-	M	-	M	S	-	-	-	M
CO2	-	-	-	-	-	-	-	M	-	M	S	-	-	-	M
CO3	-	-	-	-	-	-	-	M	-	M	S	-	-	-	M
CO4	-	-	-	-	-	-	-	M	-	M	S	-	-	-	M
CO5	-	-	-	-	-	-	-	M	-	M	S	-	-	-	M
CO6	-	-	-	-	-	-	-	M	-	M	S	-	-	-	M

S- Strong; M-Medium; L-Low

Assessment Pattern*

Cognitive Levels	Continuous Assessment Tests		Assignments			Case study Presentation with Technical Report
	1	2	1	2	3	
Remember	10	10	-	-	-	0
Understand	60	40	-	-	-	20
Apply	30	50	100	100	100	80
Analyse	0	0				0
Evaluate	0	0				0
Create	0	0				0

*Revised in 62nd Academic Council Meeting dated 29.01.2022

Sample Questions for Course Outcome Assessment

Course Outcome 1 (CO1):

1. Identify the suitable project management methodology for an organization change in an Engineering college.
2. Explain the necessity of project management.
3. Explain in detail about any two project management methodologies with examples.

Course Outcome 2 (CO2):

1. Prepare a project proposal for the new technical function to be organized by you.
2. The sales of a certain product during a fourteen-year period have been as follows: Find the least squares regression line for the data given.

Period	Sales	Period	Sales
1	2000	8	4000
2	2200	9	3900
3	2100	10	4000
4	2300	11	4200
5	2500	12	4300
6	3200	13	4900
7	3600	14	5300

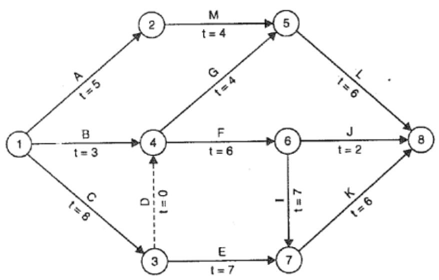
3. Consider a scenario that you are organizing an Electrical Association event on software contest. Do SWOT analysis for this assignment. Explain the outcome of the analysis.

Course Outcome 3 (CO3)

1. Prepare a work breakdown structure for a shifting a software company from one location to another and illustrate the need of WBS
2. Do the UNIDO-SCBA analysis for the new government road projects.
3. Demonstrate the risks associated in a electronics project implementation.

Course Outcome 4 (CO4)

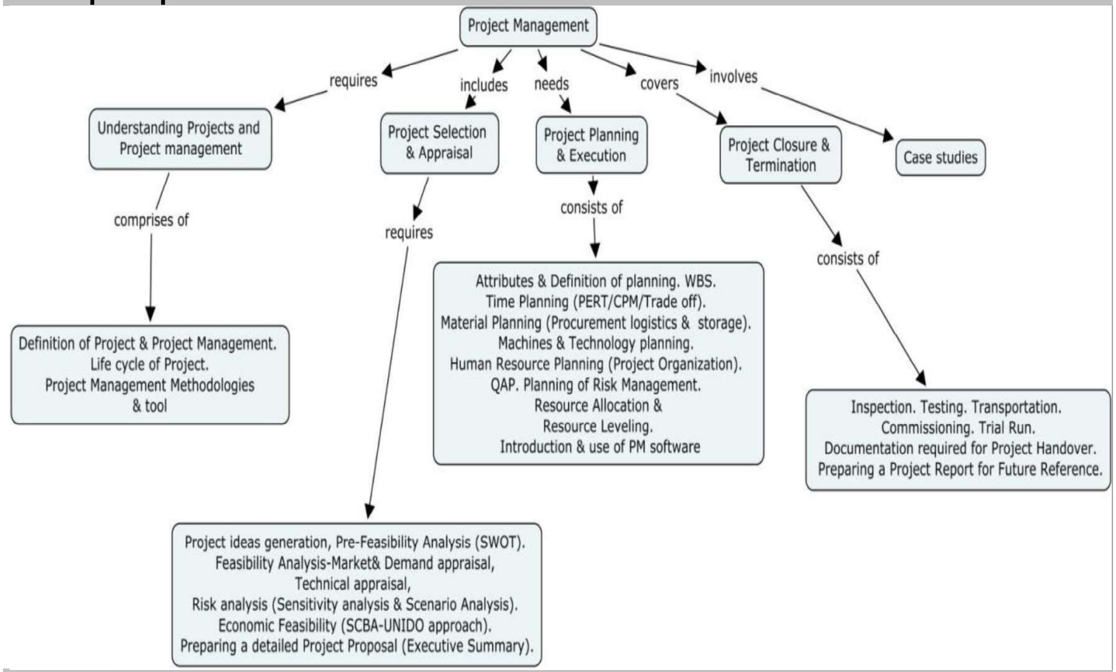
1. Create a customer database for the Modesto league baseball team. Draw a project network Complete the forward and backward pass, compute activity slack, and identify the critical path. How long will this project take? How sensitive is the network schedule? Calculate the free slack and total slack for all noncritical activities.
2. The network shows information related to a project that involves merging two marketing firms. Determine the Earliest start and finish time, Latest start time and completion time for each activity. List the critical activities and determine the project completion duration.



Course Outcome 5 (CO5)
1. Explain resource allocation in detail
2. Discuss various PM software that are being used widely.
3. Explain about the resource levelling

Course Outcome 6 (CO6)
1. Discuss the key elements to be included in project report.
2. Develop a project report for the given problem scenario.
3. List out the various activities to be considered in project closure.

Concept Map



Syllabus

Understanding Projects and Project management: Definition of Project & Project Management. Life cycle of Project. Project Management Methodologies and tools. **Project Selection & Appraisal:** Project ideas generation, Pre-Feasibility Analysis -SWOT Feasibility Analysis-Market& Demand appraisal, Technical appraisal, Risk analysis- Sensitivity analysis & Scenario Analysis. Economic Feasibility -SCBA-UNIDO approach. Preparing a detailed Project Proposal (Executive Summary). **Project Planning& Execution**: Attributes & Definition of planning. WBS. Time Planning - PERT/CPM/Trade off. Material Planning - Procurement logistics & storage. Machines & Technology planning. Human Resource Planning in Project Organization. Quality Assurance Plan. Planning of Risk Management. Resource Allocation & Resource Levelling. Introduction & use of PM software. **Project Closure & Termination:** Inspection. Testing. Transportation. Commissioning. Trial Run. Documentation required for Project Handover. Preparing a Project Report for Future Reference, Templates. **Case Studies**

Learning Resources

1. Prasanna Chandra, Projects: Planning, Analysis, Selection, Financing, Implementation and Review,Mc Graw Hill, 8th edition, 2015
2. Project planning and control using PERT and CPM, Dr.P.C.Punmia, Lakshmi publications, 2006
3. Project Management- A Managerial Approach to Planning, Scheduling, and Controlling Harold Kerzner, 10th edition John Wiley & Sons, Inc.
4. Project Management Institute (PMBOK) Guide, 5th Edition

Course Contents and Lecture Schedule

S.No.	Topic	No. of Lectures	COs
1	**Understanding Projects and Project management**:		
1.1	Definition of Project & Project Management.	1	CO1
1.2	Life cycle of Project.	1	CO1
1.3	Project Management Methodologies	2	CO1
1.4	Project Management tools	1	CO1
2	**Project Selection & Appraisal:**		
2.1	Project ideas generation, Pre-Feasibility Analysis -SWOT.	2	CO2
2.2	Feasibility Analysis-Market& Demand appraisal,	2	CO2
2.3	Technical appraisal	1	CO2
2.4	Risk analysis (Sensitivity analysis & Scenario Analysis).	2	CO3
2.5	Economic Feasibility (SCBA-UNIDO approach).	2	CO3
2.6	Preparing a detailed Project Proposal (Executive Summary).	1	CO2
3	**Project Planning& Execution**:		
3.1	Attributes & Definition of planning. WBS.	1	CO2
3.2	Time Planning (PERT).	3	CO4
3.3	CPM/Trade off	3	CO4
3.4	Material Planning (Procurement logistics & storage), Machines & Technology planning.	1	CO5
3.5	Human Resource Planning (Project Organization).	1	CO5
3.6	QAP	1	CO5
3.7	Planning of Risk Management.	1	CO3
3.8	Resource Allocation & Resource Leveling.	1	CO5
3.9	Introduction & use of PM software.	2	CO5
4	**Project Closure & Termination:**		
4.1	Inspection. Testing. Transportation.	1	CO6
4.2	Commissioning. Trial Run.	1	CO6
4.3	Documentation required for Project Handover.	1	CO6
4.4	Preparing a Project Report for Future Reference.	1	CO6
5	**Case Studies**	3	CO6
	Total	36	

Course Designers

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2. Dr.V.R.Venkatasubramani venthiru@tce.edu

18CHAB0	CONSTITUTION OF INDIA

Category	L	T	P	Credit
AC	2	0	0	0

Preamble

On the successful completion of the course, the students will be able to explain the basic features and fundamental principles of Constitution of India. The Constitution of India is the supreme law of India. Parliament of India cannot make any law which violates the Fundamental Rights enumerated under the Part III of the Constitution. The Parliament of India has been empowered to amend the Constitution under Article 368, however, it cannot use this power to change the "basic structure" of the constitution, which has been ruled and explained by the Supreme Court of India in its historical judgments. The Constitution of India reflects the idea of "Constitutionalism" – a modern and progressive concept historically developed by the thinkers of "liberalism" – an ideology which has been recognized as one of the most popular political ideology and result of historical struggles against arbitrary use of sovereign power by state. The historic revolutions in France, England, America and particularly European Renaissance and Reformation movement have resulted into progressive legal reforms in the form of "constitutionalism" in many countries. The Constitution of India was made by borrowing models and principles from many countries including United Kingdom and America.

The Constitution of India is not only a legal document but it also reflects social, political and economic perspectives of the Indian Society. It reflects India's legacy of "diversity". It has been said that Indian constitution reflects ideals of its freedom movement; however, few critics have argued that it does not truly incorporate our own AICTE Model Curriculum for Mandatory Courses & Activities (Non-Credit) for Undergraduate Degree in Engineering & Technology ancient legal heritage and cultural values. No law can be "static" and therefore the Constitution of India has also been amended more than one hundred times. These amendments reflect political, social and economic developments since the year 1950. The Indian judiciary and particularly the Supreme Court of India has played an historic role as the guardian of people. It has been protecting not only basic ideals of the Constitution but also strengthened the same through progressive interpretations of the text of the Constitution. The judicial activism of the Supreme Court of India and its historic contributions has been recognized throughout the world and it gradually made it "as one of the strongest court in the world"

Course Outcome:

On the successful completion of the course students will be able to

CO1	Explain the meaning of the constitution law and constitutionalism and Historical perspective of the Constitution of India	Understand
CO2	Explain the salient features and characteristics of the Constitution of India, scheme of the fundamental rights and the scheme of the Fundamental Duties and its legal status	Understand
CO3	Explain the Directive Principles of State Policy, Federal structure and distribution of legislative and financial powers between the Union and the States, and Parliamentary Form of Government in India	Understand
CO4	Explain the amendment of the Constitutional Powers and Procedure, the historical perspectives of the constitutional amendments in India, and Emergency Provisions.	Understand
CO5	Explain the Local Self Government – Constitutional Scheme in India, Scheme of the Fundamental Right to Equality,	Understand
CO6	Explain the scheme of the Fundamental Right to certain Freedom under Article 19, and Scope of the Right to Life and Personal Liberty under Article 21	Understand

Mapping with Programme Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	M	L	-	-	-	M	-	M	-	L	-	-
CO2	M	L	-	-	-	M	-	M	-	L	-	-
CO3	M	L	-	-	-	M	-	M	-	L	-	-
CO4	M	L	-	-	-	M	-	M	-	L	-	-
CO5	M	L	-	-	-	M	-	M	-	L	-	-
CO6	M	L	-	-	-	M	-	M	-	L	-	-

S- Strong; M-Medium; L-Low

Syllabus

1. Meaning of the constitution law and constitutionalism
2. Historical perspective of the Constitution of India
3. Salient features and characteristics of the Constitution of India
4. Scheme of the fundamental rights
5. The scheme of the Fundamental Duties and its legal status
6. The Directive Principles of State Policy – Its importance and implementation
7. Federal structure and distribution of legislative and financial powers between the Union and the States
8. Parliamentary Form of Government in India – The constitution powers and status of the President of India
9. Amendment of the Constitutional Powers and Procedure
10. The historical perspectives of the constitutional amendments in India
11. Emergency Provisions : National Emergency, President Rule, Financial Emergency
12. Local Self Government – Constitutional Scheme in India
13. Scheme of the Fundamental Right to Equality
14. Scheme of the Fundamental Right to certain Freedom under Article 19
15. Scope of the Right to Life and Personal Liberty under Article 21

Assessment Pattern

Bloom's category	**Continuous Assessment Tests**		**Seminar**
	1	**2**	**-**
Remember	40	40	0
Understand	60	60	100
Apply	0	0	0
Analyze	0	0	0
Evaluate	0	0	0
Create	0	0	0

References

1. Durga Das Basu, 'Introduction to The Constitution of India', LexisNexis Butterworths Wadhwa, 20th Edition, Reprint 2011.
2. Constitution of India, National Portal of India, Web link: https://www.india.gov.in/my-government/constitution-india

Course Designers:

1. Adapted from AICTE Model Curriculum for Undergraduate Degree Courses in Engineering & Technology, Volume-II, January 2018.

CURRICULUM AND SYLLABI

FOR

B.E. DEGREE (ELECTRONICS AND COMMUNICATION ENGINEERING) PROGRAMME

FIFTH SEMESTER

FOR THE STUDENTS ADMITTED FROM THE

ACADEMIC YEAR 2018-2019 ONWARDS

THIAGARAJAR COLLEGE OF ENGINEERING

(A Govt Aided Autonomous Institution Affiliated to Anna University)

MADURAI – 625 015, TAMILNADU

18EC510	DATA COMMUNICATION NETWORKS

Category	L	T	P	Credit
PC	2	1	0	3

Preamble

The goal of this course is to introduce the students to state-of-the-art network protocols and architectures. This course includes networking technologies such as Ethernet, Wireless local area network, and wireless personal area network, multiple access technologies, unicast and multicast routing algorithms, subnetting of internetworking, and error/congestion/flow control techniques. This course also covers the QoS Provisioning and network security.

Prerequisite

NIL

Course Outcomes

On the successful completion of the course students will be able to

COs	Course Outcome Statement	Weightage*** in %
CO1	Build a reliable Data networks using LAN technologies such as ETHERNET, WLAN and WPAN	20
CO2	Apply the unicast and multicast routing algorithms for autonomous Networks	25
CO3	Analyze the concepts of reliable data transfer and congestion control of TCP	15
CO4	Analyze the performance parameters such as delay, throughput of a network.	15
CO5	Understand the client/server model and key application layer protocols	10
CO6	Apply cryptographic algorithms and security mechanisms for secured networks	15

*** Weightage depends on Bloom's Level, number of contact hours,

CO Mapping with CDIO Curriculum Framework

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS3	Apply	Value	Mechanism	1.2, 2.1.1, 2.1.2, 2.4.2, 2.4.6, 2.5.1, 3.1.1, 3.2.3, 4.5.5, 4.6.2
CO2	TPS3	Apply	Value	Mechanism	1.2, 2.1.1, 2.1.2, 2.5.1, 3.1.1, 3.2.3, 4.5.5, 4.6.2
CO3	TPS3	Understand	Value	Mechanism	1.2, 2.1.1, 2.1.2, 2.5.1, 3.1.1, 3.2.3, 4.5.5, 4.6.2
CO4	TPS4	Analyse	Organise	Complex Overt Responses	1.2, 2.1.1, 2.1.2, 2.1.3, 2.5.1
CO5	TPS4	Analyse	Organise	Complex Overt Responses	1.2, 2.1.1, 2.1.2, 2.1.3, 2.5.1
CO6	TPS3	Understand	Value	Mechanism	1.2, 2.1.1, 2.1.2, 2.5.1

Mapping with Programme Outcomes and Programme Specific Outcomes

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	S	M	L	-	L	-	-	L	L	L	-	L	M	-	L
CO2	S	M	L	-	L	-	-	L	L	L	-	L	M	-	L
CO3	S	M	L	-	L	-	-	L	L	L	-	L	M	-	L
CO4	S	S	M	L	L	-	-	L	L	L	-	L	S	-	L

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO5	S	S	M	L	L	-	-	L	L	L	-	L	S	-	L
CO6	S	M	L	-	L	-	-	L	L	L	-	L	M	-	L

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

Cognitive Levels	Continuous Assessment Tests			Assignment			End Semester Examination
	1	2	3	1	2	3	
Remember	0	0	0	0	0	0	0
Understand	50	40	30	0	0	0	30
Apply	50	40	40	100	100	100	40
Analyse	0	20	30	0	0	0	30
Evaluate	0	0	0	0	0	0	0
Create	0	0	0	0	0	0	0

Assessment Pattern: Psychomotor

Psychomotor Skill	Assignment-1	Assignment-2	Assignment-3
Perception	-	-	-
Set	-	-	-
Guided Response	-	-	-
Mechanism	-	-	-
Complex Overt Responses	-	-	-
Adaptation	-	-	-
Origination	-	-	-

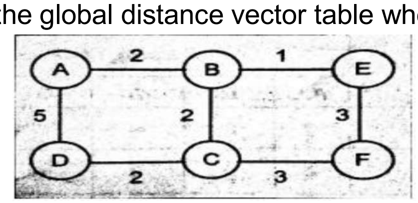
Sample Questions for Course Outcome Assessment**

Course Outcome 1 (CO1):

1. Outline the features of IEEE 802.3 protocol?
2. Justify why do you require a limit on the minimum size of Ethernet frame?
3. Write about the Bluetooth Technology and list out the applications and limitations.

Course Outcome 2 (CO2):

1. Outline the need of DVMRP?
2. Outline shortest path algorithm. Explain with suitable diagrams and examples?
3. For the given network, find the global distance vector table when.



i) Each node knows only the distances to its immediate neighbours.
ii) Each node has reported information it had in the preceding step (i) to its immediate neighbours.
iii) Step (ii) is repeated.

Course Outcome 3 (CO3):

1. How is congestion controlled? Deduct various congestion control techniques.
2. Find the 4-bit CRC code for the data bit sequence 10011011100 using the polynomial x 4+x2+1.
3. Draw a timeline diagram for the sliding window algorithm with SWS = RWS = 3 frames, For the following two situations, use a timeout interval of about 2 X RTT (a) Frame 4 is lost and (b) Frames 4-6 are lost.

Course Outcome 4 (CO4):

1. For 1 MB file over a 1Gbps network with RTT 100ms, find out the Transfer time and Throughput of the link.

2. Consider a point–to-point link 50km in length. At what bandwidth would the propagation delay equal transmit delay for 100byte packets? Calculate bandwidth for 512byte packet.
3. Suppose a 128 Kbps pt. to pt. link is set up between earth and rover on mars. The distance from earth to mars is approximately 55 Gm and data travels over the link at the speed of light.
    - Calculate minimum RTT for link
    - Calculate the delay bandwidth product for the link

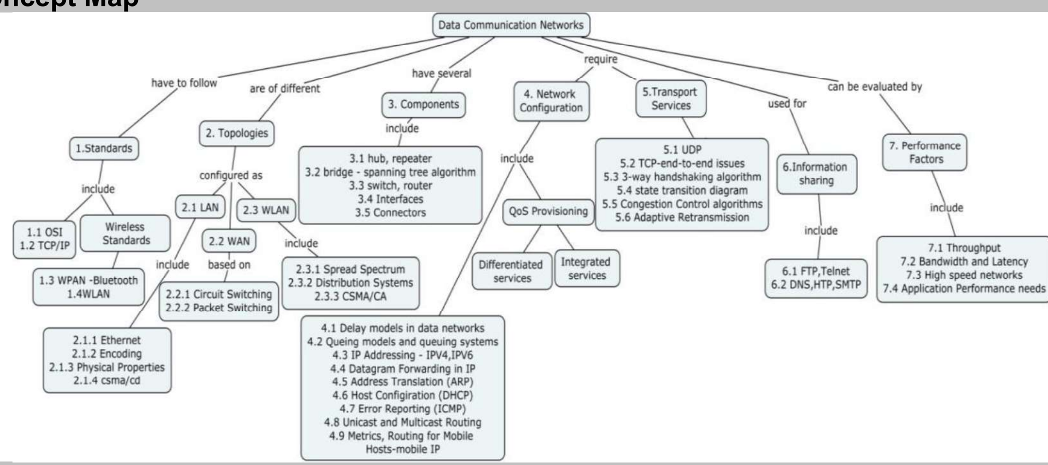
Course Outcome 5 (CO5):

1. Illustrate the various steps involved in the use of non-persistent connection of HTTP.
2. Assess the importance of Push and Pull Protocols.
3. Illustrate the sequence of events and the respective protocols involved while accessing a web page from a machine when it is connected with internet for first time.

Course Outcome 6 (CO6):

1. Design the key generation process of DES?
2. Estimate the encryption and decryption values for the RSA algorithm parameters. P=7, Q=11, E=17, M=8?
3. Evaluate the design goals of firewalls

Concept Map



Syllabus

FUNDAMENTALS & LINK LAYER: Building a network – Requirements - Layering and protocols - Internet Architecture – Network software – Performance ; Link layer Services - Framing - Error Detection and AR, Flow control – Stop and wait and sliding window protocol. **MEDIA ACCESS & INTER NETWORKING:** Media access control - Ethernet - CSMA/CD-802.3 Physical Properties, Encoding - Wireless LANs – CSMA/CA-802.11, Spread Spectrum techniques and Distribution systems, WPAN – Bluetooth, Zigbee, Internetworking - IP, subnetting CIDR, ARP, DHCP,ICMP. **ROUTING:** Routing - RIP, OSPF, metrics – Switch basics – Global Internet - BGP, IPv6, Multicast – addresses – multicast routing - DVMRP,PIM. IPv6, Mobile IP. **TRANSPORT LAYER:** Overview of Transport layer - UDP - Reliable byte stream (TCP) - Connection management - Flow control - Retransmission – TCP Congestion control - Congestion avoidance - DECbit, RED **NETWORK PERFORMANCE–** Throughput, Bandwidth and Latency, High speed networks, Application performance needs. **APPLICATION LAYER:** Traditional applications-Electronic Mail - SMTP, POP3, IMAP, MIME – HTTP – Web Services – DNS – SNMP. **NETWORK SECURITY:** Cryptography – DES and RSA, Secured Communication – Security services, VPN, Firewall

Learning Resources

1. Larry L. Peterson, Bruce S. Davie, “Computer Networks: A Systems Approach”, Fifth Edition, Morgan Kaufmann Publishers, 2011.
2. James F. Kurose, Keith W. Ross, “Computer Networking – A Top-Down Approach Featuring the Internet”, Fifth Edition, Pearson Education, 2009.
3. Nader. F. Mir, “Computer and Communication Networks”, Prentice Hall Publishers, 2010.

4. Ying-Dar Lin, Ren-Hung Hwang, Fred Baker, “Computer Networks: An Open Source Approach”,Mc Graw Hill Publisher, 2011.
5. Behrouz A. Forouzan, “Data communication and Networking”, Fourth Edition, Tata McGraw – Hill,2011.
6. Web Page http://www.cse.iitd.ernet.in/~vinay/courses/CSL858.html
7. Web Page mythili@cse.iitb.ac.in
8. https://onlinecourses.nptel.ac.in/noc18_cs38/preview
9. https://nptel.ac.in/courses/106105183/

Course Contents and Lecture Schedule

No.	Topic	No. of Hours	COs
1	**FUNDAMENTALS & LINK LAYER**		
1.1	Building a network – Requirements	1	CO1
1.2	Layering and protocols - Internet Architecture	1	CO1
1.3	Network software – Performance	2	CO1
1.4	Link layer Services - Framing	1	CO1
1.5	Error Detection	2	CO1
1.6	Flow control	2	CO1
1.7	Media access control - Ethernet (802.3)	2	CO2
1.8	Wireless LANs – 802.11	1	CO2
1.9	Bluetooth, Zigbee	1	CO2
2	**INTER NETWORKING & ROUTING**		
2.1	Switching and bridging components	1	CO2
2.2	Basic Internetworking-IP, subnetting	2	CO2
2.3	CIDR, ARP, DHCP,ICMP	2	CO2
2.4	Routing (RIP, OSPF, metrics)	2	CO3
2.5	Switch basics – Global Internet (Areas, BGP, IPv6)	2	CO3
2.6	Multicast – addresses – multicast routing (DVMRP, PIM)	2	CO3
2.7	IPv6, Mobile IP	2	CO3
3	**TRANSPORT LAYER**		
3.1	Overview of Transport layer - UDP	1	CO4
3.2	Reliable byte stream (TCP)	1	CO4
3.3	Connection management - Flow control, Retransmission	1	CO4
3.4	TCP Congestion control - Congestion avoidance (DECbit, RED)	2	CO4
4	**NETWORK PERFORMANCE**		
4.1	Throughput, Bandwidth and Latency	2	CO5
4.2	High speed networks, Application performance needs	3	CO5
5.	**APPLICATION LAYER**		
5.1	Traditional applications-Electronic Mail(SMTP, POP3,IMAP, MIME)	2	CO6
5.2	HTTP,HTTPS – Web Services	1	CO6
5.3	DNS – SNMP	2	CO6
6	**NETWORK SECURITY**		
6.1	Cryptography – DES and RSA	2	CO6
6.2	Secured Communication – Security services, VPN	1	C06
6.3	Firewall	1	C06
	Total Hours	36	

Course Designers:

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2. Dr.M.S. K. Manikandan manimsk@tce.edu
3. Dr. E. Murugavalli murugavalli@tce.edu

18EC520	ANTENNAS AND WAVE PROPAGATION	Category	L	T	P	Credit
		PC	2	0	2	3

Preamble

One of the main competencies that a present day RF engineer has to acquire is the capability to design antennas for wireless applications such as cellular and navigational applications. Antennas are important component in making wireless communication a reality. This course is essential to review EM theory and understand the fundamental principles of Antenna theory, and wave propagation with a lucid explanation of the basic concepts and equations. This course explains how antenna converts the electric and magnetic energy in to a propagating wave and vice versa. This course also explains the various types of transmitting and receiving antennas including arrays which are used for conventional broadcasting and antennas such as helix, spiral antennas used for wireless applications. The course also focus on simple design procedures and practical approach to simulate, prototype for a given wireless specification and measure the parameters of antenna for popular applications.

Prerequisite

18EC320: RF Passive Devices and Circuits, 18EC420: RF Active Circuits

Course Outcomes

On the successful completion of the course students will be able to

CO#	Course Outcome Statement	Weightage*** in %
CO1	Understand the role of antenna in real world applications and study the antenna parameters.	15
CO2	Understand the concepts of wire, loop, aperture antennas and arrays and the radiation pattern of various antenna.	20
CO3	Design, develop and validate Microstrip antenna for cellular base station applications	15
CO4	Design, develop and validate PIFA for cellular handset applications	15
CO5	To understand the role of polarization in navigation and design, develop and validate circularly polarized antenna for GPS applications	15
CO6	Explain the role of atmospheric layers in radio wave propagation	10
CO7	Apply Friss equation in link budget analysis	10

*** Weightage depends on Bloom's Level, number of contact hours

CO Mapping with CDIO Curriculum Framework

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS2	Understand	Respond	Guided Response	1.2, 2.1.1
CO2	TPS2	Understand	Respond	Guided Response	1.2, 2.1.1,
CO3	TPS3	Apply	Value	Mechanism	1.2, 2.1.1, 2.1.5, 3.1, 4.4.1, 4.5.1-4.5.4
CO4	TPS3	Apply	Value	Mechanism	1.2, 2.1.1, 2.1.5, 3.1, 4.4.1, 4.5.1-4.5.4
CO5	TPS3	Apply	Value	Mechanism	1.2, 2.1.1, 2.4.2, 3.1, 4.5.1-4.5.4
CO6	TPS2	Understand	Respond	Guided Response	1.2, 2.1.1,
CO7	TPS3	Apply	Value	Mechanism	1.2, 2.1.1, 2.1.5, 2.4.2, 3.1., 4.4.1, 4.5.1-4.5.4

Mapping with Programme Outcomes and Programme Specific Outcomes

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	S	L	L	-	-	-	-	-	M	-	-	M	S	-	M
CO2	S	M	L	-	-	-	-	-	M	-	-	M	S	-	M
C03	S	M	M	L	S	M	M	L	M	M	M	M	S	M	M
CO4	S	M	M	L	S	M	M	L	M	M	M	M	S	M	M
CO5	S	M	M	L	S	L	L	L	M	M	M	M	S	M	M
CO6	S	L	L	-	-	L	L	L	M	-	-	M	S	M	M
CO7	S	L	M	-	L	L	L	L	M	M	M	M	S	L	M

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

Cognitive Levels	Continuous Assessment Tests			End Semester Examination
	1	2	3	
Remember	40	20	20	10
Understand	40	40	20	30
Apply	20	40	60	60
Analyse	0	0	0	0
Evaluate	0	0	0	0
Create	0	0	0	0

Assessment Pattern: Psychomotor

Psychomotor Skill	Practical
Perception	-
Set	-
Guided Response	-
Mechanism	80
Complex Overt Responses	20
Adaptation	-
Origination	-

Course Level Assessment Questions:

Course Outcome (CO1)

1. Define beam width
2. What Is Meant By Effective Height?
3. Why high-gain antennas are normally used for EME (moon bounce) communications?

Course Outcome (CO2)

1. Why loop antennas are called as magnetic dipole?
2. List The Applications Of Helical Antenna?
3. What Is The Condition On Phase For The End Fire Array With Increased Directivity?

Course Outcome (CO3)

1. What kind of "radiation" is used by mobile phones and base stations?
2. Suggest and design suitable planar antenna system for the given specification:
   - Center Frequency - 800MHz
   - Dielectric constant – 3.38
   - Thickness - 1.52mm
   - VSWR - 2:1
3. Is it safe to be close to base station antennas?

Course Outcome (CO4)

1. What are the constraints in designing antenna for mobile handset?
2. What are the exposure levels from mobile phones?
3. Design a planar inverted F antenna operating in Cellular GSM lower band.

Course Outcome (CO5):

1. What is the need for circular polarization in GPS navigation?
2. What is the reason for sending two transmissions in the same band?
3. Design a circularly polarized antenna to operate at 1.575GHz.

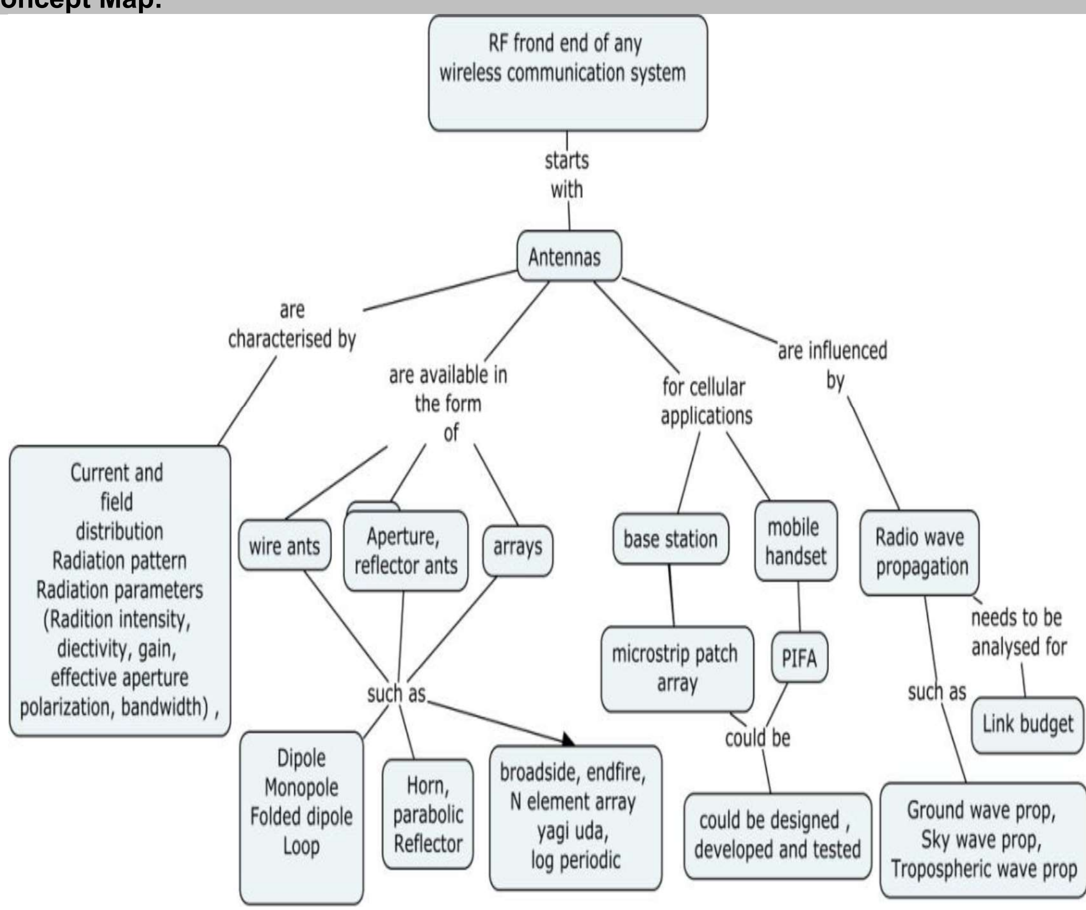
Course Outcome (CO6):

1. What are the atmospheric factors that affect the propagation of radio waves?
2. How does the earth affect ground wave and space wave propagation?
3. How are VHF signals propagated within the range of the visible horizon?

Course Outcome (CO7):

1. The output power of a 900MHz mobile phone base station transmitter is 100w. It is connected to an antenna having a gain of 15.Calculate the power delivered to the receiver kept at a distance of 25km. Gain of the receiver antenna is 20.
2. In a microwave link, two identical antennas operating at 10GHz are used with power gain of 40db, If the transmitted power is 1KW, find the received power for the range of link of 30km.
3. Consider a mobile radio system at 900-MHz carrier frequency, and with 25-kHz bandwidth. It is affected only by thermal noise (temperature of the environment E = 300F). Antenna gains at the TX and RX sides are 8 dB and -2 dB, respectively. Losses in cables, combiners, etc. at the TX are 2 dB. The noise figure of the RX is 7 dB. The 3-dB bandwidth of the signal is 25 kHz. The required operating SNR is 18 dB and the desired range of coverage is 2 km. The breakpoint is at 10-m distance; beyond that point, the path loss exponent is 3.8. The fading margin is 10 dB. What is the minimum TX Power?

Concept Map:



Syllabus:

Theory:

Fundamentals of Antennas: Review of the fundamentals of Electromagnetics and RF system, Antenna definition, Antenna in real world applications: Cellular phone, Case study (Base station and handset) principle of radiation, Radiation from current element , Thin wire antenna, dipole, Parameters- Return loss, Radiation pattern, Beamwidth, side lobes, Power Density, intensity, beam width, Directivity, Efficiency, Gain, bandwidth, polarization- Effective aperture, field regions, Types of antennas

Thin Wire , Loop and aperture antennas: Infinitesimal dipole-small dipole, finite length dipole, Half wavelength dipole, working principles of Wire antennas: Folded dipole, loop antenna, Arrays: Two element array- Broadside and Endfire, N element array, Pattern multiplication, planar arrays, Yagi -Uda and Log periodic array Aperture antennas: Horn and parabolic reflectors.

Antennas for Cellular applications: Specifications, design of Microstrip patch antenna (MPA), Cellular base station- design, feeding techniques, patch array.. Cellular handset**:** Planar Inverted F antenna (PIFA), design and reception of signals using Spectrum analyser

Antennas for Navigational applications: GPS Spec**,** Role of circular polarization in navigation, Principle of circular polarization, circularly polarized antennas, working principle of spiral, helix, design techniques for circular polarization MPA, tunning.

Wave propagation: Fundamentals of EM wave propagation, wave propagation in different environment (Ground wave, sky wave and tropospheric wave propagation, (indoor, and urban), parameters, Friss equation, Link budget analysis, Cellular link calculations.

Practical:

1. Design and characterization of wire antennas: monopole, dipole and FM reception
2. Radiation pattern measurement of Yagi-Uda Antenna and TV signal reception
3. Design and simulation Patch antenna for cellular Base station
4. Prototype and testing of antenna for cellular station application
5. Development of PIFA for cellular application
6. Simulation and prototyping of antenna for cellular handset
7. Design and simulation antenna for GPS application
8. Range measurement of PIFA using Link Budget measurement
9. Internal assessment test-EMF survey in college campus

Learning Resources:

1. C. A. Balanis, "Antenna Theory and Design", 3rd Ed., John Wiley & Sons., 2005.
2 John D.Kraus, ”Antennas for all Applications”, Tata McGraw Hill ,2002
3 W. L. Stutzman, and G. A. Thiele, "Antenna Theory and Design", 2nd Ed., John Wiley & Sons., 1998.
4 C. A. Balanis, "Antenna Theory and Design", 4th Ed., John Wiley & Sons., 2016.
5 F.E.Terman, “Electronic and Radio Engineering”, Mc Graw Hill, 1985.
6 A.R. Harish and M.Sachidananda, “Antenna and wave propagation”, Oxford University Press., 2007
7 NPTEL Course Antenna and wave propagation: https://nptel.ac.in/courses/108101092/
8 WWW.amanogawa.con
9 www, orbanmicrowave.com
10 Course handouts prepared by RF Special interest Group, TCE

Course Contents and Lecture Schedule

Module No	Topics	No. of Lectures	COs
1.	**Fundamentals of Antennas:** Introduction to PO, CO of the course, overview of the course Review of the fundamentals of Electromagnetics and RF system, ,	1	CO1
2.	Antenna definition, Antenna in real world applications: Cellular phone, Case study (Base station and handset), principle of radiation, Radiation from current element , Thin wire antenna, dipole	1	CO1
3.	,Parameters- Return loss, Radiation pattern, Beamwidth, side lobes,	1	CO1
4.	Power Density, intensity, beam width, Directivity, Efficiency, Gain, bandwidth,	1	CO1
5.	polarization-Effective aperture, field regions, Types of antennas	1	CO1
	Assignment 1		
6.	**Thin Wire, Loop and aperture antennas**: Infinitesimal dipole-small dipole, finite length dipole, Half wavelength dipole,	2	CO2
7.	working principles of Wire antennas: Folded dipole, loop antenna	1	CO2
8.	Arrays: Two element array- Broadside and Endfire, N element array, Pattern multiplication, planar arrays	1	CO2
9.	Yagi -Uda and Log periodic array Aperture antennas: Horn and parabolic reflectors.	1	CO2
10.	**Antennas for Cellular applications:** Specifications, design of Microstrip patch antenna (MPA), Cellular base station- design, feeding techniques, patch array..	2	CO3
11.	Cellular handset**:** Planar Inverted F antenna (PIFA), design and reception of signals using Spectrum analyser	2	CO3
12.	**Antennas for Navigational applications:** GPS Spec**,** Role of circular polarization in navigation, Principle of circular polarization, antennas types	2	CO4
13.	Working principle of spiral, helix, design techniques for circular polarization MPA, tunning.	2	CO4
	Assignment 2		
14.	**Wave propagation**: Fundamentals of EM wave propagation, wave propagation in different environment (Ground wave, ,	2	CO6
15.	sky wave and tropospheric wave propagation, (indoor, and urban), parameters	2	CO6
16.	Friss equation, Link budget analysis, Cellular link calculations.	2	CO6
	Assignment 3		
	Total	**24**	

Course Designers:

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18EC530	ANALOG AND DIGITAL COMMUNICATION SYSTEMS	Category	L	T	P	Credit
		PC	2	1	0	3

Preamble

The course “18EC520: Analog and Digital Communication Systems” is offered in the fifth semester and is the first course on communication systems. This course aims at designing Analog and Digital communication systems that are used for the transmission of information from source to destination. A detailed quantitative framework for analog and digital transmission techniques is addressed.

Prerequisite

14EC340 Signals and Systems, 14EC440 Signal Processing

Course Outcomes

On the successful completion of the course students will be able to

CO#	Course Outcome Statement	Weightage in %
CO1	Characterize the different analog modulation schemes in time and frequency domains.	10
CO2	Analyze the performance of analog modulation schemes in the presence of additive white Gaussian noise.	10
CO3	Describe the principle of pulse modulation techniques namely PAM, PPM PCM, DPCM and DM	10
CO4	Determine the minimum number of bits per symbol required to represent the source and the maximum rate at which reliable communication can take place over the channel	20
CO5	Detect and correct the errors introduced in the channel using error control coding schemes.	15
CO6	Design the baseband pulse for ISI free transmission over finite bandwidth channels	10
CO7	Apply estimation and detection theory for the development of digital communication transmitters and receivers for various digital modulation schemes and analyze their BER performances	25

CO Mapping with CDIO Curriculum Framework

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS3	Apply	Value	Mechanism	1.2, 2.1.1, 2.1.2, 2.4.2, 2.4.5, 2.4.6, 3.1.1, 3.2.3, 4.5.5, 4.6.2
CO2	TPS4	Analyze	Organise	Complex Overt Responses	1.2, 2.1.1, 2.1.2, 2.4.2, 2.4.5, 3.1.1, 3.2.3, 4.5.3, 4.5.5, 4.6.2
CO3	TPS3	Apply	Value	Mechanism	1.2, 2.1.1, 2.1.2, 2.4.2, 2.4.5, 2.5.1, 3.2.3
CO4	TPS3	Apply	Value	Mechanism	1.2, 2.1.1, 2.1.2, 2.1.4, 2.4.2, 2.4.5, 4.4.1,4.4.3
CO5	TPS3	Apply	Value	Mechanism	1.2, 2.1.1, 2.1.2, 2.1.4, 2.4.2, 2.4.5, 4.4.1, 4.4.3
CO6	TPS3	Apply	Value	Mechanism	1.2, 2.1.1, 2.1.2, 2.14, 2.1.5, 2.4.2, 2.4.5, 4.4.3
CO7	TPS4	Analyze	Organise	Complex Overt Responses	1.2, 2.1.1, 2.1.2, 2.1.4, 2.1.5, 2.4.2, 2.4.5, 2.5.1, 3.2.5, 4.4.3, 4.5.3, 4.5.5, 4.6.2

Mapping with Programme Outcomes and Programme Specific Outcomes

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1.	S	M	L	-	-	-	-	-	L	L	-	L	S	L	L
CO2.	S	S	M	L	-	-	-	-	L	L	-	L	S	L	L
CO3.	M	L	-	-	-	-	-	-	L	L	-	L	S	M	L
CO4	S	M	L	-	-	-	-	-	L	L	-	L	S	L	L
CO5	S	M	L	-	-	-	-	-	L	L	-	L	S	M	L
CO6	S	M	L	-	-	-	-	-	L	L	-	L	S	M	L
CO7	S	S	M	L	-	-	-	-	L	L	-	L	S	M	L

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

Cognitive Levels	Continuous Assessment Tests			Assignment			End Semester Examination
	1	2	3	1	2	3	
Remember	10	10	10	0	0	0	10
Understand	10	10	20	0	0	0	10
Apply	80	60	60	100	70	50	60
Analyse	0	20	20	0	0	20	20
Evaluate	0	0	0	0	0	0	0
Create	0	0	0	0	0	0	0

Assessment Pattern: Psychomotor

Psychomotor Skill	Assignment-1	Assignment-2	Assignment-3
Perception	-	-	-
Set	-	-	-
Guided Response	-	-	-
Mechanism	-	30	30
Complex Overt Responses	-	-	-
Adaptation	-	-	-
Origination	-	-	-

Sample Questions for Course Outcome Assessment

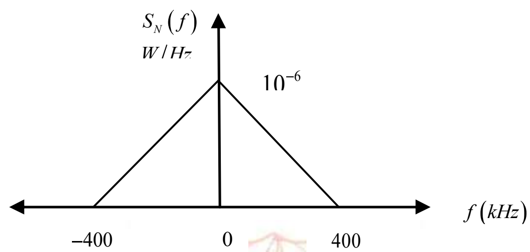
Course Outcome 1 (CO1):

1. Using the message signal $m(t) = 1/(1+t^2)$, determine the modulated waves for the following methods of modulation,
   a. Amplitude modulation with 50 percent modulation
   b. Double sideband – suppressed carrier modulation
   c. Single side band modulation with only the upper side band transmitted.
   d. Single side band modulation with only the lower side band transmitted.
2. The single tone modulating signal, $m(t) = A_m.\cos(2\pi f_m t)$ is used to generate the VSB
   a. signal
   $s(t) = (1/2).a.A_m.A_c.\cos[2\pi(f_c + f_m)t] + (1/2).A_m.A_c(1-a).\cos[2\pi(f_c - f_m)t]$
   b. where, ‘a’ is a constant, less than unity, representing the attenuation of the upper side frequency.
   c. Find the Quadrature component of the VSB signal s(t).
   d. The VSB signal, plus the carrier $A_c.\cos(2\pi f_c t)$, is passed through an envelope detector. Determine the distortion produced by the Quadrature component.
   e. What is the value of constant, ‘a’ for which this distortion reaches its worst possible condition?.

3. An angle modulated signal with carrier frequency, $\omega_c = 2\pi * 10^5$ is described by $\phi_{EM}(t) = 10.\cos\left(\omega_c t + 5.\sin 3000t + 10.\sin 2000\pi t\right)$. Find the power of the modulated signal, frequency deviation, Δf, deviation ratio, β and phase distortion, $\Delta\phi$

Course Outcome 2 (CO2):

1. Why is De-Emphasis used in FM?
2. A DSB – SC modulated signal is transmitted over a noisy channel, with the power spectral density of the noise being as shown in the figure. The message bandwidth is 4 kHz and the carrier frequency is $200\,kHz$. Assuming that the average power of the modulated wave is 10 watts, determine the output signal – to – noise ratio of the receiver.



3. Determine the improvement in post detection signal to noise ration in FM receiver with pre –emphasis and de-emphasis circuits in dB.

Course Outcome 3 (CO3):

1. The speech signal is transmitted over a PCM channel with 8-bit accuracy. Assume the speech is base band limited to 3.6 KHz. Determine the bit rate.
2. A sinusoidal signal $x(t) = a_o \cos(2\pi f_o t)$ is applied to a delta modulator that operates with a sampling period, T_s and step size, $\Delta = 2\delta$.
   (a) Find the expression for amplitude, a_0 to avoid slope overload distortion.
   (b) Compute the maximum permissible value of the output signal power.
   (c) Compute the variation of Quantization noise in delta modulation.
   (d) Find the maximum value of output signal to noise ratio.
3. A PCM System uses a uniform quantizer followed by a 8 bit binary encoder. The bit rate of the system is 64 Mbps. What is the maximum message bandwidth for which the system operates satisfactorily?

Course Outcome 4 (CO4):

1. Consider a discrete memoryless source with source alphabet , S = {s_o, s_1, s_2} and source statistics {0.7,0.15,0.15}. Calculate the entropy of the source. Calculate the entropy of the second – order extension of the source.
2. Define average mutual information and average self information.
3. Why the theory of information is relevant for understanding the principles of digital communication systems?

Course Outcome 5 (CO5):

1. The parity check bits of a (7,3) linear block code are generated by $c_4 = d_1 + d_2, c_5 = d_2 + d_3, c_6 = d_1 + d_2 + d_3, c_7 = d_1 + d_3$, where d_1, d_2, and d_3 are the message digits.
   a. Find the Generator Matrix and Parity Check Matrix for this code
   b. Find the minimum weight of this code.
2. Find the error correcting capabilities of this code.A systematic (6,3) linear block code has the generator matrix $\begin{bmatrix} 1 & 0 & 0 & 1 & 1 & 0 \\ 0 & 1 & 0 & 0 & 1 & 1 \\ 0 & 0 & 1 & 1 & 0 & 1 \end{bmatrix}$. Construct the Standard array and determine the correctable error patterns and their corresponding syndromes.

3. The (3,1) convolutional encoder is shown in figure.1. Assume that four information bits $(x_1 \quad x_2 \quad x_3 \quad x_4)$, followed by two zero bits, have been encoded and sent via a binary symmetric channel. The received sequence is $(111 \quad 111 \quad 111 \quad 111 \quad 111 \quad 111)$. Find the most likely data sequence using Viterbi decoding algorithm.

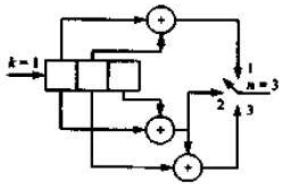


Figure 1

Course Outcome 6 (CO6):

1. What is the advantage of using partial response signals? For the duobinary pulse

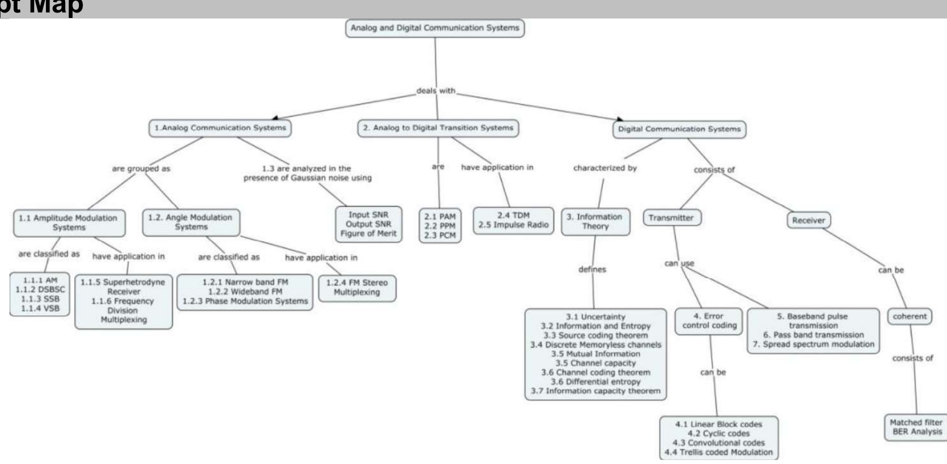
$$x(nT) = \begin{cases} 1, & for \quad n = 0,1 \\ 0, & otherwise \end{cases}$$, write the equation for the overall signal (transmitter followed by channel and receiver) and its spectrum.

1. Prove the Nyquist condition for zero ISI in digital communication system. Discuss the effect of choosing symbol rate $(1/T)$ greater than, equal to and less than twice the bandwidth (2W).
2. The binary data stream [00 10 11 0] is applied to duo-binary system. Construct the duo-binary coder output and corresponding receiver output. Assume that there is Pre-Coder at the input.

Course Outcome 7 (CO7):

1. Consider a random variable $\chi \in \{x_1 = -1, x_2 = +1\}$. Given an observation of the random variable $y = x + n$; where n is a zero mean Gaussian random variable with variance, σ^2 independent of x. The decision regions of the ML detector at the receiver subsystem is given as $y = \left(\frac{x_1 + x_2}{2}\right) + \frac{\sigma^2}{x_1 - x_2} . \ln\left|\frac{p(x_2 = +1)}{p(x_1 = -1)}\right|$. Now suppose $\sigma^2 = 0.5$ and $y = -0.1$, find the decision for the following cases with apriori probabilities, (i) $p(x_1) = p(x_2) = 0.5$ (ii) $p(x_1) = 0.2$ & $p(x_2) = 0.8$.
2. Using Gram – Schmidt Orthogonalization procedure, find the set of orthonormal basis for FSK modulation scheme.
3. Compare the BER performance of BPSK, BASK and BFSK modulation scheme.

Concept Map



Syllabus

Analog Communication Systems: Amplitude Modulation, Double Side Band Suppressed Carrier Modulation, Single side band Modulation, Vestigial Side band Modulation, Super heterodyne Receiver, Frequency Division Multiplexing, Angle Modulation Systems: Narrow band and wideband FM, Generation and demodulation of FM waves, Phase Modulation systems, Noise Analysis.

Analog to Digital Transition Systems: Pulse Amplitude Modulation, Pulse Position Modulation, Pulse Code Modulation, DPCM, Delta Modulation, Time Division Multiplexing

Information Theory: Uncertainty, Information and entropy, source coding theorem, Discrete Memoryless channels, Mutual Information, Channel capacity, Channel coding theorem, Differential entropy, Mutual Information and channel capacity theorem

Error control coding: Linear block codes, cyclic codes, convolutional codes, Trellis coded Modulation

Baseband Pulse transmission: Inter Symbol Interference problem, Nyquist criterion, Raised cosine pulse, partial response signals

Passband Transmission: Gram-Schmidt Orthogonalization Procedure, Detection of known signals in noise, Correlation receiver, Matched Filter receiver, Binary Amplitude Shift Keying, Binary Phase Shift Keying, Binary Frequency Shift Keying, QAM**,** BER Analysis

Spread Spectrum Modulation: Pseudo noise sequences, Discrete sequence spread spectrum with coherent BPSK, Signal space dimensionality and processing gain, Frequency hop spread spectrum modulation

Learning Resources

1. Simon Haykin and Michael Moher, "Communication systems" John Wiley & Sons, Fifth Edition, 2016
2. Simon Haykin and Michael Moher, "An Introduction to Analog and Digital Communications", John Wiley & Sons, second Edition, 2006.
3. Leon W. Couch II, " Digital and Analog Communication Systems", Prentice Hall, 1997
4. Sam Shanmugam, "Digital and Analog Communication Systems", 2nd ed, John Wiley, 1992.
5. B. Carlson, "Introduction to Communication systems", 3rd Edition, McGraw Hill, 1989
6. NPTEL Course Digital Communication: https://nptel.ac.in/courses/117101051/

Course Contents and Lecture Schedule

Module No.	Topic	No. of Lectures
1	**Analog Communication Systems**	
1.1	Amplitude Modulation	1
1.2	Double Side band Suppressed Carrier Modulation	1
1.3	Single side band Modulation	1
1.4	Vestigial Side band Modulation	1
1.5	Super heterodyne Receiver	1
1.6	Frequency Division Multiplexing	1
	Angle Modulation Systems:	
1.7	Narrow band and Wideband Frequency Modulation	1
1.8	Generation and Demodulation of FM waves	1
1.9	Phase Modulation systems	1
1.10	Noise analysis	2
2	**Analog to Digital Transition Systems**	
2.1	Pulse Amplitude Modulation and Pulse Position Modulation	1
2.2	Pulse Code Modulation	1
2.3	Digital Pulse Code Modulation	1
2.4	Delta Modulation	1

2.5	Time Division Multiplexing	1
3	**Information Theory**	
3.1	Uncertainty, Information and entropy	1
3.2	source coding theorem	1
3.3	Discrete Memoryless channels	1
3.4	Mutual Information, Channel capacity	1
3.5	Channel coding theorem	1
3.6	Differential entropy, Mutual Information and Channel capacity theorem	2
4	**Error Control Coding**	
4.1	Linear block codes	1
4.2	cyclic codes	1
4.3	convolutional codes	2
4.4	Trellis coded Modulation	1
5	**Baseband Pulse transmission**	
5.1	Inter Symbol Interference problem, Nyquist criterion	2
5.2	Raised cosine pulse, partial response signals	1
6	**Passband Transmission**	
6.1	Gram-Schmidt Orthogonalization Procedure	1
6.2	Detection of known signals in noise	1
6.3	Correlation receiver, Matched Filter receiver	1
6.4	Binary Amplitude Shift Keying	1
6.5	Binary Phase Shift Keying	1
6.6	Binary Frequency Shift Keying	1
6.7	QAM	1
6.8	BER Analysis	1
7	**Spread Spectrum Modulation**	
7.1	Pseudo noise sequences	1
7.2	Discrete sequence spread spectrum with coherent BPSK	1
7.3	Signal space dimensionality and processing gain	1
7.4	Frequency hop spread spectrum modulation	1
	Total	41

Course Designers:

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18EC560	DIGITAL IMAGE PROCESSING	Category	L	T	P	Credit
		PC	2	0	2	3

Preamble

The purpose of this course is to provide the basic concepts and methodologies for Digital Image Processing in three different levels. At the lower-level, the course introduces the terminology of image processing, image acquisition, digitization, formation, storage and the relationship between pixels. Further, it provides the image enhancement by improving the contrast and noise removal in spatial domain and applications of transformations for enhancement and coding. In the middle-level, it addresses region based segmentation, representation and description processes to extract meaningful information with geometrical operations. Morphological processing is introduced to clean up and cluster such regions for real world image processing applications.

Prerequisite

14EC340 Signals and Systems, 14EC440 Signal Processing

Course Outcomes

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

COs	Course Outcome Statement	Weightage in %
CO 1	Demonstrate the digital image acquisition, digitization, formation, storage and the relationship between pixels.	15
CO 2	Enhance the visual perception of the digital imagery from contrast/brightness degradation and by removing noise in spatial domain.	15
CO 3	Apply image transformations such as Fourier and DCT for image enhancement and coding.	20
CO 4	Extract regions of interest from an image using region based segmentation by region splitting, merging and watershed segmentation	15
CO 5	Represent the segmented boundary by chain code and shape numbers and describe it using shape number, Fourier and Euler number with structural and geometric operations.	15
CO 6	Apply image processing algorithms to solve real-world image processing problems such as number plate detection, Counting cars based on color, Cyst detection in MRI/CT, Non-destructive testing with IR, thermal images and Change detection.	20

CO Mapping with CDIO Curriculum Framework

CO #	TCE Profi. Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	**Affective**	**Psychomotor**	
CO1	TPS2	Understand	Respond	Guided Response	1.2, 2.4.6, 2.5.1, 4.1.1, 4.1.2
CO2	TPS3	Apply	Value	Mechanism	1.2, 2.2.3, 3.1, 3.2.3, 3.3.1, 4.1.1, 4.1.2, 4.3.2, 4.5.3
CO3	TPS3	Apply	Value	Mechanism	1.2, 2.2.3, 3.1, 3.2.3, 3.3.1, 4.1.1, 4.1.2, 4.3.2, 4.5.3
CO4	TPS3	Apply	Value	Mechanism	1.2, 2.2.3, 3.1, 3.2.3, 3.3.1, 4.3.2, 4.5.3
CO5	TPS2	Apply	Value	Mechanism	1.2, 2.2.3, 3.1, 3.2.3, 3.3.1, 4.3.2, 4.5.3
CO6	TPS3	Apply	Value	Mechanism	1.2, 2.1.3, 2.1.5, 2.2.3, 2.3.1, 2.4.6, 2.5.1, 3.1, 3.3.1, 4.1.1, 4.1.2, 4.3.2, 4.5.3

Mapping with Programme Outcomes

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	M	L	-	-	M	-	-	L	L	L	-	-	L	-	L
CO2	S	S	M	L	M	M	-	L	M	M	-	L	M	S	L
CO3	S	S	M	L	M	L	L	L	M	M	-	L	M	S	L
CO4	S	S	M	L	M	L	-	L	M	M	-	L	M	M	L
CO5	S	S	M	L	M	M	L	L	M	M	-	L	M	S	L
CO6	S	S	M	L	S	M	M	L	M	M	-	L	S	S	M

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

Cognitive Levels	Continuous Assessment Tests			End Semester Examination
	1	2	3	
Remember	10	10	10	10
Understand	10	10	10	10
Apply	80	80	80	80
Analyse	0	0	0	0
Evaluate	0	0	0	0
Create	0	0	0	0

Assessment Pattern: Psychomotor

Psychomotor Skill	Practical
Perception	-
Set	-
Guided Response	-
Mechanism	80
Complex Overt Responses	20
Adaptation	-
Origination	-

Sample Questions for Course Outcome Assessment

Course Outcome 1 (CO1):

1. Distinguish CT and MRI imaging techniques and List the Pros and Cons.
2. Consider the image segment shown.
   Let v = {0,1}, and obtain the shortest 8 and m-path between p and q. If a particular path does not exist between these two points state the reason. Repeat the same for v {1,2}.
   3 2 1 0 (q)
   2 1 2 0
   1 1 1 1
   (p) 1 0 1 2
3. Illustrate two dimensional sampling (down sample to 2X2) and 4 bit (16 gray levels) quantization for the following 8 bit sub image and state the reasons for the effects due to these processes?

255	255	255	255	255	255	255	255
255	200	255	150	255	50	50	255
255	200	255	150	255	50	50	255
255	200	255	150	255	50	50	255
255	200	255	150	255	50	50	255
255	200	255	150	255	50	50	255
255	200	255	150	255	50	50	255
255	255	255	255	255	255	255	255

Course Outcome 2 (CO2):

1. Justify whether the image is poor in contrast. Identify the category of contrast. Is there any possibility to apply histogram equalization for the enhancement? If Yes, Justify and apply Histogram equalization for the following 6 bit image segment of size 6X6? Write the inference on image segment before and after equalization.

35	55	60	55	40	60
55	35	35	60	60	52
60	48	45	55	38	48
51	40	60	45	40	40
49	40	60	35	35	55
62	48	55	62	45	35

2. Demonstrate the following gray-level transformations for image enhancement via
   i) Gamma correction
   ii) Gray level slicing
   iii) Contrast Stretching
3. Suggest a suitable filter to remove noise but still preserve edges. Give the transfer function of it.

Course Outcome 3 (CO3):

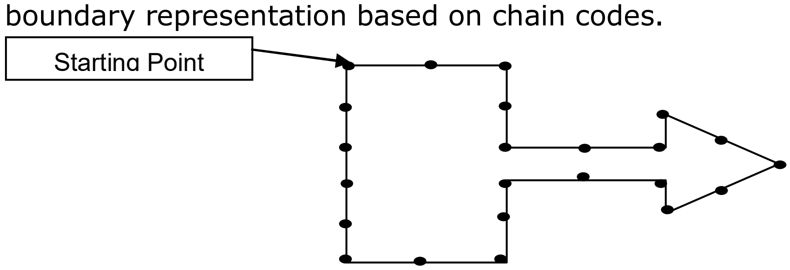
1. Illustrate the procedure step by step for JPEG image compression and write the significance of DCT.
2. Apply Discrete Fourier Transform for the following image data?
   [220 100; 120 250] [2x2] matrix. Write the significance of log function while visualizing the Fourier spectrum. Also, illustrate how Fourier transform properties are helpful in different digital image processing applications. Obtain it's inverse also.
3. Apply Discrete Cosine Transform for the following image data.
   [100 200; 150 200] [2x2] matrix. Also, illustrate how DCT is used for JPEG image Compression?

Course Outcome 4 (CO4):

1. The region-growing algorithm starts with a seed pixel. Suggest a way or gray-level range to choose the seed pixel for the following two applications.
   a. Segmenting the fractured portion of a leg in a X-Ray image
   b. Segmenting defective welds for an image captured in industry
2. Illustrate whether or not closed boundaries always result from application of watershed segmentation algorithm.
3. Demonstrate region split and merge algorithm and apply morphological algorithms to segment the satellite image into different regions.

Course Outcome 5 (CO5):

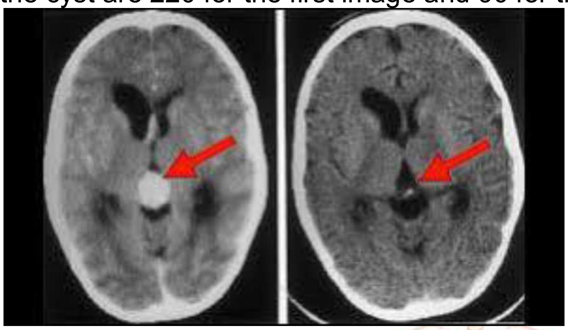
1. Write the Euler number if the shape contains 4 edges, 3 faces and 5 vertices.
2. Obtain the shape number for the following fig. List the limitations towards boundary representation based on chain codes.



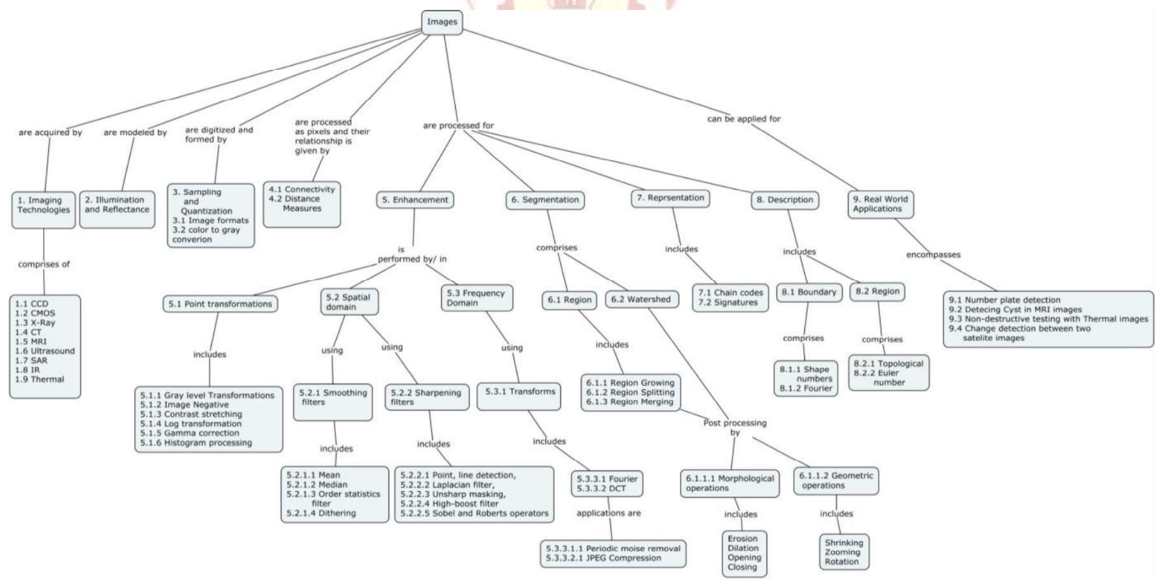
3. Sketch the signature plots for the following geometrical figures: Rectangle, Ellipse and 5- point star. How will it be Scale normalized?

Course Outcome 6 (CO6):

1. Develop an algorithm to localize the license plate using suitable preprocessing, edge detection and morphological processing for intelligent traffic surveillance system to capture the vehicles which are not following the traffic rules.
2. Suggest an algorithm to find the change between two satellite images (taken in 2004 and 2014). The image captured the Madurai area. How will you find vaigai river has been encroached and how much encroached from the change detection algorithm.
3. The region-growing algorithm starts with a seed pixel. Suggest a way or gray level range to choose the seed pixel for the following application. Segment the brain tumour of a MRI image (cyst is indicated by an arrow). Assume the intensity values of the cyst are 220 for the first image and 90 for the second image.



Concept Map



Syllabus

Theory:

Image acquisition and Fundamentals: Introduction to Image processing, it's need and applications **–** Elements of Human Visual Perception-Image acquisition- Sensors-CCD, CMOS, Imaging modalities- X-Ray, CT, MRI, Ultrasound, SAR, IR, Thermal- Imaging Components of an Image processing system. Digital Image model**,** Image formats, Image Sampling and Quantization **–**Basic relationship between pixels- Connectivity- 4, 8 and m connectivity and Distance measures- Euclidean, city-block, chessboard, Color model- RGB,CMY,HSI, Color space conversion-RGB to HSV and YCbCr. **Image Enhancement: Point transformations-** Gray level Transformations **–**Image Negative, Contrast stretching, Log transformation- Gamma correction-Histogram processing **Spatial Filtering**- Noise removal-Noise models **–** Salt and Pepper, Smoothing-Periodic **–** mean-median filters-Order statistics filter- Dithering**:** Gray level thresholding- Binary image- Sharpening-**Edges-** Point, line detection, Laplacian filter, unsharp masking, high-boost filter, and Sobel and Roberts operators. **Spectral representation for enhancement and coding:** Fourier- Discrete cosine Transform – Spectrum-Frequency domain filtering –Periodic noise removal-JPEG compression. **Segmentation:** Region based segmentation – Region growing– Region splitting and merging, Watershed segmentation- Gray-scale Morphological operations: Erosion, Dilation, Opening, closing-Geometric operations: Shrinking, Zooming and Rotation by Interpolations. **Representation and Description:** Boundary representation-Chain codes–Signatures-Boundary descriptors–Shape numbers-Fourier descriptors-Regional Descriptors-Topological descriptors-Euler number. **Real world Applications:** Number plate detection, Detecting cyst/tumour in MRI images, Non-destructive testing with Thermal images, Change detection between two satellite images

Practical:

1. Functional Programming: Program that generates a test pattern image
2. HVS and color space: (RGB to HSV, YCbCr color space)
3. Image enhancement: Point transformations: Image negative, log-transformation, contrast-stretching, histogram equalization
4. Image enhancement - Spatial filtering: Apply an averaging filter of an increasing size of mask and comment (Salt and pepper noise)
5. Image enhancement - Spatial filtering – Edges- Laplacian filter, unsharp masking, high-boost filter, and Sobel and Roberts operators
6. Dithering: Threshold a gray scale image to get binary, Add noise to the original image and threshold, Compare and comment.
7. Spectral representation for enhancement and coding - DFT, DCT of simple images containing an edge or a box.
8. Image enhancement: Filtering in the frequency domain: Perform LP of different size (spatial). Add periodic noise and remove using frequency filtering methods
9. Segmentation: Region growing, region splitting and merging, and watershed segmentation
10. Morphological operations: Erosion, Dilation, Opening, closing Selection of the structuring element, Increase the size of structuring element – Locating an object - comment
11. Geometric operations: Shrinking, Zooming and Rotation by Interpolations Comment on the quality of a thumbnail-size using different interpolation methods
12. **Mini project:**
    1. Image fusion of vari-focused images
    2. Creation of HDR images (Differently exposed images)
    3. Experimenting Visual disabilities
    4. Counting car colors
    5. Color balancing - Automatic way
    6. Vehicle license plate detection.
    7. Detecting cyst/tumour in MRI/CT /Ultra sound images.
    8. Testing Non-destruction testing in IR/Thermal images.
    9. Change detection between two remotely sensed satellite images taken in different periods.
    10. Missing component detection in an automated industrial inspection application.

Learning Resources

1. Oge Marques, “Practical Image and Video Processing using MATLAB”, Wiley-IEEE Press, 2011, ISBN: 978-0-470-04815-3.
2. Rafael.C.Gonzalez, Richard.E. Woods and Steven L. Eddins, “Digital Image Processing using Matlab”, 2nd Edition, Gatesmark Publishing, 2009, ISBN 9780982085400.
3. Al.Bovik, “The Essential Guide to Image Processing”, Academic Press, 2009.
4. Anil K.Jain, “Fundamentals of Digital Image Processing”, Pearson Education 2003.

5. William K. Pratt, “Digital Image Processing”, Third Edition, John Wiley & Sons, Inc.,2001, ISBNs: 0-471-37407-5.
6. NPTEL course Digital Image Processing: https://nptel.ac.in/courses/noc18_ee40/
7. www.imageprocessingplace.com/
8. http://www.mathworks.com/
9. https://www.coursera.org/course/images

Course Contents and Lecture Schedule

No.	Topic	No. of Lectures	CO
1	Image acquisition:		
1.1	Introduction to Image processing, it's need and applications – Elements of Human Visual Perception	2	1
1.2	Image acquisition- Sensors-CCD, CMOS, Imaging modalities: X-Ray, CT, MRI, Ultrasound	1	1
1.3	SAR	1	1
1.4	IR, Thermal		
1.5	Imaging Components of an Image processing system		
1.6	**Practical:** Functional Programming: Program that generates a test pattern image	2	1
2	Fundamentals: Digital Image model, Image formats	1	1
2.1	Image Sampling and Quantization		
2.2	Basic relationship between pixels, Connectivity- 4, 8 and m connectivity	1	1
2.3	Distance measures- Euclidean, city-block, chessboard		
	Color model-RGB,CMY,HSI, Color space conversion-RGB to HSV and YCbCr	1	1
2.4	**Practical:** HVS and color space: (RGB to HSV, YCbCr color space)	2	1
3.	**Image Enhancement:** Point transformations- Gray level Transformations	1	2
3.1	Image Negative, Contrast stretching, Log transformation-Gamma correction	1	2
3.2	Histogram processing	1	2
3.3	**Practical:** Image enhancement: Point transformations: Image negative, log-transformation, contrast-stretching, histogram equalization	2	2
3.4	**Spatial Filtering**-Noise models – Salt and Pepper, Periodic	1	2
3.5	Mean-median filters-Order statistics filter		
3.6	**Practical**: **Image enhancement** - Spatial filtering – Edges-Laplacian filter, unsharp masking, high-boost filter, and Sobel and Roberts operators	1	2
3.7	Dithering: Gray-level thresholding- Binary image	1	2
3.8	**Practical: Dithering**: Threshold a gray-scale image to get binary, Add noise to the original image and threshold, Compare and comment	2	2
3.9	**Edges-** Point, line detection, Laplacian filter, unsharp masking	1	2
3.10	High-boost filter, and Sobel and Roberts operators	1	2
4	**Spectral representation for enhancement and coding:**		
4.1	Fourier	2	3
4.2	Discrete cosine Transform	1	3
4.3	**Practical:** Spectral representation for enhancement and coding- DFT, DCT of simple images containing an edge or a box.	2	3

4.4	Spectrum-Frequency domain filtering –Periodic noise removal-	1	3
4.5	JPEG compression	2	3
4.6	**Practical:** Image enhancement: Filtering in the frequency domain: Perform LP of different size (spatial). Add periodic noise and remove using frequency filtering methods	2	3
5	**Segmentation:** Region based segmentation	1	4
5.1	Region growing– Region splitting and merging	1	4
5.2	Watershed Segmentation	1	4
5.3	**Practical: Segmentation:** Region growing, region splitting and merging, and watershed segmentation		
5.4	Gray-scale Morphological operations: Erosion, Dilation	1	4
5.5	Opening, closing, structuring element		
5.6	Geometric operations: Shrinking, Zooming and Rotation by Interpolations	2	4
5.7	**Practical: Morphological operations:** Erosion, Dilation, Opening, closing Selection of the structuring element, Increase the size of structuring element – Locating an object	2	4
6.	**Representation and Description:** Boundary representation	1	5
6.1	Chain codes–Signatures		
6.2	Boundary descriptors–Shape numbers-Fourier descriptors	1	5
6.3	Regional Descriptors-Topological descriptors-Euler number		
6.4	**Practical:** Geometric operations: Shrinking, Zooming and Rotation by Interpolations Comment on the quality of a thumbnail-size using different interpolation methods	2	4
7.	**Real world Applications:** Number plate detection	2	6
7.2	Detecting cyst/tumour in MRI sound images	1	6
7.3	Non-destructive testing with Thermal images	1	6
7.4	Change detection between two satellite images		
	Mini project:		6
	Total	48	

Course Designers:

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18EC570	DATA COMMUNICATION NETWORKING LABORATORY

Category	L	T	P	Credit
PC	0	0	2	1

Preamble

The goals of this course are to supplement the theory course '14EC510 Data Communication Networks' and to assist the students in obtaining a better understanding of the characteristics of data communication networks by giving hands on programming and lab activities to the students in practicing the data communication concepts and protocols. This lab course also supports in developing IoT based process control applications.

Prerequisite

NIL

Course Outcomes

On the successful completion of the course students will be able to

CO#	Course Outcome Statement	Weightage in %
CO1	Analyze the throughput performance of multiple access protocols in network topologies	10
CO2	Demonstrate structured cabling concepts using Straight through, Cross over and Rollover cables	10
CO3	Use the routing algorithms and configure routers using Packet Tracer/e-Sim CISCO simulator	10
CO4	Analyze the network performance using packet sniffer tools – NETMON / Wireshark	10
CO5	Apply Socket Programming to build/configure network applications	20
CO6	Determine the network performance using network simulator package – NS2/NS3 to simulate the point-to-point networks and analyze their performance	20
CO7	Develop an IoT based process control applications using Arduino programming	20

CO Mapping with CDIO Curriculum Framework

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS3	Apply	Value	Mechanism	1.2.4, 2.1.1, 2.1.2, 2.2.2, 2.2.3, 2.4.2, 2.4.6, 2.5.1, 3.1.2, 3.2.3, 4.6.2
CO2	TPS3	Apply	Value	Mechanism	1.2.4, 2.1.1, 2.1.2, 2.2.2, 2.2.3, 2.4.2, 2.4.6, 2.5.1, 3.1.2, 3.2.3, 4.6.2
CO3	TPS3	Apply	Value	Mechanism	1.2.4, 2.1.1, 2.1.2, 2.2.2, 2.2.3, 2.4.2, 2.4.6, 2.5.1, 3.1.2, 3.2.3, 4.6.2
CO4	TPS3	Apply	Value	Mechanism	1.2.4, 2.1.1, 2.1.2, 2.2.2, 2.2.3, 2.4.2, 2.4.6, 2.5.1, 3.1.2, 3.2.3, 4.6.2
CO5	TPS3	Apply	Value	Mechanism	1.2.4, 2.1.1, 2.1.2, 2.2.2, 2.2.3, 2.4.2, 2.4.6, 2.5.1, 3.1.2, 3.2.3, 4.6.2
CO6	TPS3	Apply	Value	Mechanism	1.2.4, 2.1.1, 2.1.2, 2.2.2, 2.2.3, 2.4.2, 2.4.6, 2.5.1, 3.1.2, 3.2.3, 4.6.2

Mapping with Programme Outcomes and Programme Specific Outcomes

Cos	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	S	M	L	-	S	-	-	L	S	S	L	-	S	-	L
CO2	S	M	L	-	S	-	-	L	S	S	L	-	S	-	L
CO3	S	M	L	-	S	-	-	L	S	S	L	-	S	-	L
CO4	S	M	L	-	S	-	-	L	S	S	L	-	S	-	L
CO5	S	M	L	-	S	-	-	L	S	S	L	-	S	-	L
CO6	S	M	L	-	S	-	-	L	S	S	L	-	S	-	L

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

Cognitive Levels	Model Examination	End Semester Examination
Remember		
Understand		
Apply	70	70
Analyse		
Evaluate		
Create		

Assessment Pattern: Psychomotor

Psychomotor Skill	Practical Component
Perception	
Set	
Guided Response	
Mechanism	30
Complex Overt Responses	
Adaptation	
Origination	

List of Experiments/Activities with CO Mapping

1. Construct network topologies such as bus and star using trainer kit and analyze their throughput of MAC protocols for the given parameters. (CO1)
   a. Simulate an Ethernet LAN using N-nodes (6-10)
   b. Set packet size, duration, bit delay.
   c. Set error rate and data rate
   d. Compare throughput for different LAN topologies
2. Implement Structured cabling concepts for TIA/EIA-358B standard to connect devices
3. using the following types: (CO2)
   a. Straight through cable
   b. Cross over cable
   c. Roll over cable
4. Implement routing concepts (CO3)
   a. to apply routing protocols such as RIP and OSPF using Packet Tracer
   b. to configure the CISCO routers using e-Sim Simulator for the given inter-
   c. connected subnets using IOS modes and commands
   d. to find routing table, trace path between devices and verify the connectivity
5. Use Protocol Analyzer/ Sniffing Tools - Wireshark/ NETMON to capturing network data
6. traffic (CO4)
   a. to explore HTTP and DNS services
   b. to explore TCP and UDP services
   c. to explore IP services
   d. to explore link layer services

7. Develop the following client-server models using Socket programming for TCP and UDP
8. protocols (CO5)
    a. Time Server
    b. Chat Server
    c. File Server
    d. Math Server
9. Determine network performance of the given network using network simulator packages **–**
10. NS2/NS3 (CO6)
    a. Construct point-to-point/local area networks with appropriate links and nodes
    b. Set the queue size, packet size and packet interval time.
    c. Choose suitable link parameters such as link delay and link bandwidth for CBR / FTP traffic with UDP / TCP agents
11. Develop IoT based mini projects / prototype development for remote process control
12. applications using the following: (CO7)
    a. Data acquisition and control using sensors and actuators
    b. Arduino Programming for processing control
    c. Choose appropriate wireless modules for communication
    d. Data control using appropriate actuators / data analysis using R

Learning Resources

1. NPTEL Video Lecture on “Computer Networks”, weblink: https://onlinecourses.nptel.ac.in/noc19_ee11/course
2. Virtual Lab of IIT Kharagpur, Weblink: http://vlabs.iitkgp.ernet.in/ant/
3. Lab Manual in LMS, Weblink https://murugavalli.gnomio.com/

Course Designers:

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3. Dr. E. Murugavalli murugavalli@tce.edu

18EC580	ANALOG AND DIGITAL COMMUNICATIONS LABORATORY	Category	L	T	P	Credit
		PC	0	0	2	1

Preamble

The course “18EC580: Analog and Digital Communications Laboratory” is offered in the fourth semester concurrent with the course on “Analog and Digital Communication Systems”. The purpose of this course is to give hands on training to the students in understanding the theory of communications and practicing sessions used in analog and digital communication systems. This will improve the understanding capability of the communications and simulation capability of the communications.

Prerequisite

18EC440 Signal Processing

Course Outcomes

On the successful completion of the course students will be able to

CO#	Course Outcome Statement	Weightage in %
CO1	Measure the directional characteristics of microphone and loud speaker	10
CO2	Construct and test Analog modulation and demodulation circuits	15
CO3	Construct and test circuits for pulse amplitude and time division multiplexing and de-multiplexing circuits	20
CO4	Generate and detection of digital modulation techniques using MATLAB	20
CO5	Improve the BER performance of modulation techniques by proper channel coding	20
CO6	Construct and test circuits for spread spectrum modulation and demodulation	15

CO Mapping with CDIO Curriculum Framework

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS3	Apply	Value	Mechanism	1.2.4, 2.1.1, 2.1.2, 2.2.2, 2.2.3, 2.4.2, 2.4.6, 2.5.1, 3.1.2, 3.2.3, 4.6.2
CO2	TPS3	Apply	Value	Mechanism	1.2.4, 2.1.1, 2.1.2, 2.2.2, 2.2.3, 2.4.2, 2.4.6, 2.5.1, 3.1.2, 3.2.3, 4.6.2
CO3	TPS3	Apply	Value	Mechanism	1.2.4, 2.1.1, 2.1.2, 2.2.2, 2.2.3, 2.4.2, 2.4.6, 2.5.1, 3.1.2, 3.2.3, 4.6.2
CO4	TPS3	Apply	Value	Mechanism	1.2.4, 2.1.1, 2.1.2, 2.2.2, 2.2.3, 2.4.2, 2.4.6, 2.5.1, 3.1.2, 3.2.3, 4.6.2
CO5	TPS3	Apply	Value	Mechanism	1.2.4, 2.1.1, 2.1.2, 2.2.2, 2.2.3, 2.4.2, 2.4.6, 2.5.1, 3.1.2, 3.2.3, 4.6.2

Mapping with Programme Outcomes and Programme Specific Outcomes

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	S	M	L	-	S	-	-	-	M	M	-	L	S	L	L
CO2	S	M	L	-	S	-	-	-	M	M	-	L	S	L	L
CO3	S	M	L	-	S	-	-	-	M	M	-	L	S	L	L
CO4	S	M	L	-	S	-	-	-	M	M	-	L	S	M	L
CO5	S	M	L	-	S	-	-	-	M	M	-	L	S	M	L
CO6	S	M	L	-	S	-	-	-	M	M	-	L	S	L	L

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

Cognitive Levels	Model Examination	End Semester Examination
Remember		
Understand		
Apply	70	70
Analyse		
Evaluate		
Create		

Assessment Pattern: Psychomotor

Psychomotor Skill	Practical Component
Perception	
Set	
Guided Response	
Mechanism	30
Complex Overt Responses	
Adaptation	
Origination	

List of Experiments/Activities with CO Mapping

1. Characteristics of microphone and loud speaker
2. AM Modulation and demodulation
3. FM modulation and demodulation using PLL.
4. Preemphasis and deemphasis
5. Time Division Multiplexing and Demultiplexing
6. Transeiver Design for BPSK modulation scheme over AWGN channel and BER analysis using MATLAB
7. Transeiver Design for QPSK modulation scheme over AWGN channel and BER analysis using MATLAB
8. Spread Spectrum Modulation and Demodulation

Learning Resources

1. TCE Analog and Digital Communication Lab Manual
2. www.ece.ucf.edu/files/labs/EEL4515_LabManual.pdf

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18ES590	SYSTEM THINKING

Category	L	T	P	Credit
ES	1	-	2	2

Preamble

Systems thinking is the integrated paradigm for systems science and system approaches to practice. It is concerned with understanding or intervening in problem situations, based on the principles and concepts of the system model. It can help to provide a common language and an intellectual foundation and make practical system concepts, principles, patterns and tools accessible to systems engineering. System thinking considers the similarities between systems from different domains in terms of a set of common systems concepts, principles, and patterns. The scope of systems thinking is a starting point for dealing with real-world situations using a set of related systems concept. The system thinking is viewed as both a set of founding ideas for the development of systems theories and practices and also as a pervasive way of thinking need by those developing and applying them. This systems approach is a way of tackling real-world problems and making use of the concepts, principle, patterns of systems thinking to enable the systems to be engineered and used.

Prerequisite

Nil

Course Outcomes

On the successful completion of the course students will be able to

CO Number	Course Outcome Statement	Weightage in %
CO1	Explain the concepts of systems thinking, System engineering and Systems Life Cycle	10
CO2	Identify system elements, interactions, boundary and environment for the given system descriptions	10
CO3	Develop a functional architecture with appropriate primary function(s) and sub-functions of the identified system	15
CO4	Develop a physical architecture with appropriate sub-systems and components of the identified system	15
CO5	Prepare a system requirement specification review documents for the various stages of acquisition phase of the identified system	20
CO6	Develop a system model with logical and physical architecture using system modelling tool like SysML	30

CO Mapping with CDIO Curriculum Framework

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS2	Understand	Respond	-	1.1, 2.3.1, 2.3.2
CO2	TPS3	Apply	Value	-	1.1, 2.1.1, 2.3.1,2.3.2, 2.3.3, 2.3.4, 2.4.4, 4.3.1,
CO3	TPS3	Apply	Value	Mechanism	1.1, 2.1.1, 2.3.1,2.3.2, 2.3.3, 2.3.4, 2.4.4, 3.1.2, 3.2.3, 3.2.4, 3.2.5, 3.2.6, 4.3.1, 4.3.2, 4.3.3, 4.4.5, 4.5.1
CO4	TPS3	Apply	Value	Mechanism	1.1, 2.1.1, 2.3.1,2.3.2, 2.3.3, 2.3.4, 2.4.4, 3.1.2, 3.2.3, 3.2.4, 3.2.5, 3.2.6, 4.3.1, 4.3.2, 4.3.3, 4.4.5, 4.5.1
CO5	TPS3	Apply	Value	Mechanism	1.1, 2.1.1, 2.3.1,2.3.2, 2.3.3,

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
					2.3.4, 2.4.4, 3.1.2, 3.2.3, 3.2.4, 3.2.5, 3.2.6, 4.3.1, 4.3.2, 4.3.3, 4.4.5, 4.5.1
CO6	TPS3	Apply	Value	Mechanism	1.1, 2.1.1, 2.3.1,2.3.2, 2.3.3, 2.3.4, 2.4.4, 3.1.2, 3.2.3, 3.2.4, 3.2.5, 3.2.6, 4.3.1, 4.3.2, 4.3.3, 4.4.5, 4.5.1

Mapping with Programme Outcomes and Programme Specific Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	M	L	-	-	-	-	-	-	-	-	-	-
CO2	S	M	L	-	-	L	L	L	L	L	-	M
CO3	S	M	L	-	-	M	M	M	L	M	M	S
CO4	S	M	L	-	-	M	M	M	L	M	M	S
CO5	S	M	L	-	-	M	M	M	L	M	M	S
CO6	S	M	L	-	S	M	M	M	L	M	M	S

S- Strong; M-Medium; L-Low

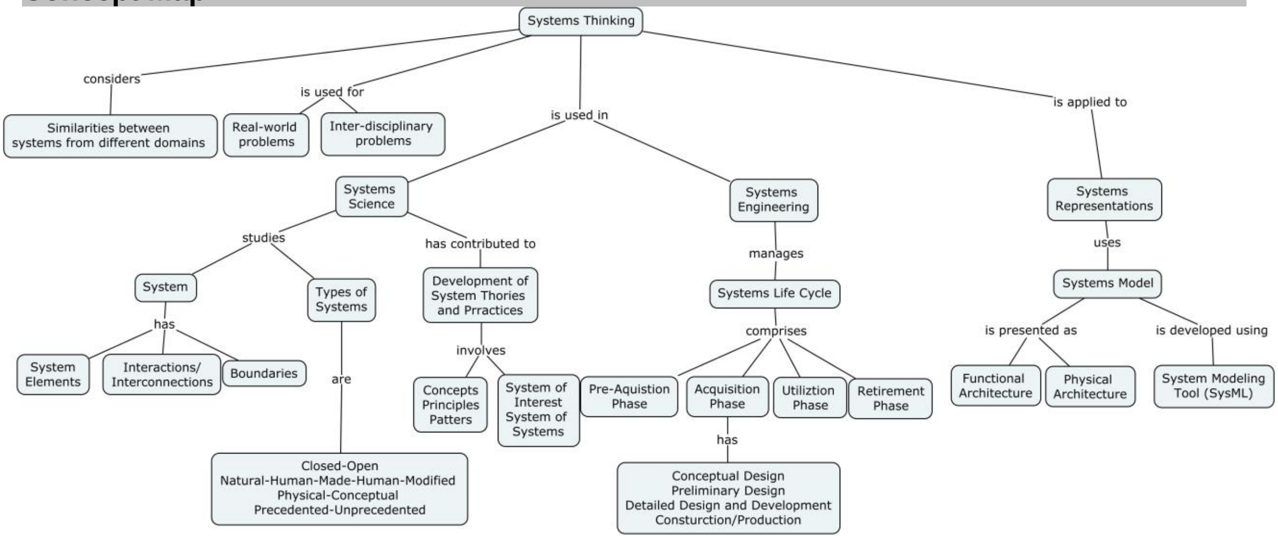
Assessment Pattern: Cognitive Domain

Cognitive Levels	**Continuous Assessment Test -2**
Remember	20
Understand	40
Apply	40
Analyse	-
Evaluate	-
Create	-

Phases	**Deliverables**	**Marks**	**Course Outcomes**
Continuous Assessment			
Continuous Assessment Test-1		10	CO1 and CO2
Review 1 – Functional & Physical Architecture and System Requirement Specification	Technical Report	25	CO3, CO4 and CO5
Review 2 – Systems Modeling	Technical Report	15	CO6
End-Semester Examination			
Demonstration	Virtual Prototype with simulation	60	CO1, CO2, CO3, CO4 CO5 and CO6
Poster Presentation	Poster	40	

- Reports are to be submitted at each review. The report and presentation will be evaluated based on Rubrics.
- Demonstration of Virtual Prototype with simulation and Poster presentation will be evaluated by two faculty members nominated by their respective Head of the Department.

Concept Map



Syllabus

1.0 Systems Fundamentals: System - Definition, System Elements, Interactions, System Boundary, - Types of Systems: Closed-Open, Natural-Human-Made-Human-Modified, Physical-Conceptual and Precedented-Unprecedented. Systems science - Systems approaches. Systems Thinking: Concepts, principles and pattens. System of Interest - Systems of System. Systems Engineering: Product, Service, Enterprise. System Life Cycle: Pre-acquisition phase, Acquisition Phase, Utilization Phase and Retirement Phase.
2.0 Acquisition Phase: Conceptual Design: Business needs and requirements, Stakeholder needs and requirements, System Requirement Specification, Functional Base Line, System Requirement Review – Functional Architecture. Preliminary Design: Configuration items, Allocated Baseline, Preliminary Design Review – Physical Architecture. Detailed Design and Development: System Modeling, Product Base Line, Critical Design Review. Construction/Production: Formal Qualification Review, Acceptance Test and Evaluation.
3.0 Systems Modeling: System Model - Types of models – System Modeling Concepts – Modeling Standards. System Architecture: Logical Architecture Model – Physical Architecture Model. Systems Life Cycle Process Model: Vee model.

Learning Resources

1. A Guide to Guide to the Systems Engineering Body of Knowledge (SEBoK), version 2.2, INCOSE Systems Engineering Research Center and IEEE Computer Society, Released 31 October 2019 – https://www.sebokwiki.org/w/images/sebokwiki-farm!w/8/8b/SEBoK_v2.1.pdf
2. Systems Engineering Handbook, A Guide for Systems Life Cycle Processes and Activities, 4th Edition, INCOSE-TP-2003-002-04, 2015.
3. R. Ian Faulconbridge, Michael Ryan, “Systems Engineering Practice”, Argos Argos Press, 2014.
4. Jon Holt and Simon Perry, “SysML for Systems Engineering”, The Institution of Engineering and Technology, London, United Kingdom, 2008.
5. Sanford Friedenthal, Alan Moore and Rick Steiner, “A Practical Guide To SysML: The Systems Modeling Language, Third edition, Morgan Kaufmann, an imprint of Elsevier, 2015
6. Coursera course on Introduction to Systems Engineering - R. Ian Faulconbridge, Michael Ryan of The University of New South Wales, Sydney.
7. NPTEL Course: Systems Engineering Theory and Practice – IIT Kanpur – Prof. Deepu Philip (Last offered in 2019) - https://nptel.ac.in/courses/110/104/110104074/

Course Contents and Lecture Schedule

Module No.	Topic	No. of Hours		Course Outcome
		In-Class	Hands-on	
1.	**Systems Fundamentals:** System - Definition, System Elements, Interactions, System Boundary	1	-	CO1
1.1	Types of Systems: Closed-Open, Natural-Human-Made-Human-Modified, Physical-Conceptual and Precedented-Unprecedented.	1	2	CO1
1.2	Systems science - Systems approaches.	1	-	CO1
1.3	Systems Thinking: Concepts, principles and pattens.	1	-	CO1
1.4	System of Interest - Systems of System. Systems Engineering: Product, Service, Enterprise System Life Cycle: Pre-acquisition phase, Acquisition Phase, Utilization Phase and Retirement Phase.	2	2	CO2
2.	**Acquisition Phase**			
2.1	Conceptual Design: Business needs and requirements, Stakeholder needs and requirements, System Requirement Specification, Functional Base Line, System Requirement Review – Functional Architecture.	1	4	CO3
2.2	Preliminary Design: Configuration items, Allocated Baseline, Preliminary Design Review – Physical Architecture.	1	4	CO3
2.3	Detailed Design and Development: System Modeling, Product Base Line, Critical Design Review.	1	4	CO4
2.4	Construction/Production: Formal Qualification Review, Acceptance Test and Evaluation.	1	4	CO5
3.	**Systems Modeling**			
3.1	System Model - Types of models – System Modeling Concepts – Modeling Standards.	1	2	CO6
3.2	System Architecture: Logical Architecture Model – Physical Architecture Model.	1	4	CO6
3.3	Systems Life Cycle Process Model: Vee model.	1	2	CO6
	Total	14	28	

Course Designers:

1. Dr.S.J.Thiruvengadam sjtece@tce.edu
2. Dr.S.Saravana Perumaal sspmech@tce.edu
3. Dr.C.Jeyamala jeyamala@tce.edu

18CHAC0	ESSENCE OF INDIAN KNOWLEDGE	Category	L	T	P	Credit
		AC	2	0	0	0

Preamble

On the successful completion of the course, the students will be able to explain the concept of Indian Traditional Knowledge along with Indian Modern Knowledge. Traditional Knowledge Systems or Indigenous Knowledge Systems are a body of knowledge, which is very ancient and deep rooted. They have their origins in the remote past. Their systematisation and canonisation gave rise to the elite (the Greater Tradition) science. The nature of Traditional Knowledge System is diverse. It covers, among other things, literary, artistic and scientific works; songs, dances, medical treatments and practices; manufacturing and industry; and agricultural technologies and techniques. There is a dramatically growing national and international interest in incorporating Traditional Knowledge Systems, including Traditional Ecological Knowledge, into truly participatory approaches to development.

Course Outcome:

On the successful completion of the course students will be able to

CO1	Explain the concept of Traditional Knowledge and Modern knowledge of India.	Understand
CO2	Explain the need and importance of protecting Traditional Knowledge, Knowledge sharing, and Intellectual property rights over Traditional Knowledge.	Understand
CO3	Explain about the use of Traditional Knowledge to meet the basic needs of human being.	Understand
CO4	Explain the rich biodiversity materials and knowledge preserved for practicing traditional lifestyle.	Understand
CO5	Explain the use of Traditional Knowledge in Manufacturing and Industry.	Understand
CO6	Explain about the cultural expression and modern applications of Traditional Knowledge	Understand

Mapping with Programme Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	M	L	-	-	-	S	M	M	M	M	-	L	M	-	M
CO2	M	L	-	-	-	S	M	M	M	M	-	L	M	-	M
CO3	M	L	-	-	-	S	M	M	M	M	-	L	M	-	M
CO4	M	L	-	-	-	S	M	M	M	M	-	L	M	-	M
CO5	M	L	-	-	-	S	M	M	M	M	-	L	M	-	M
CO6	M	L	-	-	-	S	M	M	M	M	-	L	M	-	M

S- Strong; M-Medium; L-Low

Syllabus

Traditional and Modern Knowledge: Two Worlds of Knowledge - Phase of Explorers, Sir Arthur Cotton and Irrigation, Smallpox Vaccination, Late Nineteenth Century, Voelcker, Howard and Agriculture, Havell and Indian Art; Indians at the Encounter - Gaekwad of Baroda and Technical Education, Science Education and Modern Industries, Hakim Ajmal Khan and Ayurveda, R. N. Chopra and Indigenous Drugs, Gauhar Jaan and Indian Classical Music; Linking Science and the Rural - Tagore's Sriniketan Experiment, Marthandam, the YMCA Model, Gandhi's Thoughts on Development, Nehru's View of Growth; Post-Independence Era - Modernization and Traditional Knowledge, Social Roots of Traditional Knowledge Activism, Global Recognition for Traditional Knowledge. **Global Mechanisms of Protection and Sharing:** For Recognition and Protection - United Nations Educational, Scientific and Cultural Organization (UNESCO), World Health Organization (WHO), International Labour Organization (ILO), UN Working Group on Indigenous Populations, Evolution of Other Organizations; Norms of Sharing - United Nations Environment Programme (UNEP), World Intellectual Property Organization (WIPO), World Trade

Organization (WTO); IPR and Traditional Knowledge - Theoretical Background, Positive Protections of TK, Defensive Strategies, IPR Facilitation for TK. **Traditional Knowledge for Basic Needs:** Indian Midwifery Tradition—The Dai System, Surface Flow Irrigation Tanks, Housing - A Human Right, Changing Priorities—Niyamgiri. **Biodiversity and Genetic Resources:** Jeevani - The Wonder Herb of Kanis, A Holistic Approach - FRLHT, Basmati - In the New Millennium, AYUSH-Based Cosmetics. **Traditional Knowledge in Manufacturing and Industry:** Drug Discovery, A Sweetener of Bengal, The Sacred Ring of Payyanur, Channapatna Toys. **Traditional Cultural Expressions:** Banarasi Saree, Music, Built and Tangible Heritage, Modern Yoga, Sanskrit and Artificial Intelligence, Climate Change and Traditional Knowledge.

Assessment Pattern

Bloom's category	Continuous Assessment Tests		Seminar
	1	2	-
Remember	40	40	0
Understand	60	60	100
Apply	0	0	0
Analyze	0	0	0
Evaluate	0	0	0
Create	0	0	0

Learning Resources:

1. Nirmal Sengupta "Traditional Knowledge in Modern India Preservation, Promotion, Ethical Access and Benefit Sharing Mechanisms" Springer, 2019.
2. Amit Jha,"Traditional Knowledge System in India", Atlantic Publishers and Distributors Pvt Ltd, 2009.
3. Basanta Kumar Mohanta, Vipin Kumar Singh "Traditional Knowledge System and Technology in India", Pratibha Prakashan, 2012.
4. Kapil Kapoor, Michel Danino "Knowledge Traditions and Practices of India", Central Board of Secondary Education, 2012.
5. NPTEL video lecture on "Ayurvedic Inheritance of India", Video link: https://nptel.ac.in/courses/121/106/121106003/#.
6. Youtube video on "Introduction to Indian Knowledge Systems", Video link: https://www.youtube.com/watch?v=LZP1StpYEPM.
7. Youtube video on "12 Great achievements of Indian Civilization", Video link: https://www.youtube.com/watch?v=xmogKGCmclE.

Course Designers:

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CURRICULUM AND SYLLABI

FOR

B.E. DEGREE (ELECTRONICS AND COMMUNICATION ENGINEERING) PROGRAMME

SIXTH SEMESTER

FOR THE STUDENTS ADMITTED FROM THE

ACADEMIC YEAR 2018-2019 ONWARDS

THIAGARAJAR COLLEGE OF ENGINEERING

(A Govt Aided Autonomous Institution Affiliated to Anna University)

MADURAI – 625 015, TAMILNADU

18EC610	ACCOUNTING AND FINANCE	Category	L	T	P	Credit
		HSS	3	0	0	3

Preamble

Engineering profession involves lots of decision making. The decisions may range from operation to non-operation. For taking decisions of these kinds, an engineer needs among other data about the organization routine operations and non-routine operations. Accounting is a science which provides all the data by recording, classifying, summarizing and interpreting the various transactions taking place in an organization and thereby helps an engineer in taking vital decisions in an effective manner. Finance is an allied but a separate field relying on accounting and enables engineers in taking useful financial and cost related decisions by providing well defined concepts, tools and techniques

Prerequisite

Nil

Course Outcomes

On the successful completion of the course students will be able to

CO Number	Course Outcome Statement	Weightage in %
CO1	Prepare financial statements of accounting and analyze them with common size statements and comparative statements.	20
CO2	Prepare cost sheet, depreciation and its applications in business.	15
CO3	Compute various types of budgets in an organization	15
CO4	Practice break even analysis and activity based costing systems for business applications.	15
CO5	Compute working capital requirements and long term investment decisions.	20
CO6	Apply the appropriate sources of finance and mobilize the right quantum of finance and use them in most profitable investment avenues	15

CO Mapping with CDIO Curriculum Framework

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS3	Apply	Value	Mechanism	1.1, 2.3.4, 2.4.3, 3.2.3, 4.2.1, 4.2.2.
CO2	TPS3	Apply	Value	Mechanism	1.1, 2.3.4, 2.4.6, 3.2.3, 3.2.4, 4.2.2
CO3	TPS3	Apply	Value	Mechanism	1.1, 2.3.4, 2.4.6, 3.2.3, 3.2.4, 4.2.2
CO4	TPS3	Apply	Value	Mechanism	1.1, 1.2, 2.3.4, 2.4.6, 2.4.7, 3.2.3, 3.2.4, 4.2.2
CO5	TPS3	Apply	Value	Mechanism	1.1, 2.3.4, 2.4.6, 2.4.7, 3.2.3,3.2.4, 4.2.2
CO6	TPS3	Apply	Value	Mechanism	1.1, 1.2, 2.3.4, 2.3.3, 2.4.6, 2.4.7, 3.2.3, 3.2.4, 4.2.1, 4.2.2

Mapping with Programme Outcomes and Programme Specific Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO1	PSO2
CO1	S	M	L	-	-	M	S	M	S	S	S	S	-	-
CO2	S	M	L	-	-	-	M	M	S	S	S	M	-	-
CO3	S	M	L	-	-	-	-	S	S	S	S	S	-	-
CO4	S	M	L	-	M	M	L	S	S	S	S	M	-	-
CO5	S	M	L	-	S	M	M	S	S	S	M	M	-	-
CO6	S	M	L	-	-	M	M	S	S	M	M	S	-	-

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

Cognitive Levels	Continuous Assessment Tests			Assignment			End Semester Examination
	1	2	3	1	2	3	
Remember	20	20	20	-	-	-	20
Understand	30	30	30	-	-	-	20
Apply	50	50	50	100	100	100	60
Analyse	-	-	-	-	-	-	-
Evaluate	-	-	-	-	-	-	-
Create	-	-	-	-	-	-	-

Assessment Pattern: Psychomotor

Psychomotor Skill	Miniproject/Assignment/Practical Component
Perception	
Set	
Guided Response	
Mechanism	Assignment
Complex Overt Responses	
Adaptation	
Origination	

Sample Questions for Course Outcome Assessment

Course Outcome 1(CO1):

1. Define accounting.
2. Explain in detail about accounting concepts and conventions.
3. Prepare Trading Account, Profit and Loss Account and Balance Sheet from the following

S.NO	PARTICULARS	Debit balances (in Rs)	Credit balances(in Rs)
1	Capital		300000
2	Bank	15000	
3	Plant and machinery	40000	
4	Land and building	60000	
5	Debtors	20000	
6	Creditors		40000
7	Cash	70000	
8	Purchases and sales	35000	50000
9	Purchase returns and sales returns	7000	4000
10	Bills receivable	3000	

11	Bills payable		5000
12	Wages	40000	
13	Salaries	30000	
14	Discount		4000
15	Stock on Jan 2017	10000	
16	Furniture	7000	
17	Carriage inwards	5000	
18	Carriage outwards	6000	
19	Advertising	10000	
20	Travelling expense	3000	
21	Loans		60000
22	Vans	100000	
23	Telephone	2000	
	Total	**463000**	**463000**

4. From the following particulars, prepare comparative balance sheet of Malar Ltd as on 31st March 2017 and 31st March 2018.

Particulars	**31st March 2017**	**31st March 2018**
I EQUITY AND LIABILITIES 1. Shareholders' fund a) Share capital b) Reserves and surplus 2. Non-current liabilities Long-term borrowings 3. Current liabilities Trade payables	2,00,000 50,000 30,000 20,000	2,50,000 50,000 60,000 60,000
Total	**3,00,000**	**4,20,000**
II ASSETS 1. Non-current assets a) Fixed assets b) Non - current investments 2. Current assets a)Inventories b) Cash and cash equivalents	1,00,000 50,000 75,000 75,000	1,50,000 75,000 1,50,000 45,000
Total	**3,00,000**	**4,20,000**

Course Outcome 2(CO2):

1. Define cost sheet. Comment the uses of it.
2. Classify the cost according to function.
3. Prepare cost sheet in the book of Vimi from the following particulars.

Opening stock: -	Raw material	=	Rs 5,000
	Finished goods	=	Rs 4,000
Closing stock:	Raw material	=	Rs 4,000
	Finished goods	=	Rs 5,000
Raw material purchased		=	Rs 50,000
Wages paid to labours		=	Rs 20,000
Chargeable expenses		=	Rs 2,000
Rent and Taxes		=	Rs 7,400
Power		=	Rs 3,000
Experimental expenses		=	Rs 600
Sale of wastage of material		=	Rs 200
Office management salary		=	Rs 4,000
Office printing & stationery		=	Rs 200

Salaries to salesman = Rs 2,000
Commission to travelling agents = Rs 1,000
Sales = Rs 1, 00,000

Course Outcome 3(CO3):
1. Define budget and budgeting.
2. Classify the budget based on function.
3. Explain the advantages and applications of budgetary control.
4. Define depreciation.
5. From the forecast of income and expenditure prepare a cash budget for the months from April to June 2019.

Month	Sales Rs	Purchases Rs	Wages Rs	Office expenses Rs	Selling expenses Rs
Feb	70,000	45,000	4,500	2,700	1,800
Mar	72,000	43,000	4,700	3,000	2,000
Apr	75,000	44,000	4,900	2,900	2,200
May	71,000	40,000	5,000	3,000	2,100
Jun	70,000	42,000	5,000	2,800	1,900

- Plant worth Rs25, 000 purchased in June. 40% payable immediately and the remaining in two equal instalments in subsequent months.
- Advance tax payable in April Rs 4500
- Period of credit allowed
  - By suppliers 2 months
  - To customer 1 month
- Dividend payable Rs 7000 in June
- Delay in payment of wages and office expenses 1 month and selling expenses 1 month. Expected cash balance on 1st April Rs 30,000

Machinery expected to sell on May is Rs 20,000

Course Outcome 4 (CO4):
1. What is meant by breakeven point?
2. List the business applications of breakeven analysis.
3. From the following information calculate the Breakeven point in terms of units and breakeven point in terms of sales. Sales....Rs.10, 000, Variable costs Rs.6, 000, fixed costs Rs.2000: profit Rs.2, 000; No. Of units produced 1,000 units.
4. Calculate the breakeven point and margin of safety from the following information Fixed cost ...Rs.10, 000, sales in Rs.25, 000, selling price per unit Rs.30; variable Cost per unit Rs.10

Course Outcome 5(CO5):
1. What is meant by working capital?
2. Classify capital budgeting decisions.
3. From the following information extracted from the books of a manufacturing company, compute the operating cycle in days and the amount of working capital required:
   Period Covered = 365 days

Average period of credit allowed by suppliers = 16 days
Average Total of Debtors Outstanding = 480
Raw Material Consumption = 4,400
Total Production Cost = 10,000
Total Cost of Sales = 10,500
Sales for the year = 16,000

Value of Average Stock maintained:
Raw Material = 320
Work-in-progress = 350

Finished Goods = 260

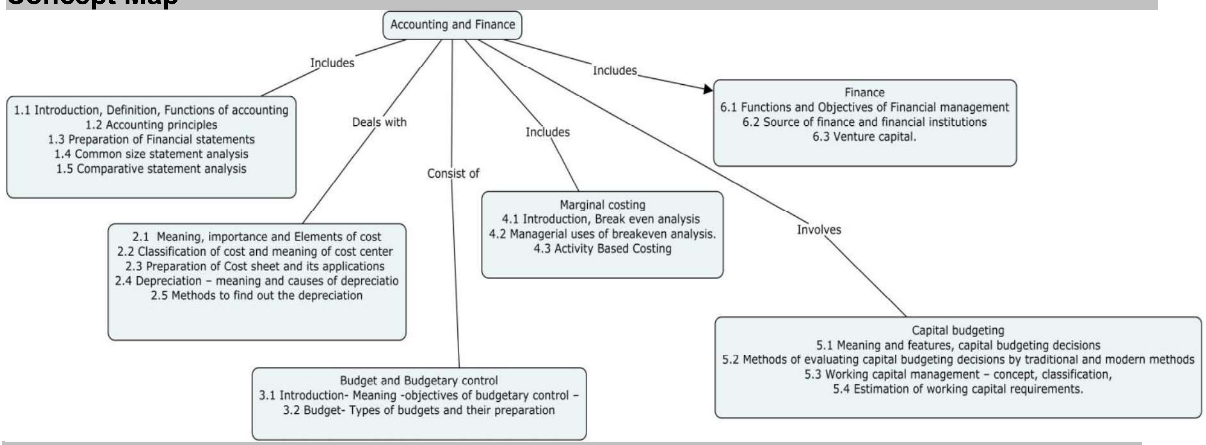
4. From the following data of a project, Calculate IRR and suggest whether the project is to be undertaken or not if the cut off rate is 9%.

Cash Out flow (Rs.)		1,50,000
Cash Inflow(Rs.)	**Year 1**	41,000
	Year 2	50,000
	Year 3	50,000
	Year 4	42,000

Course Outcome 6(CO6):

1. List the sources of finance.
2. What is meant by dividend?
3. Suggest suitable sources of finance to start a business with a capital of 60 crores.

Concept Map



Syllabus

Accounting –Introduction, definition, accounting principles-functions of accounting **—** Preparation of Financial statements and their analysis with the common size and comparative statements.

Cost Accounting - Meaning and importance -Elements of cost- classification of cost- Cost centre, Preparation of cost sheet and its applications. Depreciation **–** meaning and causes of depreciation, Methods to find out the depreciation

Budget and Budgetary control- Introduction-Meaning -objectives of budgetary control **–** Budget-Types of budgets and their preparation.

Marginal costing- Introduction, Break even analysis **–**Managerial of breakeven analysis. Activity based Costing

Capital budgeting- Meaning and features, capital budgeting decisions, Methods of evaluating capital budgeting decisions by traditional and modern methods, Working capital management - concept, classification, estimation of working capital requirements.

Finance: Functions, Objectives of financial management and Source of finance and financial institutions, Venture capital.

Learning Resources

- M.C.Shukla,T.S.Grewal,"AdvancedAccounts-Volume-I,2010 Reprint, S. Chand & company Ltd.,2010.
- Prasanna Chandra, "Financial Management-Theory and practice" seventh Reprint,Tata McGraw-Hill publishing company Limited,2010.
- P.S.Boopathi Manickam "Financial and Management Accounting" PSG publications 2009.
- Don R. Hansen and Maryanne M. Mowen "Cost Management: Accounting and Control, Fifth Edition" Thomson, 2006.
- Michael C . Ehrhardt and Eugene F. Brigham, "Financial Management: Theory and Practice -thirteenth edition" South-Western cengage learning, 2011
- Pandey, "Financial Management", Vikas Publishing House Pvt. Ltd., 2007

- Paramasivan.C, Subramanian.T, “Financial management” New Age international Publishers, 2014.
- https://nptel.ac.in/courses/110101003/
- https://swayam.gov.in/nd1_noc19_mg38/preview
- Website: https://www.youtube.com/watch?v=P9JIBbZas3w

Course Contents and Lecture Schedule

Module No	Topic	No. of Lectures	COs
1	**Accounting**		CO1
1.1	Introduction, Definition, Functions of accounting	1	
1.2	Accounting principles	1	
1.3	Preparation of Financial statements	3	
1.4	Common size statement analysis	1	
1.5	Comparative statement analysis	1	
2	**Cost Accounting**		CO2
2.1	Meaning, importance and Elements of cost	1	
2.2	classification of cost and meaning of Cost centre,	1	
2.3	Preparation of Cost sheet and its applications	3	
2.4	Depreciation – meaning and causes of depreciation	1	
2.5	Methods to find out the depreciation	2	
3	**Budget and Budgetary control**		CO3
3.1	Introduction- Meaning -objectives of budgetary control –	1	
3.2	Budget- Types of budgets and their preparation	4	
4	**Marginal costing**		CO4
4.1	Introduction, Break even analysis	2	
4.2	Managerial uses of breakeven analysis.	1	
4.3	Activity Based Costing	2	
5	**Capital budgeting**		CO5
5.1	Meaning and features, capital budgeting decisions	1	
5.2	Methods of evaluating capital budgeting decisions by traditional and modern methods	4	
5.3	Working capital management – concept, classification,	1	
5.4	Estimation of working capital requirements.	1	
6	**Finance**		CO6
6.1	Functions and Objectives of Financial management	1	
6.2	Source of finance and financial institutions	3	
6.3	Venture capital.	1	
	Total	**37 hrs**	

Course Designers:

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18EC620	CONTROL SYSTEMS	Category	L	T	P	Credit
		PC	2	1	0	3

Preamble

Control Systems plays vital role in the advance of engineering and science. Automatic control has become an important and integral part of modern manufacturing and industrial processes. Advances in the theory and practice of automatic control provide the means for attaining optimal performance of dynamic systems improving productivity.

Prerequisite

18EC340 Signals and Systems, Laplace Transforms

Course Outcomes

On the successful completion of the course students will be able to

CO#	Course Outcome Statement	Weightage in %
CO1	Develop a mathematical model for a given system in Laplace domain and time domain.	10
CO2	Compute transfer function of multiple subsystems modelled as block diagram/ signal flow graph/ state space representation	15
CO3	Compute and describe the output response and steady state error of first, second and higher order systems for standard input signals	20
CO4	Determine the stability of a system using Routh Hurwitz/ Root locus/ Nyquist criterion.	20
CO5	Find the closed loop frequency response and time response parameter given the open loop frequency response.	20
CO6	Design PID controller with frequency response method and computational optimization approach	15

CO Mapping with CDIO Curriculum Framework

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS3	Apply	Value	Guided Response	1.2, 2.1.1, 2.1.2, 2.1.4, 2.1.5, 2.4.1, 2.4.2, 2.4.5, 3.2.3, 3.2.5,
CO2	TPS3	Apply	Value	Guided Response	1.2, 2.1.1, 2.1.2, 2.1.4, 2.1.5, 2.4.1, 2.4.2, 2.4.5, 3.2.3, 3.2.5,
CO3	TPS3	Apply	Value	Guided Response	1.2, 2.1.1, 2.1.2, 2.1.4, 2.1.5, 2.4.1, 2.4.2, 2.4.5, 3.2.3, 3.2.5,
CO4	TPS4	Apply	Value	Mechanism	1.2, 2.1.1, 2.1.2, 2.1.3, 2.1.4, 2.1.5, 2.4.1, 2.4.2, 2.4.5, 3.2.3, 3.2.5,
CO5	TPS4	Apply	Value	Mechanism	1.2, 2.1.1, 2.1.2, 2.1.3, 2.1.4, 2.1.5, 2.4.1, 2.4.2, 2.4.5, 3.2.3, 3.2.5,
CO6	TPS3	Apply	Value	Mechanism	1.2, 2.1.1, 2.1.2, 2.1.3, 2.1.4, 2.1.5, 2.4.1, 2.4.2, 2.4.5, 3.2.3, 3.2.5,

Mapping with Programme Outcomes and Programme Specific Outcomes

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	S	M	L	-	L	-	-	M	M	M	-	L	M	-	M
CO2	S	M	L	-	L	-	-	M	M	M	-	L	M	-	M
CO3	S	M	L	-	L	-	-	M	M	M	-	L	M	-	M
CO4	S	M	L	-	L	-	-	M	M	M	-	L	M	-	M
CO5	S	M	L	-	L	-	-	M	M	M	-	L	M	-	M
CO6	S	M	L	-	L	-	-	M	M	M	-	L	M	-	M

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

Cognitive Levels	Continuous Assessment Tests			Assignment			End Semester Examination
	1	2	3	1	2	3	
Remember	0	0	0	0	0	0	0
Understand	20	20	20	0	30	30	20
Apply	80	80	80	100	40	40	80
Analyse	0	0	0	0	0	0	0
Evaluate	0	0	0	0	0	0	0
Create	0	0	0	0	0	0	0

Assessment Pattern: Psychomotor

Psychomotor Skill	Assignment-1	Assignment-2	Assignment-3
Perception	-	-	-
Set	-	-	-
Guided Response	-	-	-
Mechanism	-	30	30
Complex Overt Responses	-	-	-
Adaptation	-	-	-
Origination	-	-	-

Sample Questions for Course Outcome Assessment

Course Outcome 1 (CO1):

1. Find the transfer function $G(s)=C(s)/R(s)$ corresponding to the differential equation
$$\frac{d^3c}{dt^3}+3\frac{d^2c}{dt^2}+7\frac{dc}{dt}+5c=\frac{d^2r}{dt^2}+4\frac{dr}{dt}+3r$$
2. Find the transfer function relating the capacitor voltage $V_C(s)$ to the input voltage $V(s)$ in Figure.1.

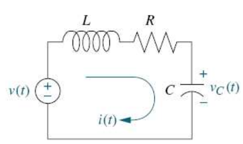


Figure.1

3. Find the state space representation of the transfer function shown in Figure.2.

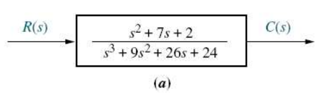


Figure.2.

Course Outcome 2 (CO2):

2. Consider the unit step response of a unity feedback control system whose open loop transfer function is $G(s)=\frac{1}{s(s+1)}$. Determine the rise time, peak time, maximum overshoot and settling time.
3. Compare the rise time, peak time and maximum overshoot of the following systems.
   a. $\frac{C(s)}{R(s)}=\frac{36}{s^2+2s+36}$ b. $\frac{C(s)}{R(s)}=\frac{16}{s^2+6s+16}$
4. If the step response of a network is $1-e^{-\alpha t}$, what is the impulse response?

Course Outcome 3 (CO3):

1. Simplify the block diagram shown in Figure 3, then obtain the closed loop transfer function $C(s)/R(s)$.

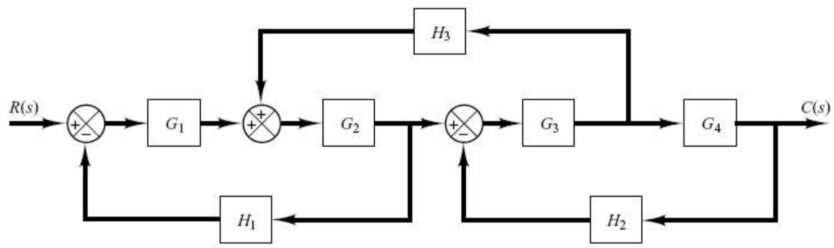


Figure.3

2. Consider the signal flow graph shown in Figure1. The gain X_5/X_1 is

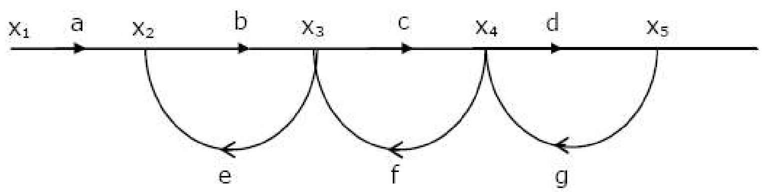


Figure 4.

3. Find the closed loop transfer function $T(s) = C(s)/R(s)$ for the system shown in Figure.5. using block diagram reduction

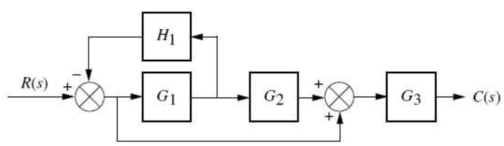


Figure.5.

Course Outcome 4 (CO4):

1. How many poles are in the right half plane, in the left plane and on the $j\omega$ axis for the open loop system of Figure.6.

$$R(s) \rightarrow \boxed{\frac{s^2+4s-3}{s^4+4s^3+8s^2+20s+15}} \rightarrow C(s)$$

Figure.6.

2. In the system of Figure.7, let $G(s) = \dfrac{K(s+2)}{s(s-1)(s+3)}$. Find the range of K for closed loop stability.

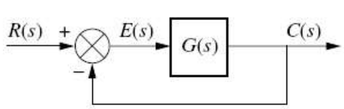


Figure.7.

3. For the system shown in Figure.8. make an accurate plot of the root locus and find the following:
   a. The breakaway and break-in points
   b. The range of K to keep the system stable
   c. The value of K that yields a stable system with critically damped second order poles.

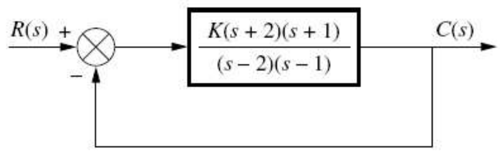


Figure.8.

Course Outcome 5 (CO5):

1. Draw the Bode diagram of the transfer function $G(s)=\dfrac{100(s+1)}{s(s+5)}$.
2. Draw the Polar plot of the transfer function $G(s)=\dfrac{5}{s(s+1)(s+2)}$
3. Design a lag compensator by using frequency response method for the system with open loop transfer function $G(s)=\dfrac{1}{s(s+1)(0.5s+1)}$.

Course Outcome 6 (CO6):

1. Consider the electronic circuit involving two operational amplifiers shown in Figure 9. This is a modified PID controller in that the transfer function involves an integrator and a first-order lag term. Obtain the transfer function of this PID controller.

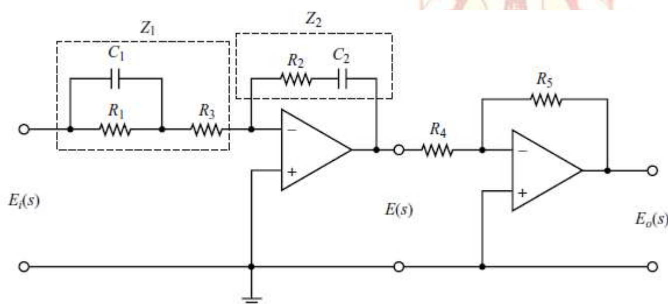


Figure.9

2. In practice, it is impossible to realize the true differentiator. Hence, we always have to approximate the true differentiator $T_d s$ by something like $\dfrac{T_d s}{1+\gamma T_d s}$ One way to realize such an approximate differentiator is to utilize an integrator in the feedback path. Show that the closed-loop transfer function of the system shown in Figure.10 is given by the preceding expression. (In the commercially available differentiator, the value of γ may be set as 0.1.)

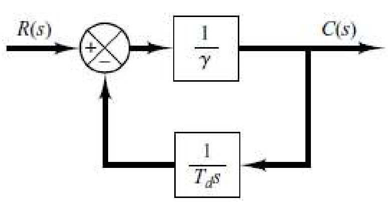


Figure.10

3. Consider the system shown in Figure 11. This is a PID control of a second-order plant $G(s)$. Assume that disturbances $D(s)$ enter the system as shown in the diagram. It is assumed that the reference input $R(s)$ is normally held constant, and the response characteristics to disturbances area very important consideration in this system.

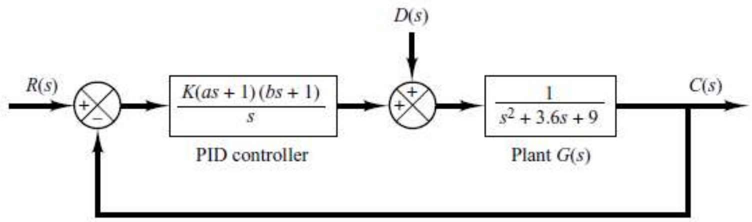
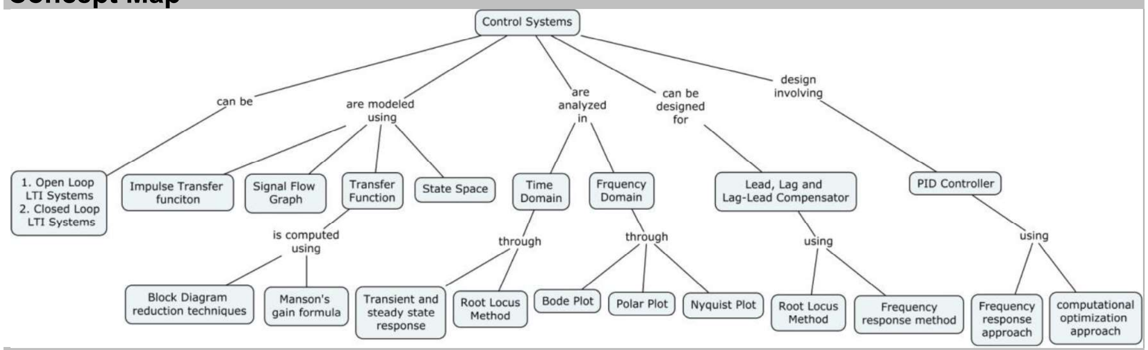


Figure.11

Concept Map



Syllabus

Modeling of Control Systems: Open loop LTI systems, Closed loop LTI systems, Modelling in Laplace Domain, Laplace transform review, transfer function, electrical network transfer function, Electric circuits analogs, Modelling in time domain, general state-space representation, converting a transfer function to state space, converting from state space to a transfer function

Reduction of multiple subsystems: Block diagrams, Analysis and design of feedback systems, signal flow graphs, Mason's rule, signal flow graph of state equation.

Time response: Poles, zeros and system response, First order systems, second order Systems, General second order systems, underdamped second order systems, Higher order systems, System response with additional poles, system response with zeros, Effects of non linearities upon time response

Stability: Routh Hurwitz criterion, Root locus techniques, Nyquist stability

Frequency response techniques: Bode plot, Nyquist diagram, Gain margin, phase margin, transient response via gain adjustment, Lag compensation, Lead compensation, Lag-Lead compensation

PID Controllers: Design of PID controller using frequency response approach and computational optimization approach

Learning Resources

1. Norman Nise, " Control System Engineering" John Wiley & Sons, 6th Edition,2011
2. Katsuhiko Ogata, "Modern Control Engineering", 4th Edition, Prentice Hall,2002
3. Richard C.Dorf and Robert H.Bishop, "Modern Control Systems" Twelfth Edition, Prentice Hall, 2011.
4. https://nptel.ac.in/courses/108101037/
5. https://ocw.mit.edu/courses/aeronautics-and-astronautics/16-30-feedback-control-systems-fall-2010/

Course Contents and Lecture Schedule

No.	Topic	No. of Lectures	COs
1	**Modeling of Control Systems**		
1.1	Open loop LTI systems, Closed loop LTI systems	1	CO1
1.2	Modelling in Laplace Domain, Laplace transform review	1	CO1
1.3	Transfer function	1	CO1
1.4	Electrical network transfer function	1	CO1

1.5	Electric circuits analogs	1	CO1
1.6	Modelling in time domain, general state-space representation	1	CO2
1.7	Converting a transfer function to state space	1	CO2
1.8	Converting from state space to a transfer function	1	CO2
2	**Reduction of multiple subsystems**		
2.1	Block diagrams	1	CO2
2.2	Analysis and design of feedback systems	1	CO2
2.3	signal flow graphs	1	CO2
2.4	Mason's rule	1	CO2
2.5	signal flow graph of state equation	1	CO2
3	**Time response**		
3.1	Poles, zeros and system response	1	CO3
3.2	First order systems, second order Systems	1	CO3
3.3	General second order systems, underdamped second order systems	1	CO3
3.4	Higher order systems	1	CO3
3.5	System response with additional poles	1	CO3
3.6	system response with zeros	1	CO3
3.7	Effects of non linearities upon time response	1	CO3
4	**Stability**		
4.1	Routh Hurwitz criterion	1	CO4
4.2	Root locus techniques	2	CO4
4.3	Nyquist stability	2	CO4
5	**Frequency response techniques**		
5.1	Bode plot	2	CO5
5.2	Nyquist diagram	1	CO5
5.3	Gain margin, phase margin	1	CO5
5.4	Transient response via gain adjustment	1	CO5
5.5	Lag compensation	1	CO5
5.6	Lead compensation	1	CO5
5.7	Lag-Lead compensation	1	CO5
6	**PID Controllers**		
6.1	Design of PID controller using frequency response	2	CO6
6.2	approach and computational optimization approach	1	CO6
	Total	36	

Course Designers:

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18EC630	DATA STRUCTURES AND ALGORITHMS	Category	L	T	P	Credit
		ES	2	0	0	2

Preamble

The study of data structures is important for efficient way of organising big data and implement cost effective algorithms to process the data in solving any real-world application. This course aims at introducing the abstract concepts for data organization and manipulation using data structures such as stacks, queues, linked lists, binary and multi-way trees, heaps, hash tables and graphs. It also discusses about implementation and time complexity of algorithms including various sorting algorithm, graph algorithms and dynamic programming paradigm.

Prerequisite

18EC360 Programming for Problem Solving

Course Outcomes

On the successful completion of the course students will be able to

CO#	Course Outcome Statement	Weightage in %
CO1	Implement linear data structures such as stack, queue, linked lists	25
CO2	Implement non-linear data structures such as binary trees, multi-way trees and priority queues.	30
CO3	Analyze the time complexity of various sorting and hashing algorithms.	15
CO4	Apply dynamic programming and graph algorithms in solving real time problem.	15
CO5	Choose appropriate data structure and algorithms to solve a problem efficiently.	15

CO Mapping with CDIO Curriculum Framework

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS3	Apply	Value	Mechanism	1.1, 2.1.1, 2.1.2, 2.4.3, 4.5.3
CO2	TPS3	Apply	Value	Mechanism	1.1, 2.1.1, 2.1.2, 2.4.3, 4.5.3
CO3	TPS3	Apply	Value	Mechanism	1.1, 2.1.1, 2.1.2, 2.4.3, 4.5.3
CO4	TPS4	Analyze	Organize	Complex Overt Responses	1.1, 2.1.1, 2.1.2, 2.1.3, 2.3.1, 2.4.3, 4.5.3
CO5	TPS4	Analyze	Organize	Complex Overt Responses	1.1, 2.1.1, 2.1.2, 2.1.3, 2.3.1, 2.4.3, 3.1.1, 3.1.2, 3.2.4, 4.5.1, 4.5.3

Mapping with Programme Outcomes and Programme Specific Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	S	M	L	-	M	-	-	-	-	-	-	L	M	-	-
CO2	S	M	L	-	M	-	-	-	-	-	-	L	M	-	-
CO3	S	M	L	-	M	-	-	-	-	-	-	L	M	-	-
CO4	S	S	M	L	M	-	-	-	-	-	-	L	S	-	-
CO5	S	S	M	L	M	-	-	-	S	S	-	L	S	-	L

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

Cognitive Levels	Continuous Assessment Tests			Assignment			End Semester Examination
	1	2	3	1	2	3	
Remember	0	0	0	0	0	0	0
Understand	20	20	20	0	0	0	20
Apply	60	60	60	100	60	60	50
Analyse	20	20	20	0	40	40	30
Evaluate	0	0	0	0	0	0	0
Create	0	0	0	0	0	0	0

Assessment Pattern: Psychomotor

Psychomotor Skill	Assignment-1	Assignment-2	Assignment-3
Perception	-	-	-
Set	-	-	-
Guided Response	-	-	-
Mechanism	-	-	-
Complex Overt Responses	-	-	-
Adaptation	-	-	-
Origination	-	-	-

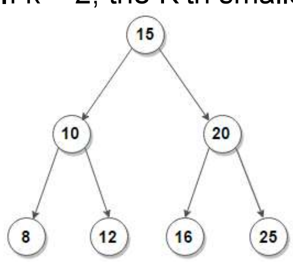
Sample Questions for Course Outcome Assessment

Course Outcome 1 (CO1):

1. Given a linked list, split it into two lists where each list containing alternating elements from the original list. The elements in the new lists may be in any order. For example, if the original list is {a, b, a, b, a}, then one sublist should be {a, a, a} and the other should be {b, b}.
2. Write a program to implement operations of queue using linked list

Course Outcome 2 (CO2):

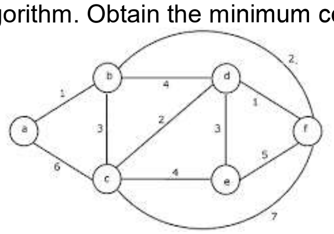
1. Given a Binary Search Tree and a positive number K, find K'th smallest and K'th largest element in BST. For example, consider below binary search tree. If k = 2, the K'th smallest element is 10 and K'th largest element is 20.



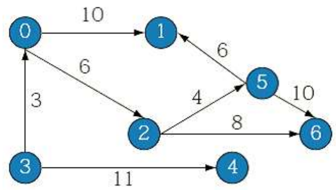
2. Write the algorithm for inserting the keys into a B- tree and insert the keys 12, 9, 6, 3, 15, 56, 36, 34, 28, 45, 74, 71, 60, 55, 1, 5, 7, 4, 24, 27, 50, 52 into a B-tree of order 5. Draw the resultant B-tree after deleting the keys 23, 74, 45, 6, 9 from the constructed tree.

Course Outcome 3 (CO3):

1. Write the procedure to find minimum spanning tree of a graph shown below using Kruskal's algorithm. Obtain the minimum cost using Kruskal's algorithm. (5)



2. Obtain the topological sorting of the process flow of a manufacturing company shown below.



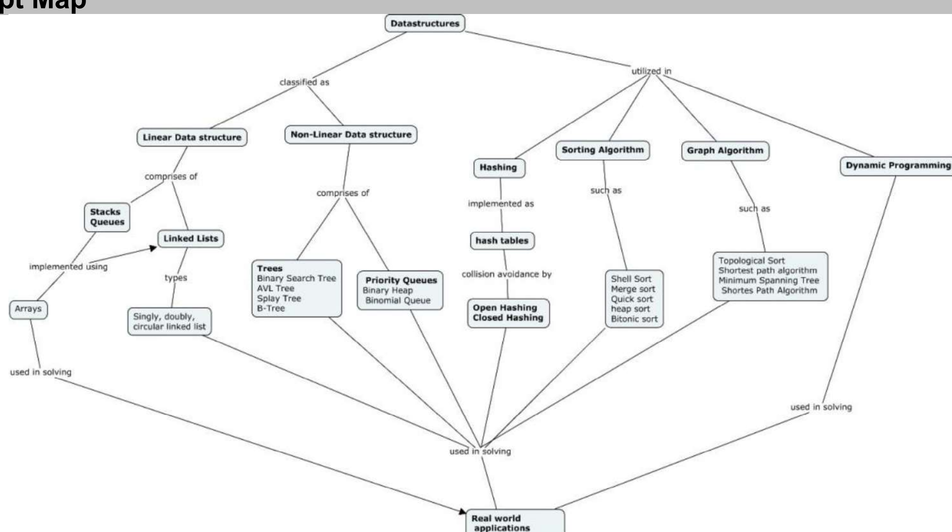
Course Outcome 4 (CO4):

1. Analyze the time complexity of insertion sort if (i) all keys are equal (ii) keys already sorted (iii) keys in descending order
2. Given input keys {55, 45, 66, 77, 95, 98, 79} and a hash function h(x) = x (mod 10), analyze the performance of hashing done by open hashing and closed hashing techniques.

Course Outcome 5 (CO5):

1. Given an arithmetic expression, develop an algorithm to check for matching parenthesis and choose an appropriate data structure to implement the algorithm efficiently.
2. Analyze the efficiency of using singly linked list and doubly linked list for checking whether a given text is palindrome or not.

Concept Map



Syllabus

Overview: Role of data structures and algorithms in data organization, Abstract Data Types, Asymptotic measures, Types of algorithms: Divide and Conquer, greedy, back tracking, dynamic programming, parallel algorithms

Linear Data Structures: Implementation of Stacks, Queues, Linked Lists and applications.

Nonlinear Data Structures: Implementation of Binary Search tree, AVL tree, Splay Tree, B-tree and Priority Queues: Binary Heaps, Binomial heap, applications.

Hashing: Hash tables, Hash functions, Collision Resolution: Open Addressing, Closed Hashing

Sorting Algorithms: Implementation and time complexity analysis of Shell Sort, Quick Sort, Heap sort, Merge Sort, Bitonic sort (parallel algorithm)

Graph Algorithms: Graph Terminologies, Topological Sorting, Shortest Path Algorithms, Minimum Spanning Tree algorithms, Case study on Data science/ Big Data problems modelled as Graph

Dynamic Programming: Elements of dynamic programming, knapsack problem, Longest Common subsequence

Learning Resources

- Mark Allen Weiss, "Data Structures and Algorithm Analysis in C ", 2ndedition, Pearson Education, 2002.
- Lipschutz and G.A.V. Pai, "Data Structures with C", Tata McGraw-Hill, 2010.
- Michael T., Goodrich, "Data Structures and Algorithms in C++", 2nd edition, John Wiley, 2016.
- Sartaj Sahni, "Data Structures, Algorithms and applications in C++", 2nd edition, Silicon Press, 2017.
- Adam Drozdek," Data Structures and Algorithms in C++", 4th edition, Cengage Learning, 2013.
- Michael T., Goodrich, "Data Structures and Algorithms in Python", 2nd edition, John Wiley, 2016.
- Mark Allen Weiss, "Data Structures and Algorithm Analysis in java ", 6th edition, Pearson Education, 2014.
- Nell Dale, "C++ Data structures", 6th edition, Jones and Bartlett Publishers, 2016.
- Cormen, Thomas, Charles Leiserson, et al. *Introduction to Algorithms*. 3rd edition, MIT Press, 2009.
- Coursera course on "Big Data Graph Analytics", https://www.coursera.org/learn/big-data-graph-analytics/home/welcome
- NPTEL course on "Programming, Data Structures And Algorithms Using C", https://nptel.ac.in/noc/courses/noc18/SEM1/noc18-cs25/
- NPTEL course on "Data Structure and Algorithms using Java" - https://onlinecourses.nptel.ac.in/noc20_cs85/

Course Contents and Lecture Schedule

No.	Topic	No. of Hours	Cos
1	**Overview**		
1.1	Role of data structures and algorithms in data organization, Data Abstraction and Abstract Data Types, Asymptotic measures, Types of algorithms: Divide and Conquer, greedy, back tracking, dynamic programming, parallel algorithms	2	CO1
2	**Linear Data structures**		
2.1	Basic operations and applications of Stacks, Queues	3	CO1
2.2	Linked Lists: Single Linked List – Doubly Linked List – Circular Linked	2	CO1
3	**Non-linear Data structures**		
3.1	Basic operations and applications of Binary Search Tree, AVL tree	2	CO2
3.2	Splay Tree, B-tree	2	CO2
3.3	Priority Queues: Binary Heaps, Binomial heap	2	CO2
	Assignment 1: B+ tree, Trie Tree, Red-Black Tree		
4	**Hashing**		
4.1	Hash tables, Hash functions.	1	CO3
4.2	Collision Resolution: Open Addressing, Closed Hashing	1	CO3
5	**Sorting Algorithms**		
5.1	Shell sort, Quick Sort, Heap Sort	2	CO3

5.2	Merge Sort, Bitonic sort (Parallel Algorithm)	1	CO3
	Assignment 2: Parallel Algorithms		
6	**Graph Algorithms**		
6.1	Topological Sorting	1	CO4
6.2	Minimum Spanning Tree Algorithms	1	CO4
6.3	Shortest Path Algorithms	1	CO4
6.4	Case study on Data science/ Big Data problems modelled as Graph	1	CO4
7	**Dynamic Programming**		
7.1	Elements of dynamic programming, knapsack problem	1	CO4
7.2	Longest Common subsequence	1	CO4
	Assignment 3: Real Time Applications of data structures and algorithms in different fields		
	***CO5 covered in complete syllabus**	24	

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18EC660	DIGITAL COMMUNICATION SYSTEM DESIGN

Category	L	T	P	Credit
PC	1	0	2	2

Preamble

The course is offered as theory cum practical course. The objective of this course is to design, simulate and implement a complete digital communication system. The theory part gives the state of the art in digital synchronization for a communication system. The practical part of the course provides hands on training for the students to simulate and implement a complete digital communication system for the transmission of text/image over real time channels.

Prerequisite

18EC580 Analog and Digital Communications Laboratory

Course Outcomes

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

CO#	Course Outcome Statement	Weightage in %
CO1	Describe the functionalities of sub blocks of digital communication system	10
CO2	Design and simulate the mapper, pulse shaper and matched filter for a digital communication transceiver	15
CO3	Determine the tapped delay line model for the wire line channel.	
CO4	Simulate the timing, carrier recovery algorithm for a digital communication system	15
CO5	Design and simulate equalizer and the detector for the digital communication receiver	20
CO6	Implement the complete the digital communication transceiver in Universal Software Radio Peripheral (USRP)	20
CO7	Transmit and receive the given text and image through the digital communication transceiver.	20

CO Mapping with CDIO Curriculum Framework

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS2	Understand	Respond	-	1.2, 2.1.1, 2.1.2, 2.1.3, 2.4.3
CO2	TPS3	Apply	Value	Mechanism	1.2, 2.1.1, 2.1.2, 2.1.3, 2.4.3, 2.4.4, 3.1.1, 3.1.2, 3.2.5, 3.2.6
CO3	TPS3	Apply	Value	Mechanism	1.2, 2.1.1, 2.1.2, 2.1.3, 2.4.3, 2.4.4, 3.1.1, 3.1.2, 3.2.5, 3.2.6
CO4	TPS3	Apply	Value	Mechanism	1.2, 2.1.1, 2.1.2, 2.1.3, 2.4.3, 2.4.4, 3.1.1, 3.1.2, 3.2.5, 3.2.6
CO5	TPS3	Apply	Value	Mechanism	1.2, 2.1.1, 2.1.2, 2.1.3, 2.4.3, 2.4.4, 3.1.1, 3.1.2, 3.2.5, 3.2.6
CO6	TPS3	Apply	Value	Mechanism	1.2, 2.1.1, 2.1.2, 2.1.3, 2.4.3, 2.4.4, 3.1.1, 3.1.2, 3.2.5, 3.2.6, 4.5.3, 4.5.5
CO7	TPS4	Analyze	Organise	Complex Overt Responses	1.2, 2.1.1, 2.1.2, 2.1.3, 2.1.4, 2.1.5, 2.4.3, 2.4.4, 2.4.6, 3.1.1, 3.1.2, 3.2.5, 3.2.6, 4.5.3, 4.5.5

Mapping with Programme Outcomes and Programme Specific Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	S	M	L	-	-	-	-	-	S	-	-	-	M	-	M
CO2	S	M	L	-	S	-	-	M	S	-	-	-	M	-	M
CO3	S	M	L	-	S	-	-	M	S	-	-	-	M	-	M
CO4	S	M	L	-	S	-	-	M	S	-	-	-	M	-	M
CO5	S	M	L	-	S	-	-	M	S	-	-	-	M	-	M
CO6	S	M	L	-	S	-	-	M	S	S	-	-	M	-	S
CO7	S	S	M	L	S	-	-	M	S	S	-	-	M	-	S

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

Cognitive Levels	Continuous Assessment Tests			End Semester Examination
	1	2	3	
Remember	0	0	0	Lab Examination
Understand	20	20	20	
Apply	80	60	60	
Analyse	0	20	20	
Evaluate	0	0	0	
Create	0	0	0	

Assessment Pattern: Psychomotor

Psychomotor Skill	Practical
Perception	-
Set	-
Guided Response	50
Mechanism	50
Complex Overt Responses	-
Adaptation	-
Origination	-

Sample Questions for Course Outcome Assessment

Course Outcome 1 (CO1):

1. Show that $I(X:Y) = H(X) + H(Y) - H(XY)$.
2. Draw the block diagram of digital communication system and explain the individual sub blocks.
3. Consider the four waveforms shown in Figure.1. Determine the dimensionality of the waveform and set of basis functions.

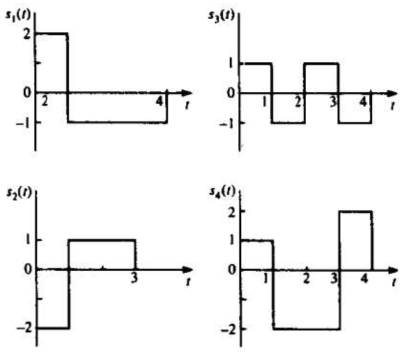


Figure.1

Course Outcome 2 (CO2):

1. Calculate the bandwidth required to transmit data at the rate of 5000bps with the following specification.
    a. 16 QAM constellations filtered with RC pulses of roll off factor=0.5.
    b. 16 QAM constellations filtered with Nyquist pulses
2. For a data rate of 9600 bps data transmission with 4 PAM modulation over a channel with transfer function given by, $C(f) = \frac{1}{1+\left(\frac{f}{2400}\right)^2}$ .Obtain the transmit filter and receive filter frequency response assuming channel compensation at transmitter.
3. For data rate of 4800bps data transmission with 2 PAM modulation over a channel with transfer function given by,

    $$|C(f)| = \frac{1}{\sqrt{1+\left(\frac{f}{W}\right)^2}} \quad |f| \le W$$

    Where W =4800.Obtain the transmit filter and receive filter frequency response assuming compensation at both transmitter and receiver.

Course Outcome 3 (CO3):

1. Suppose that $h(t) = g(t) - 0.5g(t-T)$,is the received pulse, with the transmitted pulse $g(t)$ as unit energy pulse and T as the symbol time. Obtain the equivalent white noise filter model.
2. Given an input sequence $I_n = \{1,1,-1\}$ and the impulse response of the equivalent channel $x(n) = \{1, 0.5\}$ .Determine the noise free output of the channel.
3. The impulse response of a channel is given by $h = \{1, 0.5.0.25\}$ .Determine the sample autocorrelation.

Course Outcome 4 (CO4):

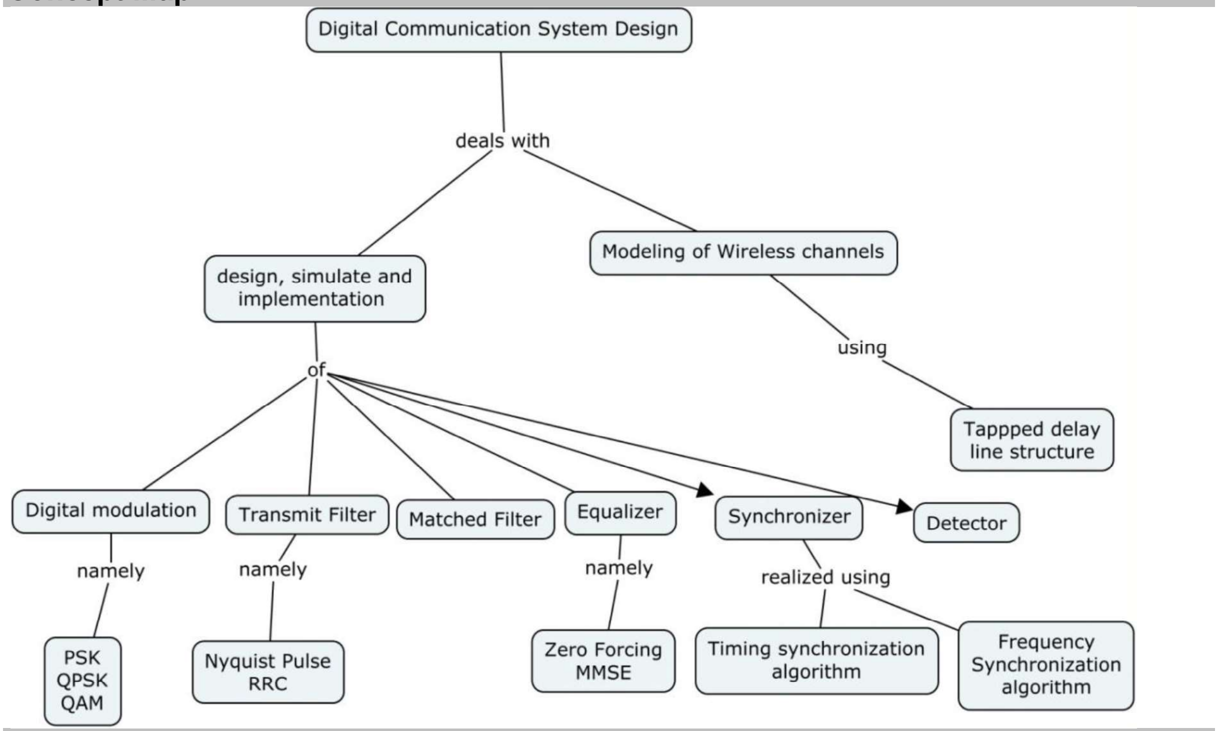
1. In the transmission and reception of signals to and from moving vehicles, the transmitted signal frequency is shifted in direct proportion to the speed of the vehicle. The so called Doppler frequency shift imparted to a signal that is received in a vehicle travelling at a velocity v relative to a fixed transmitter is given by the formula $f_0 = \pm\frac{v}{\lambda}$, where λ is he wavelength and the sign depends on the direction (moving toward or moving away) that the vehicle is travelling relative to the transmitter. Suppose that a vehicle is travelling at a speed of 100 km/h relative to a base station in a mobile cellular communication system. The signal is a narrowband signal transmitted at a carrier frequency 1 GHz.
    a. Determine the Doppler frequency shift.
    b. What should be the bandwidth of a Doppler frequency tracking loop if the loop is designed to track Doppler frequency shifts for vehicles travelling at speeds up to 100 km/h?
2. Repeat the problem (2) if the signal bandwidth is 2 MHz centred at 1 GHz
3. Consider a 600 baud signal with 100 % excess bandwidth. Design a pre-filter for square law timing recovery. Will the pre-filter improve performance?

Course Outcome 5 (CO5):

1. Derive the transfer function of zero forcing equalizer. Consider $X(z) = (1.16 + 0.4z^{-1} + 0.4z)$,
    a. Determine the transfer function and impulse response of the zero forcing equalizer.
    b. Determine the transfer function of equivalent equalizer with whitening filter.

2. Binary PAM is used to transmit information over an un-equalized channel. The noise free un-equalised samples are given as, $\nu_{un}(k)=\left\{0.2, \underset{\uparrow}{0.3}, 0.2\right\}$; Obtain the coefficient of three tap equalizer which gives an output of $\nu_{eq}(k)=\left\{0, \underset{\uparrow}{1}, 0\right\}$;Also find the $\nu_{eq}(k)$ for $k=\pm 2, \pm 3$.
3. Suppose that a three tap MMSE equalizer is used to equalize a channel as shown below. Assume that the white noise density is 0.1.Determine the equalizer coefficients. Also determine the minimum error.

Concept Map



Syllabus

Theory: Digital Communication Transceiver functional block diagram, Review of modulation, pulse shaping and matched filtering, Modelling of wire line channel, Phase Locked Loops, Frequency Synchronization, Timing synchronization, Equalization and detection**,** USRP functional block diagram, realization of transceiver on USRP with wire line channel

Practical

1. Design and simulation of Pulse Shape filters — CO2
2. Design and simulation of Matched filters — CO2
3. Design and simulation of digital Phase Locked Loops — CO2
4. Design and simulation of timing recovery algorithms — CO4
5. Design and simulation of carrier recovery algorithms — CO4
6. Design and simulation of equalizer — CO5
7. Design and simulation of a end to end PSK transceiver — CO6
8. Design and simulation of a end to end QPSK/QAM transceiver — CO6
9. Realization of Transceiver in USRP platform — CO7
10. Text and image transmission using digital modulation techniques in USRP platform — CO7

Learning Resources

- John R. Barry, Edward A. Lee and David G. Messerschmitt, “Digital Communication”, Springer Science & Business Media, 2004.

- John. G. Proakis, Masoud Salehi, “Digital Communication”, McGraw-Hill Education; 5th edition, 2007.
- Heinrich Meyr Marc Moeneclaey Stefan A. Fechtel, “Digital Communication Receivers Synchronization, Channel Estimation, and Signal Processing”, JOHN WILEY & SONS, INC, 1998.
- Umberto Mengali & Aldo N.D.Andrea, “Synchronization techniques for receivers”, Plenum Press, 1997.
- Prof. Suvra Sekhar Das, IIT Kharagpur, Modern Digital Communication Techniques, NPTEL Video Lectures, https://nptel.ac.in/courses/117/105/117105144/

Course Contents and Lecture Schedule

No.	Topic	No. of Hours	COs
1	Digital Communication System Design		
1.1	Digital Communication Transceiver functional block diagram	1	CO1
1.2	Review of modulation	1	CO1
1.3	pulse shaping and matched filtering	2	CO2
1.4	Phase Locked Loops	1	CO2
1.5	Modelling of wire line channel	1	CO3
1.6	Frequency Synchronization	1	CO4
1.7	Timing synchronization	1	CO4
1.8	Equalization and detection	2	CO5
1.9	USRP functional block diagram	1	CO6
1.10	realization of transceiver on USRP with wire line channel	1	CO7
	Total	12	

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18EC670	DATA STRUCTURES AND ALGORITHMS LABORATORY

Category	L	T	P	Credit
ES	0	0	2	1

Preamble

The course is designed to supplement the theory course '18EC630 Data structures and Algorithms' by giving a practical exposure to design and analyse linear and non-linear data structures to the students. The course also provides students to identify and apply the suitable data structure and algorithms for the given real-world problem.

Prerequisite

18EC360 Programming for Problem Solving

Course Outcomes

On the successful completion of the course students will be able to

CO#	Course Outcome Statement	Weightage in %
CO1	Implement linear data structures such as stack, queue and linked link in solving real world application	30
CO2	Implement insertion, removal, search and traversal operations in non-linear data structures such as binary search tree and AVL tree.	10
CO3	Implement insertion, find minimum and remove operations in binary heap data structure.	10
CO4	Implement Hash table with different collision resolution techniques.	10
CO5	Analyse the time complexity of sorting algorithms.	10
CO6	Implement graph algorithms such as topological sorting, minimum spanning tree and shortest path routing algorithm.	10
CO7	Design and implement dynamic programming concepts for solving real world problems.	10
CO8	Choose appropriate data structure and algorithms in implementing a given case study application.	10

CO Mapping with CDIO Curriculum Framework

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS3	Apply	Value	Mechanism	1.1, 2.1.1, 2.1.2, 2.4.3, 4.5.3
CO2	TPS3	Apply	Value	Mechanism	1.1, 2.1.1, 2.1.2, 2.4.3, 4.5.3
CO3	TPS3	Apply	Value	Mechanism	1.1, 2.1.1, 2.1.2, 2.4.3, 4.5.3
CO4	TPS3	Apply	Value	Mechanism	1.1, 2.1.1, 2.1.2, 2.4.3, 4.5.3
CO5	TPS4	Analyze	Organise	Complex Overt Responses	1.1, 2.1.1, 2.1.2, 2.1.3, 2.3.1, 2.4.3, 4.5.3
CO6	TPS3	Apply	Value	Mechanism	1.1, 2.1.1, 2.1.2, 2.4.3, 4.5.3
CO7	TPS3	Apply	Value	Mechanism	1.1, 2.1.1, 2.1.2, 2.4.3, 4.5.3
CO8	TPS4	Analyze	Organise	Complex Overt Responses:	1.1, 2.1.1, 2.1.2, 2.1.3, 2.3.1, 2.4.3, 3.1.1, 3.1.2, 3.2.4, 4.5.1, 4.5.3

Mapping with Programme Outcomes and Programme Specific Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	S	M	L	-	S	-	-	-	-	-	-	-	M	-	-
CO2	S	M	L	-	S	-	-	-	-	-	-	-	M	-	-
CO3	S	M	L	-	S	-	-	-	-	-	-	-	M	-	-
CO4	S	M	L	-	S	-	-	-	-	-	-	-	M	-	-
CO5	S	S	M	L	S	-	-	-	-	-	-	-	S	L	-
CO6	S	M	L	-	S	-	-	-	-	-	-	-	M	-	-
CO7	S	M	L	-	S	-	-	-	-	-	-	-	M	-	-
CO8	S	S	M	L	S	-	-	-	S	S	-	S	S	L	S

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

Cognitive Levels	Model Examination/ Mini Project	End Semester Examination
Remember	-	-
Understand	-	-
Apply	70	70
Analyse	30	30
Evaluate	-	--
Create	-	

Assessment Pattern: Psychomotor

Psychomotor Skill	Practical Component
Perception	-
Set	-
Guided Response	-
Mechanism	-
Complex Overt Responses	-
Adaptation	-
Origination	-

List of Experiments/Activities with CO Mapping

1. a. Implement basic operations on Stack ADT using arrays - CO1
   b. Implement Infix to Postfix conversion using Stack ADT
2. a. Implement operations on Queue ADT using arrays- CO1
   b. Implement Round Robin Scheduling using QueueADT
3. a. Implement insertion, deletion and searching operations in linked list - CO1
   b. Implement Polynomial addition and Josephus problem using Linked Lists
4. Implement insertion, deletion and searching operations in Binary Search Tree - CO2
5. Implement insertion, deletion and searching operations in AVLTree – CO2
6. Implement insertion, Find_Min and delete operation in Binary Heaps– CO3
7. Implement Hash table with different collision resolution Techniques – CO4
8. Analyze time complexity of insertion, merge and quick sort algorithms – CO5
9. Implement the following graph algorithms – CO6
   a. Topological sorting using depth first search,
   b. Minimum Spanning Tree Algorithm using Kruskal's algorithm,
   c. Shortest path algorithm using Dijkstra's Algorithm
10. Implement dynamic programming concept in solving a given problem – CO7
11. **Mini Project -** Given a case study problem identify suitable data structure and algorithm for solving it.- CO8

Learning Resources

- Mark Allen Weiss, "Data Structures and Algorithm Analysis in C ", 2nd edition, Pearson Education, 2002.
- Sartaj Sahni, "Data Structures, Algorithms and applications in C++", 2nd edition, Silicon Press, 2017.
- Michael T., Goodrich, "Data Structures and Algorithms in C++", 2nd edition, John Wiley, 2016.
- Adam Drozdek," Data Structures and Algorithms in C++", 4th edition, Cengage Learning, 2013.
- Michael T., Goodrich, "Data Structures and Algorithms in Python", 2nd edition, John Wiley, 2016.
- Mark Allen Weiss, "Data Structures and Algorithm Analysis in java ", 6th edition, Pearson Education, 2014.
- Bjarne Stroustrup, "The C++ Programming Language", Fourth Edition, Pearson Education, 2013
- NPTEL course on "Programming, Data Structures And Algorithms Using C", https://nptel.ac.in/noc/courses/noc18/SEM1/noc18-cs25/
- NPTEL course on "Data Structure and Algorithms using Java" - https://onlinecourses.nptel.ac.in/noc20_cs85/

Course Designers:

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18ES690	ENGINEERING DESIGN PROJECT	Category	L	T	P	Credit
		Project	1	0	4	3

Preamble

An engineer must understand the economic, social, political, sustainability and environmental contexts in which the need arises. Engineering solutions are always created in response to some societal/industrial need. Understanding the societal/industrial need is central to success in engineering design. Therefore, the engineering students have been assigned on the problem identification phase of engineering design. Now, they have an opportunity to reflect and realise the knowledge that have been gained through the courses such as 18ES150 Engineering Exploration, 18ES290 Lateral Thinking, 18ES390 Design Thinking, 18XX490 Project Management and 18ES590 System Thinking. This course will enable the students to integrate CDIO Skill-based courses and their domain-specific courses. More specifically, by employing the broad knowledge they gain from experiences in foundation elective, general elective and audit courses, students are better equipped to provide engineering solution societal and/or industrial needs.

Prerequisite

Nil

Course Outcomes

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

CO Number	Course Outcome Statement	Weightage in %
CO1	Execute different phases of engineering design project including functional composition and design specification in a team.	20
CO2	Evaluate the alternate engineering design approaches as per the performance criteria with design verification and validation.	20
CO3	Evaluate a design with the use of test verification matrix / Design Failure Mode Effect Analysis (DFMEA)/ Usability testing	15
CO4	Explain the significance of Intellectual Property rights and the procedure for searching and filing a patent.	15
CO5	Exhibit team work with appropriate conflict management strategies.	10
CO6	Prepare appropriate design documents and deliver effective technical presentations	10

CO Mapping with CDIO Curriculum Framework

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS3	Apply	Value	Mechanism	1.1, 1.2, 2.1.1, 3.1.2, 3.2.3, 3.2.6, 4.1.2
CO2	TPS5	Evaluate	Organise	Adaptation	1.1, 1.2, 2.1.2, 2.5.1, 2.5.2, 3.1.2, 3.2.3, 3.2.6, 4.1.2
CO3	TPS5	Evaluate	Organise	Adaptation	1.1, 1.2, 2.1.3, 3.1.2, 3.2.3, 3.2.6, 4.1.2, 4.3.1
CO4	TPS2	Understand	Respond	Guided Response	1.1, 1.2, 2.1.4, 3.1.2, 3.2.3, 3.2.6, 4.1.2, 4.4.1
CO5	TPS3	Apply	Value	Mechanism	1.1, 1.2, 2.1.5, 3.1.2, 3.2.3, 3.2.6, 4.1.2, 4.4.1
CO6	TPS3	Apply	Value	Mechanism	1.1, 1.2, 2.1.4, 3.1.2, 3.2.3, 3.2.6, 4.1.2, 4.4.1

Mapping with Programme Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S	M	L	-	-	M	M	M	S	S	S	S
CO2	S	S	S	M	-	M	M	M	S	S	S	S
CO3	S	S	S	M	S	M	M	S	S	S	S	S
CO4	M	L	-	-	-	M	M	-	-	-	-	S
CO5	S	M	L	-	-	M	M	S	S	S	M	S
CO6	S	M	L	-	-	-	-	S	S	S	-	S

S- Strong; M-Medium; L-Low

Assessment Pattern:

Phases	Deliverables	Marks	Course Outcomes
Continuous Assessment			
Review 1 – Engineering Design Project Selection, functional decomposition and Specification	Technical Report	10	CO1, C06
Review 2 – Evaluation of Design Approaches	Technical Report	20	CO2, CO5, CO6
Review 3 – Design Verification and validation	Technical Report	20	CO3, CO4, CO6
End-Semester Examination			
Demonstration	Prototype	60	CO1, CO2, CO3, CO4 CO5, CO6
Design Portfolio Presentation	Portfolio Document	40	

- Reports are to be submitted at each review. The report and presentation will be evaluated based on customized Rubrics for periodic reviews.
- Demonstration and Design Portfolio presentation will be evaluated by two faculty members nominated by their respective Head of the Department.

Syllabus

Project Selection – Search Phase, Preliminary Design Review (PDR) and Critical Design Review (CDR), Project Specification, Proposal Report, Proposal Presentation

Engineering Design Process - The NASA Design Approach, Design Verification and Validation ,Design Verification Plan – DFMEA, test verification matrix, Usability testing, DRIDS-V Design Approach and Plan

Intellectual Property Rights – Trademarks, Copyrights and Patents, Types of patents, Searching patents, Filing Patents

Team formation and Communication – Types of teams, Team Conflict Management – common causes, cultural styles and conflict, Project Team Evaluation, Conducting Meetings and Making Presentations

Learning Resources

- Harvey F. Hoffman, “The Engineering Capstone Course: Fundamentals for Students and Engineers”, Springer, 2014
- https://sharepoint.ecn.purdue.edu/epics/teams/Public%20Documents/EPICS_Design_Process.pdf?_ga=2.252800138.2089889711.1612784342-1089955741.1612784342

Course Contents and Lecture Schedule

Module No	Topic	No. of Lectures	Course Outcome
1	**Project Selection**		
	Search Phase, Preliminary Design Review (PDR) and Critical Design Review (CDR), Project Specification,	2	CO1, CO6

	Proposal Report, Proposal Presentation		
2	**Engineering Design Process**		
2.1	The NASA Design Approach	1	CO2
2.2	Design Verification and Validation	1	CO2
2.3	Design Verification Plan – DFMEA, test verification matrix, Usability testing,	2	CO3
2.4	DRIDS-V Design Approach and Plan	1	CO3
3	**Intellectual Property Rights**		
3.1	Trademarks, Copyrights and Patents,	1	CO4
3.2	Types of patents, Searching patents,.	1	CO4
3.3	Filing Patents	1	CO4
4	**Team formation and Communication**		
4.1	Types of teams, Team Conflict Management – common causes, cultural styles and conflict,	1	CO5
4.2	Project Team Evaluation, Conducting Meetings and Making Presentations	1	CO5, CO6
	Total	**12**	

Course Designers:

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CURRICULUM AND SYLLABI

FOR

ENGINEERING SCIENCE ELECTIVE COURSES

B.E. DEGREE PROGRAMME

IN

ELECTRONICS AND COMMUNICATION ENGINEERING

FOR THE STUDENTS ADMITTED IN THE

ACADEMIC YEAR 2018-19 ONWARDS

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING
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18ECEA0	MEMS TECHNOLOGY	Category	L	T	P	Credit
		ES	3	0	0	3

Preamble

MEMS has been identified as one of the most promising technologies for the 21st Century and has the potential to revolutionize both industrial and consumer products by combining silicon-based microelectronics with micromachining technology. This course starts with the glimpses of MEMS covering the introduction and origin of MEMS, driving force for MEMS development, commercial applications, fabrication process and packaging techniques. The latter half of the course will be devoted to provide a thumb rule in designing, modelling of micro sensors and micro actuators. They are also exposed to the MEMS CAD tools available in the Design centre. Special weight is given to design circuits and do simulation with Comsol, Intellisuite and Coventorware. By taking this course, students can make good preparations for their research in relevant areas.

Prerequisite

Nil

Course Outcomes

On the successful completion of the course students will be able to

CO Number	Course Outcome Statement	Weightage in %
CO1	Summarize the Concept of miniaturization, need for MEMS in various applications, Micro fabrication techniques	20
CO2	Apply knowledge of micro fabrication techniques to design Micro sensors	20
CO3	Apply knowledge of micro fabrication techniques to design Micro actuators	10
CO4	Apply micro fabrication techniques to design a micro accelerometers	10
CO5	Apply the concepts of micro machining to design devices for diversifying areas	20
CO6	Acquire skills in computer aided design tools for modelling and simulating MEMS device	20

CO Mapping with CDIO Curriculum Framework

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS2	Understand	Respond	-	1.3, 2.4.6
CO2	TPS3	Apply	Value	-	1.3, 2.1.1, 2.1.2, 2.1.3, 2.5.1
CO3	TPS3	Apply	Value	-	1.3, 2.4.6
CO4	TPS3	Apply	Value	-	1.3, 2.1.1, 2.1.2, 2.5.1
CO5	TPS3	Apply	Value	-	1.3, 2.4.6
CO6	TPS3	Apply	Value	-	1.3, 2.1.1, 2.1.2, 2.5.1

Mapping with Programme Outcomes and Programme Specific Outcomes

Cos	PO1	PO2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2	PSO 3
CO1	M	L	-	-	-	-	-	-	-	-	-	-	L	L	L
CO2	S	M	L	-	L	-	-	L	-	L	-	L	L	-	-
CO3	S	M	L	-	L	-	-	L	-	L	-	L	L	-	-
CO4	S	M	L	-	L	-	-	L	-	L	-	L	L	-	-
CO5	S	M	L	-	L	-	-	L	-	L	-	L	L	-	-
CO6	S	M	L	-	L	-	-	L	-	L	-	L	L	-	-

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

Cognitive Levels	Continuous Assessment Tests			Assignment			End Semester Examination
	1	2	3	1	2	3	
Remember	0	0	0	0	0	0	0
Understand	50	40	20	50	0	0	20
Apply	50	60	80	50	100	100	80
Analyse	0	0	0	0	0	0	0
Evaluate	0	0	0	0	0	0	0
Create	0	0	0	0	0	0	0

Assessment Pattern: Psychomotor

Psychomotor Skill	Assignment-1	Assignment-2	Assignment-3
Perception	-	-	-
Set	-	-	-
Guided Response	-	-	-
Mechanism	-	-	-
Complex Overt Responses	-	-	-
Adaptation	-	-	-
Origination	-	-	-

Sample Questions for Course Outcome Assessment

Course Outcome 1(CO1):

1. Tabulate the direct analogy of electrical and mechanical domains.
2. Classify MEMS packages. Based on the need for packaging of MEMS devices classify and differentiate various packaging methodologies.

Course Outcome 2(CO2):

1. With neat diagram explain the functioning of micro pressure sensor.
2. Explain the working principle of a thermal flow sensor.

Course Outcome 3 (CO3):

1. Explain in detail the ink jet printer head and its fabrication process flow in detail.
2. Explain the working principle of micro pumps.

Course Outcome 4 (CO4):

1. Derive a formula for estimating the natural frequency of a micro accelerometer with negligible damping effect.
2. Determine the equivalent spring constant K and natural frequency Wm of a cantilever beam element in a micro accelerometer .The beam is made of silicon with a Young's modulus of 190 MPa, length of the beam is 100um, width is 10um and mass is 10 mg.

Course Outcome 5 (CO5):

1. Discuss the integration of micro optics with MEMS
2. Explain the sensing mechanism used in biomedical micro systems

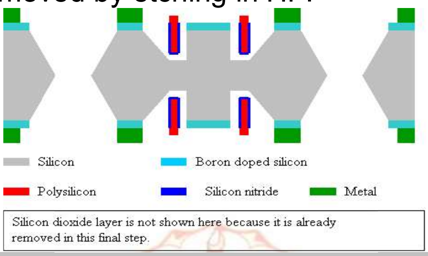
Course Outcome 6(CO6):

1. Discuss the steps involved in developing a micro machined cantilever using any MEMS CAD tool (e.g. Coventorware software)
2. Given the following description of a micro machined accelerometer, draw the step-by-step process flow with cross-section diagrams. For your convenience, the cross-section of the final device is also given below.

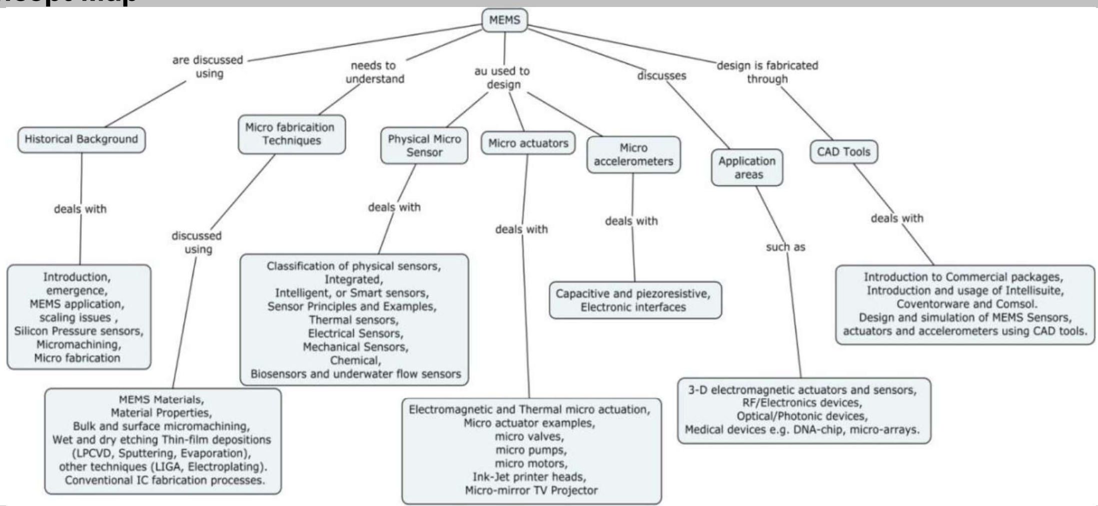
In order to micro fabricate a micro machined accelerometer, combinations of bulk and surface micromachining techniques are used. The process has seven masks and involves double-sided processing utilizing silicon dioxide as a sacrificial layer. The device structure is defined by anisotropic etching at the end of the process.

The process begins with a shallow p++ boron diffusion, defining the proof-mass and supporting rim, on a <100> silicon wafer that is polished on both the sides. Then, 60 um deep trenches are DRIE etched in the silicon and are used later to form the vertical electrodes. The trenches are then refilled completely with a combination of LPCVD silicon dioxide (sacrificial layer), silicon nitride, and doped polysilicon. The polysilicon trench refilling is used to form vertical sense/drive electrodes and high aspect ratio springs to support the proof mass. After polysilicon deposition, annealing is followed to alleviate any compressive stress in the polysilicon.

Next, the polysilicon and nitride films are etched using RIE and another LPCVD silicon dioxide (capping oxide) is deposited. The oxide is patterned to form contact openings to the bulk silicon for the subsequent etch in the EDP. Then, contact metal is electroplated. To minimize the etch-time in the EDP and help undercut the electrodes by the etchant, some of the single-crystal silicon is etched by DRIE. After the DRIE, EDP etch is followed not only to release the proof mass and the supporting rim but also to etch the unnecessary silicon around the sense/drive electrodes. This step is important to achieve high-sensitivity. Finally, the sacrificial oxide layer is removed by etching in HF.



Concept Map



Syllabus

Historical Background: Introduction, emergence, MEMS application, scaling issues, Silicon Pressure sensors, Micromachining, Micro fabrication. **Micro Fabrication Techniques:** MEMS Materials, Material Properties, Bulk and surface micromachining, Wet and dry etching Thin-film depositions (LPCVD, Sputtering, Evaporation), other techniques (LIGA, Electroplating). Conventional IC fabrication processes. **Physical Micro Sensors**: Classification of physical sensors, Integrated, Intelligent, or Smart sensors, Sensor Principles and Examples, Thermal sensors, Electrical Sensors, Mechanical Sensors, Chemical, Biosensors and underwater flow sensors. **Micro Actuators**: Electromagnetic and Thermal micro actuation, Micro actuator examples, micro valves, micro pumps, micro motors, Ink-Jet printer heads, Micro-mirror TV Projector. **Micro Accelerometer**: Capacitive and piezoresistive, Electronic interfaces. **Application Areas:** 3-D electromagnetic actuators and sensors, RF/Electronics devices, Optical/Photonic devices, Medical devices e.g. DNA-chip, micro-arrays. **Computer Aided Design of MEMS:** Introduction to Commercial packages, Introduction and usage of Intellisuite, Coventorware and Comsol, Design and simulation of MEMS Sensors, actuators and accelerometers using CAD tools.

Learning Resources

- Stephen D. Senturia, "Micro system Design" by, Kluwer Academic Publishers, 2001.

- Tai Ran Hsu, MEMS & Micro system Design and Manufacture, Tata McGraw Hill, New Delhi 2002
- Marc Madou, Fundamentals of Micro fabrication, CRC Press, 2ndEdition, 2002.
- Julian W. Gardner and Vijay K. Varadan, Micro sensors, MEMS, and Smart Devices, John Wiley & Sons Ltd, 1stEdition, reprinted 2007
- Fundamentals of Micro fabrication by, CRC Press, 1997.Gregory Kovacs, Micro machined Transducers Sourcebook WCB McGraw-Hill, Boston, 1998.
- M.-H. Bao, Micromechanical Transducers: Pressure sensors, accelerometers, and gyroscopes by Elsevier, New York, 2000.
- http://nptel.ac.in/courses/'MEMS and Micro Systems.

Course Contents and Lecture Schedule

Module No.	Topic	No. of Hours	CO
1.	**Historical Background**		
1.1	Introduction, emergence, MEMS application	1	CO1
1.2	Scaling issues, Micromachining, Micro fabrication, Conventional IC fabrication processes.	1	CO1
1.3	Silicon Pressure sensors	1	CO1
2	**Micro fabrication Techniques:**,		
2.1	MEMS Materials, Material Properties	1	CO1
2.2	Bulk and surface micromachining, Wet and dry etching	1	CO1
2.3	Thin-film depositions (LPCVD, Sputtering, Evaporation),	1	CO1
2.4	LIGA, Electroplating	1	CO1
3	**Physical Micro sensors**		
3.1	Classification of physical sensors, Integrated, Intelligent, or Smart sensors,	1	CO2
3.2	Sensor Principles and Examples, Thermal sensors	2	CO2
3.3	Electrical Sensors, Mechanical Sensors,	1	CO2
3.4	Chemical, Biosensors	1	CO2
3.5	Underwater flow sensors	2	CO2
4	**Micro actuators**		
4.1	Electromagnetic and Thermal micro actuation, Micro actuator examples	1	CO3
4.2	Micro valves, micro pumps, micro motors,3D printing	6	CO3
4.3	Ink-Jet printer heads, Micro-mirror TV Projector	2	CO3
5	**Micro accelerometer** :,		
5.1	Capacitive and piezoresistive	1	CO4
5.2	Electronic interfaces	1	CO4
6	**Application Areas:**		
6.1	3-D electromagnetic actuators and sensors,	1	CO5
6.2	RF/Electronics devices,	1	CO5
6.3	Optical/Photonic devices, Medical devices e.g. DNA-chip, micro-arrays	1	CO5
7	**Computer aided design of MEMS:**		
7.1	Introduction to Commercial packages, Introduction and usage of Intellisuite, Coventorware and Comsol.	2	CO6
7.2	Design and simulation of MEMS Sensors using CAD tools	3	CO6
7.3	Design and simulation of MEMS actuators using CAD tools	3	CO6
7.4	Design and simulation of MEMS accelerometers using CAD tools	3	CO6
	Total hrs	36	

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18ECEB0	FUNDAMENTALS OF MACHINE LEARNING	Category	L	T	P	Credit
		ES	2	1	0	3

Preamble

The objective of this course is to provide the mathematical background necessary for developing Machine Learning Algorithms. In this course, mathematical topics namely linear algebra, analytical geometry, multivariate calculus and probability theory are covered. This course also covers dimensionality reduction, classification, density estimation and regression methods which are the building blocks of machine learning.

Prerequisite

NIL

Course Outcomes

On the successful completion of the course students will be able to

CO#	Course Outcome Statement	Weightage in %
CO1	Calculate the prediction value of particular test data point using probability theory	15
CO2	Determine suitable matrix decomposition method for an intuitive interpretation of the data and more efficient learning	15
CO3	Determine the parameter that maximize the performance measure in machine learning using multivariate calculus	15
CO4	Determine the suitable linear regression function in a diverse range of research areas in machine learning.	15
CO5	Represent the data in compact form with Principal Component Analysis	15
CO6	Represent the characteristics of data compactly using probability distributions	15
CO7	Classify the data using Support Vector Machine	10

CO Mapping with CDIO Curriculum Framework

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS3	Apply	Value	-	1.3, 2.1.1, 2.1.2, 2.4.1, 2.4.2, 3.1.1, 3.1.2
CO2	TPS3	Apply	Value	-	1.3, 2.1.1, 2.1.2, 2.4.1, 2.4.2, 3.1.1, 3.1.2
CO3	TPS3	Apply	Value	-	1.3, 2.1.1, 2.1.2, 2.4.1, 2.4.2, 3.1.1, 3.1.2
CO4	TPS3	Apply	Value	Mechanism	1.3, 2.1.1, 2.1.2, 2.4.1, 2.4.2, 3.1.1, 3.1.2
CO5	TPS3	Apply	Value	Mechanism	1.3, 2.1.1, 2.1.2, 2.4.1, 2.4.2, 3.1.1, 3.1.2
CO6	TPS3	Apply	Value	Mechanism	1.3, 2.1.1, 2.1.2, 2.4.1, 2.4.2, 3.1.1, 3.1.2
CO7	TPS2	Understand	Respond	Guided Response	1.3, 2.1.1, 2.1.2, 2.4.1, 2.4.3

Mapping with Programme Outcomes and Programme Specific Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	S	M	L	-	-	-	-	-	M	-	-	-	M		L
CO2	S	M	L	-	-	-	-	-	M	-	-	-	M	-	L
CO3	S	M	L	-	-	-	-	-	M	-	-	-	M	-	L
CO4	S	M	L	-	M	-	-	-	S	-	-	-	M	-	M
CO5	S	M	L	-	M	-	-	-	S	-	-	-	M	-	M

CO6	S	M	L	-	M	-	-	-	S	-	-	-	M	-	M
CO7	M	L	-	-	M	-	-	-	S	-	-	-	M	-	M

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

Cognitive Levels	Continuous Assessment Tests			Assignment			End Semester Examination
	1	2	3	1	2	3	
Remember	0	0	0	0	0	0	0
Understand	20	20	20	0	0	0	20
Apply	80	80	80	100	50	50	80
Analyse	0	0	0	0	0	0	0
Evaluate	0	0	0	0	0	0	0
Create	0	0	0	0	0	0	0

Assessment Pattern: Psychomotor

Psychomotor Skill	Assignment-1	Assignment-2	Assignment-3
Perception	-	-	-
Set	-	-	-
Guided Response	-	-	-
Mechanism	-	50	50
Complex Overt Responses	-	-	-
Adaptation	-	-	-
Origination	-	-	-

Sample Questions for Course Outcome Assessment

Course Outcome 1 (CO1):

1. Consider a statistical experiment where we model a funfair game consisting of drawing two coins from a bag (with replacement). There are coins from USA (denoted as $) and UK (denoted as £) in the bag, and since we draw two coins from the bag, there are four outcomes in total. Let us assume that the composition of the bag of coins is such that a draw returns at random a $ with probability 0:3. Find the the probability mass function
2. Consider two random variables X and Y, where X has five possible states and Y has three possible states, as shown in Figure.1. We denote by n_{ij} the number of events with state $X = x_i$ and $Y = y_j$ and denote by N the total number of events. The value c_i is the sum of the individual frequencies for the ith column, that is, $c_i = \sum_{j=1}^{3} n_{ij}$. Similarly, the value r_j is the row sum, that is, $r_j = \sum_{i=1}^{5} n_{ij}$. Using these definitions, compactly express the distribution of X and Y .

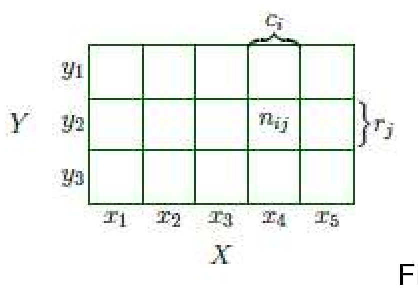


Figure.1

3. Consider a random variable X with zero mean and also $E\left[x^3\right] = 0$. Let $y = x^2$ (hence, Y is dependent on X) . Compute the covariance between X and Y .

Course Outcome 2 (CO2):

1. Compute the determinant of $A=\begin{bmatrix}1&2&3\\3&1&2\\0&0&1\end{bmatrix}$ using the Laplace expansion along the first row.
2. Compute the Eigen values, Eigen vectors and Eigen spaces of the 2×2 matrix $A=\begin{bmatrix}4&2\\1&3\end{bmatrix}$.
3. Determine the orthogonal basis function for the matrix $A=\begin{bmatrix}3&2&2\\2&3&2\\2&2&3\end{bmatrix}$

Course Outcome 3 (CO3):

1. Consider the function in Figure.2 given by $f(x)=\sin(x)+\cos(x)\in C^{\infty}$. Find the Taylor series expansion of f at $x_0=0$.

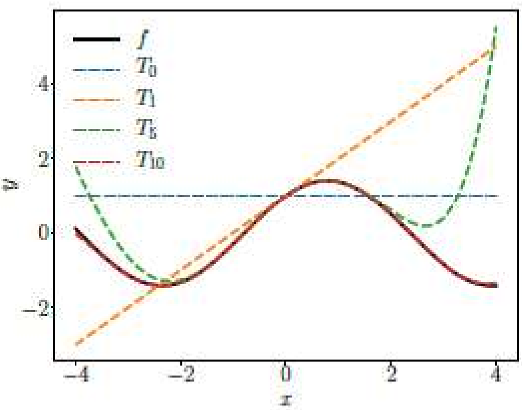


Figure.2

2. Find the gradient for the function $f(x_1,x_2)=x_1^2x_2+x_1x_2^3 \quad \in \mathbb{R}$.
3. Prove the negative entropy of $f(x)=x\log_2 x$ is convex for $x>0$.

Course Outcome 4 (CO4):

1. Find the feature matrix for a second-order polynomial and N training points $x_n \in \mathbb{R}, n=1,\cdots N$.
2. Let $b\in \mathbb{R}^m-\{\mathbf{0}_m\}$ and $y\in \mathbb{R}^m$. Prove that $\|\mathbf{b}r-\mathbf{y}\|$ is minimal when $r=\frac{(\mathbf{y}.\mathbf{b})}{\|\mathbf{b}\|^2}$.
3. Let $B=(\mathbf{b}^1,\cdots \mathbf{b}^n)\in \mathbb{R}^{m\times n}$ be a matrix having orthogonal columns (in other words, $i\neq j$ implies $(b^i,b^j)=0$) such that $m>n$. Prove that
    1. Matrix $\mathbf{B}$ has full rank, that is $rank(\mathbf{B})=n$.
    2. If $\mathbf{r}$ is the solution of the optimization problem that consists in minimizing the function $f(r)=\|\mathbf{Br}-\mathbf{y}\|^2$, then $r_j=\frac{(\mathbf{y}.\mathbf{b}^j)}{\|\mathbf{b}^j\|^2}, 1\leq j\leq n$. In other words, the components of the solution of linear regression do no influence each other.

Course Outcome 5 (CO5):

1. Let us analyze the following 3-variate dataset with 10 observations. Each observation consists of 3 measurements on a wafer: thickness, horizontal displacement, and vertical displacement. $\mathbf{x} = \begin{bmatrix} 7 & 4 & 3 \\ 4 & 1 & 8 \\ 6 & 3 & 5 \\ 8 & 6 & 1 \\ 8 & 5 & 7 \\ 7 & 2 & 9 \\ 5 & 3 & 3 \\ 9 & 5 & 8 \\ 7 & 4 & 5 \\ 8 & 2 & 2 \end{bmatrix}$. Compute the principal factors.

2. Consider a small 3 x 2 matrix, $\begin{bmatrix} 1 & 2 \\ 3 & 4 \\ 5 & 6 \end{bmatrix}$, centers the data in the matrix, calculates the covariance matrix of the centered data, and then the eigen decomposition of the covariance matrix. The eigen vectors and eigen values are taken as the principal components and singular values and used to project the original data.

3. Write a program in python to calculate the Principal Component Analysis on a dataset using the PCA () class in the scikit-learn library.

Course Outcome 6 (CO6):

1. Compute the responsibilities $r_{n,k}$ for the given Figure.3.

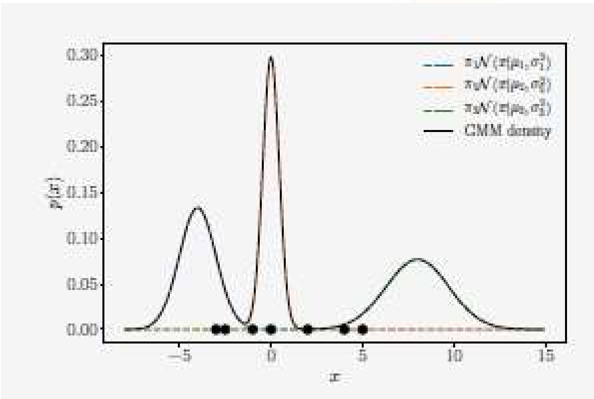


Figure.3

2. Prove the update of the mean parameters $\mu_k, k = 1, \cdots K$ of the Gaussian Mixture Model given by $\mu_k = \dfrac{\sum_{n=1}^{N} r_{nk} x_n}{\sum_{n=1}^{N} r_{nk}}$, where r_{nk} is the responsibilities.

3. Prove the update of the covariance parameters $\sum_k, k = 1, \cdots K$ of the Gaussian Mixture Model given by $\sum_k^{new} = \dfrac{1}{N_k} \sum_{n=1}^{N} r_{nk} \left(\mathbf{x}_n - \mu_k\right)\left(\mathbf{x}_n - \mu_k\right)^T$.

Course Outcomes 7 (CO7):

1. What is the distance between two parallel Hyperplanes $\left\{x \in \Re^n \middle| a^T x = b_1\right\}$ and $\left\{x \in \Re^n \middle| a^T x = b_2\right\}$?
2. Consider the data set D in $\mathbb{R}^2$ shown in Figure.4, where C is a circle centred in (6,4) having radius 3. Define a transformation $\phi : \mathbb{R}^2 \to \mathbb{R}^2$ such that $\phi(D)$ is linearly separable.

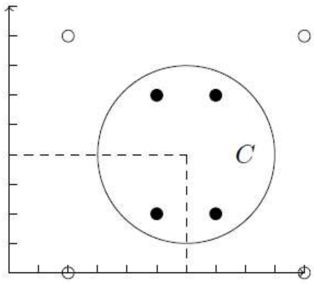
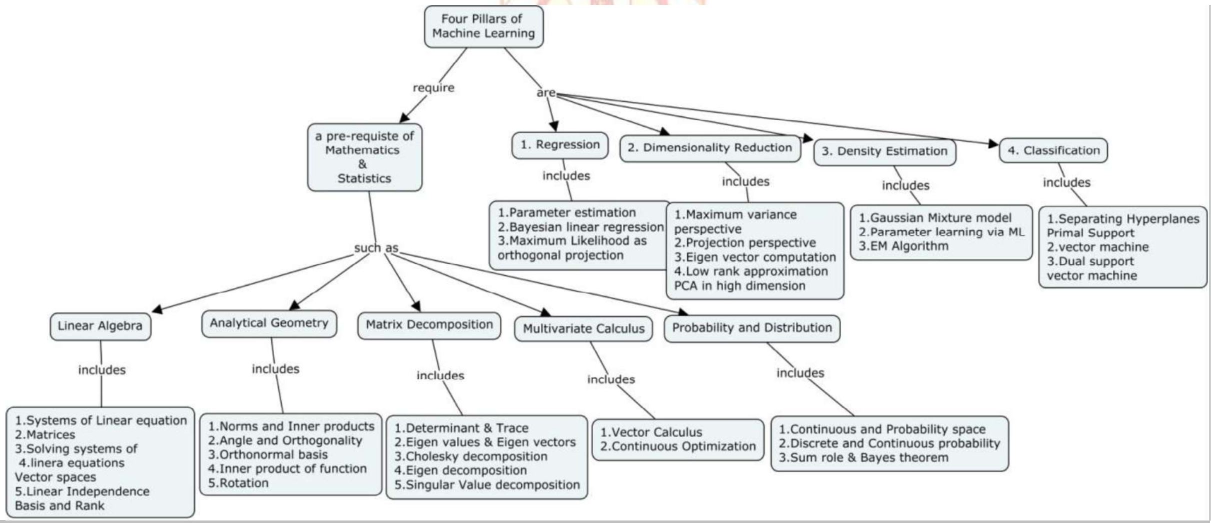


Figure.4

3. Prove that if K is not linearly separable, then K is summable.

Concept Map



Syllabus

Probability and Distribution – Continuous and probability space, Discrete and continuous probability, Sum rule, product rule and Bayes Theorem **Matrix Decomposition-**Determinant and trace, Eigen values and Eigen vectors, Cholesky decomposition, Eigen decomposition, Singular value decomposition **Multivariate Calculus-** Vector Calculus, Continuous optimization **Regression –** Parameter estimation, Bayesian linear regression, Maximum Likelihood as Orthogonal Projection **Dimensionality Reduction with Principal Component Analysis (PCA)** Maximum Variance perspective, Projection perspective, Eigenvector computation and low-rank approximations, PCA in high dimensions **Density Estimation with Gaussian Mixture Models** Gaussian mixture, Parameter learning via Maximum likelihood, EM algorithm **Classification with Support Vector Machines** Separating Hyperplanes, Primal support vector machine, dual support vector machine

Learning Resources

- Marc Peter Deisenroth, A. Aldo Faisal and Cheng Soon Ong , “ Mathematics for Machine Learning”, Cambridge University Press, 2019
- Jason Brownlee, “ Basics of Linear Algebra for Machine Learning”, ebook, 2018
- Alpaydin, Ethem. “Introduction to Machine Learning”, MIT Press, 2010.

- Dan Simovice, "Mathematical Analysis for Machine Learning and Data Mining", World Scientific, 2018.
- Mehryar Mohri, Afshin Rostamizadeh and Ameet Talwalkar, "Foundations of Machine Learning" MIT Press, 2018.

Course Contents and Lecture Schedule

No.	Topic	No. of Hours	COs
1	**Probability and Distribution**		
1.1	Continuous and probability space	1	CO1
1.2	Discrete and continuous probability	1	CO1
1.3	Sum rule, product rule and Bayes Theorem	1	CO1
1.4	Tutorial	1	CO1
2	**Matrix Decomposition**		
2.1	Determinant and trace	1	CO2
2.2	Eigen values and Eigen vectors	1	CO2
2.3	Cholesky decomposition	1	CO2
2.4	Eigen decomposition	1	CO2
2.5	Singular value decomposition	1	CO2
2.6	Tutorial	1	CO2
3	**Multivariate Calculus-**,		
3.1	Vector Calculus	2	CO3
3.2	Continuous optimization	2	CO3
3.3	Tutorial	1	CO3
4	**Regression**,		
4.1	Parameter estimation	1	CO4
4.2	Bayesian linear regression	1	CO4
4.3	Maximum Likelihood as Orthogonal Projection	2	CO4
4.4	Tutorial	1	CO4
5	**Dimensionality Reduction with Principal Component Analysis (PCA)**		
5.1	Maximum Variance perspective	1	CO5
5.2	Projection perspective	1	CO5
5.3	Eigenvector computation and low-rank approximations	2	CO5
5.4	PCA in high dimensions	1	CO5
5.6	Tutorial	1	CO5
6.	**Density Estimation with Gaussian Mixture Models**		
6.1	Gaussian mixture	1	CO6
6.2	Parameter learning via Maximum likelihood	2	CO6
6.3	EM algorithm	1	CO6
6.4	Tutorial	1	CO6
7	**Classification with Support Vector Machines**		
7.1	Separating Hyperplanes	1	CO7
7.2	Primal support vector machine	2	CO7
7.3	dual support vector machine	1	CO7
7.4	Tutorial	1	CO7
	Total	36	

Course Designers:

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18ECEC0	IOT SENSORS AND DEVICE	Category	L	T	P	Credit
		ES	3	0	0	3

Preamble

This course aims to provide students to course learn about the 'things' that get connected in the Internet of Things to sense and interact with the real world environment, and to explore and interact with the IoT bridge betweenthe cyberand physical worlds.

Prerequisite

NIL

Course Outcomes

On the successful completion of the course students will be able to

CO Number	Course Outcome Statement	Weightage in %
CO1	Describe the IoT and Embedded hardware and software.	10
CO2	Demonstrate the ability to incorporate sensors and actuators into a circuit.	20
CO3	Consturuct the IoT Intermediary devices and internet capable link.	10
CO4	Design and sketchprograms using IoT Virtual tool.	20
CO5	Apply the open and closed loop system transfer functions forIoT based system	20
CO6	Design and Test the IoT based system using use case and test case.	20

CO Mapping with CDIO Curriculum Framework

CO#	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS2	Understand	Respond	-	1.3, 2.1.5, 2.2.2, 2.3.1,
CO2	TPS3	Apply	Value	-	1.3, 2.1.5, 2.2.2, 2.3.1, 4.4.3
CO3	TPS2	Understand	Respond	-	1.3, 2.1.5, 2.2.2, 2.3.1,
CO4	TPS3	Apply	Value	-	1.3, 2.1.5, 2.2.2, 2.3.1, 4.4.3
CO5	TPS3	Apply	Value	-	1.3, 2.1.5, 2.2.2, 2.3.1, 4.4.3
CO6	TPS3	Apply	Value	-	1.3, 2.1.5, 2.2.2, 2.3.1, 4.4.3

Mapping with Programme Outcomes and Programme Specific Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	M	L	-	-	-	-	-	-	-	-	-	-	L	-	-
CO2	S	M	L	-	L	-	-	-	L	-	-	L	M	-	-
CO3	M	L	-	-	-	-	-	-	-	-	-	-	L	-	-
CO4	S	M	L	-	L	-	-	-	L	-	-	L	M	-	-
CO5	S	M	L	-	L	-	-	-	L	-	-	L	M	-	-
CO6	S	M	L	-	L	-	-	-	L	-	-	L	M	-	-

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

Cognitive Levels	Continuous Assessment Tests			Assignment			End Semester Examination
	1	**2**	**3**	1	2	3	
Remember	0	0	0	0	0	0	0
Understand	40	40	40	0	0	0	20
Apply	60	60	60	100	100	100	80
Analyse	0	0	0	0	0	0	0
Evaluate	0	0	0	0	0	0	0
Create	0	0	0	0	0	0	0

AssessmentPattern: Psychomotor

Psychomotor Skill	Miniproject/Assignment/Practical Component
Perception	-
Set	-
Guided Response	-
Mechanism	-
Complex Overt Responses	-
Adaptation	-
Origination	-

Sample Questions for Course Outcome Assessment

Course Outcome1 (CO1):

1. Explain the range of IoT and Embedded System.
2. Describe the IoT hardware and software component.
3. Explain the role of an operating system in an IoT device.

Course Outcome2 (CO2):

1. Design a circuit that lights an LED when it is sufficiently dark in a room. Demonstrate the circuit by covering the photo-resistor to darkness.
2. Design a grade separation a highway junction and a pedestrian road junction with a redundant audio alarm and a time and requests the green light by pressing the button the train can be detected by a special optical sensor.
3. Design a mobile robot, which can shoot objects in a basket at different angles in proper selection of sensor and motors and IoT Board.

Course Outcome 3 (CO3):

1. List the Microcontroller based on a set of requirements,
2. Explain the architecture of Microcontroller to Microcontroller communication.
3. Explain the communication between Microcontrollers to Computer/Cloud.

Course Outcome 4 (CO4):

1. Design a circuit and write a program that causes the built-in LED connected to pin 13 on the Arduino to blink, alternating between fast blinks and slow blinks.
2. Design a circuit and write a program that allows the user to control the LED connected to pin 13 of the Arduino. If the user sends the character '1' through the serial monitor then the LED should turn on. If the user sends the character '0' through the serial monitor then the LED should turn off.
3. Design a circuit that contains two push buttons, an LED, and any other basic components, the LED should turn on when either the first button or the second button is pressed.

Course Outcome 5 (CO5):

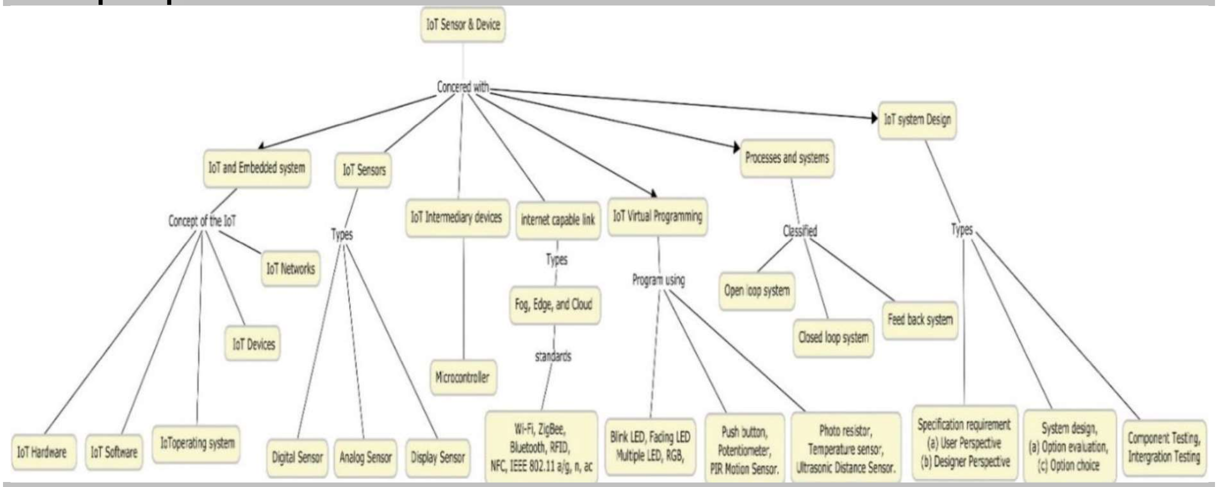
1. Design of an Unmanned Aircraft Vehicle (UAV) apply the both Yaw and Roll, pitch control and find step response, nyquist diagram, and magnitude and phase plot using open loop and closed loop system.
2. Design of an IoT based Temperature monitoring system the different ways IoT systems are controlled using open loop and closed loop system.

Course Outcome 6(CO6):

1. Design of an IoT based agricultural storage monitoring system with block diagram of following draft
    - Specification requirement document in user perspective and designer Perspective.
    - System design and option evaluation, option choice document.
    - Testing of Components and Integration testing document.
2. Design of an IoT based Implementation of Traffic Intersection Interface system with block diagram of following draft
    - Specification requirement document in user perspective and designer Perspective.
    - System design and option evaluation, option choice document.
    - Testing of Components and Integration testing document.
3. Design of an IoT based Temperature monitoring system with block diagram of following draft
    - Specification requirement document in user perspective and designer Perspective.

- System design and option evaluation, option choice document.
- Testing of Components and Integration testing document.

ConceptMap



Syllabus

IoT and Embedded system: Concept of the Internet of Things, Structure of embedded systems and interactions with the physical world, IoT hardware and software component, Role of an operating system in an IoT device, Networking enables devices and small local networks of IoT devices. **IoT Sensors:** Differentiate between different sensor types and application areas for a selected range of sensors and actuators, Incorporation sensors and actuators into a circuit. **IoT Intermediary devices and internet capable link:** Microcontroller based on a set of requirements, Communication protocols, Microcontroller to Microcontroller communication, Microcontroller to Computer/Cloud communication, Fog, Edge, and Cloud processing, Cellular networks, **IoT Virtual Programming:** Blink an LED with digital output, Blink multiple LED, Fading LED with Analog outputs, RGB LED Colour Mixing, Digital Input / Analog output, Push button, Potentiometer using serial monitor, PIR Motion Sensor, Photo resistor, Temperature sensor, Ultrasonic Distance Sensor. **Processes and systems:** Concept of both open loop and closed loop systems, Inputs, outputs, control and feedback for a system, Different ways that systems are controlled. **IoT based system Design:** Specification requirement document in user perspective and designer Perspective, System design and option evaluation, option choice document, Testing of Components and Integration testing, virtual circuit software tool to solve IoT problems.

Learning Resources

- Adrian McEwen, Hakim Cassimally "Designing the Internet of Things", Wiley Publishing,2015
- Arshdeep Bahga and Vijay Madisetti, "Internet of Things: A Hands-on Approach", 2015 Web link : https://www.universitiespress.com/details?id=9788173719547
- Sudip Misra, IIT- Kharagpur, swayam course on " Introduction to Internet of Things" https://swayam.gov.in/nd1_noc20_cs66/preview
- Ian Harris, Professor, University of California, Irvine, Coursera, Course on "Introduction to the Internet of Things and Embedded Systems"
- Iain Murray, Cesar Ortega-Sanchez, Sivas' Khaksar, Curtin University, Perth, Edx course on "IOT2x – IoT Devices and Sensors"
- Online-Virtual circuit software tool web link: https://www.tinkercad.com/learn/project-gallery;collectionId=OMOZACHJ9IR8LRE
- Kallol Bosu Roy Choudhuri "Learn Arduino Prototyping in 10 days - Your crash course to build innovative devices" Packt Publishing, 2017.

Course Contents and Lecture Schedule

Module No.	Topic	No. of Hours	Course Outcome
1	**IoT and Embedded system**		
1.1	Concept of the Internet of Things.	1	CO1
1.2	Structure of embedded systems.	1	CO1
1.3	IoT Interactions with the physical world.	1	CO1
1.4	IoT hardware and software component.	1	CO1
1.5	Role of an operating system in an IoT device.	1	CO1
1.6	Networking enables devices.	1	CO1
1.7	Small local networks of IoT devices.	1	CO1
2	**IoT Sensors**		
2.1	Differentiate between different sensor types	3	CO2
2.2	Application areas for a selected range of sensors and actuators	3	CO2
2.3	Incorporate sensors and actuators into a circuit	3	CO2
3.	**IoT Intermediary devices and internet capable link**		
3.1	Microcontroller based on a set of requirements.	1	CO3
3.2	Communication protocols.	1	CO3
3.3	Microcontroller to Microcontroller communication.	1	CO3
3.4	Microcontroller to Computer/Cloud communication.	1	CO3
3.5	Fog, Edge, and Cloud processing.	2	CO3
4	**IoT Virtual Programming**		
4.1	Blink an LED with digital output, Blink multiple LED.	1	CO4
4.2	Fading LED with Analog outputs, RGB, LED Colour Mixing.	1	CO4
4.3	Digital Input / Analog output, Push button, Potentiometer using serial monitor.	1	CO4
4.4	PIR Motion Sensor and Photo resistor, Temperature sensor, Ultrasonic Distance Sensor	2	CO4
5	**Processes and systems**		
5.1	Concept of open loop and closed loop systems, Inputs, outputs, control and feedback for a system.	2	CO5
5.2	Different ways that systems are controlled	1	CO5
6	**IoT system Design**		
6.1	Specification requirement in user and designer perspective,	2	CO6
6.2	System design and option evaluation, option choice and Testing of Components and Integration testing.	2	CO6
6.3	Virtual circuit software tool to solve IoT problems.	2	CO6
	Total No. of Hours	36	

Course Designers:

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18ECED0	BLOCKCHAIN TECHNOLOGY	Category	L	T	P	Credit
		ES	3	0	0	3

Preamble

Blockchain is an emerging technology platform for developing decentralized applications and data storage. This course includes the fundamental design and architectural primitives of Blockchain, the system and the security aspects, along with consensus mechanisms, crypto currencies, smart contracts, and problems of blockchain. The applications of Blockchain have now spread from crypto-currencies to various other domains, including business process management, smart contracts, IoT, trustworthy e-governance and so on.

Prerequisite

NIL

Course Outcomes

On the successful completion of the course students will be able to

CO Number	Course Outcome Statement	Weightage in %
CO1	Determine the role of Hash functions, digital signature and distribution systems as blockchain primitives	15
CO2	Describe the operations of crypto-currencies, Bitcoin and Ethereum	10
CO3	Apply the distributed consensus mechanisms of proof of work and proof of stake	15
CO4	Use the scripting language to write smart contracts and blockchain platforms to develop hyperledgers	20
CO5	Analyze the privacy, security and scalability problems of blockchain	20
CO6	Build the Blockchain use cases in finance, industry, IoT and e-governance,	20

CO Mapping with CDIO Curriculum Framework

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS3	Apply	Value	-	1.3, 2.1.1, 2.1.5
CO2	TPS2	Understand	Respond	-	1.3, 2.2.2
CO3	TPS3	Apply	Value	-	1.3, 2.1.1, 2.1.5
CO4	TPS3	Apply	Value	-	1.3, 2.1.1, 2.3.1, 3.2.4
CO5	TPS4	Analyze	Organise	-	1.3, 2.1.1, 2.1.5, 2.2.2, 2.3.1, 3.2,6
CO6	TPS3	Apply	Value	-	1.3, 2.1.5, 2.2.2, 3.2.6

Mapping with Programme Outcomes and Programme Specific Outcomes

Cos	PO 1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	S	M	L	-	-	-	-	-	-	-	-	L	M	-	-
CO2	M	L	-	-	-	-	-	-	-	-	-	-	L	-	-
CO3	S	M	L	-	-	-	-	-	-	-	-	L	M	-	-
CO4	S	M	L	-	S	-	-	-	-	L	-	L	M	-	L
CO5	S	S	M	L	-	-	-	-	-	L	-	M	S	-	L
CO6	S	M	L	-	L	-	-	-	-	M	-	L	M	-	M

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

Cognitive Levels	Continuous Assessment Tests			Assignment			End Semester Examination
	1	2	3	1	2	3	
Remember	15	0	0	0	0	0	0
Understand	25	40	30	0	0	0	30
Apply	60	60	50	100	100	70	50
Analyse	0	0	20	0	0	30	20
Evaluate	0	0	0	0	0	0	0
Create	0	0	0	0	0	0	0

Assessment Pattern: Psychomotor

Psychomotor Skill	Assignment-1	Assignment-2	Assignment-3
Perception	-	-	-
Set	-	-	-
Guided Response	-	-	-
Mechanism	-	-	-
Complex Overt Responses	-	-	-
Adaptation	-	-	-
Origination	-	-	-

Sample Questions for Course Outcome Assessment

Course Outcome 1 (CO1):

1. Describe the requirements and characteristics of hash function.
2. User A wants to digitally sign his/her document to user B by using the global parameters, prime number p = 71 and its primitive root, alpha = 2. The signed document needs to be verified by user B. Assume that user A's private key, X_A is 7, the random value k is 3 and its message is 10. Verify user A's digital signature in user B using appropriate public key method.
3. Consider an Elliptic Curve signature scheme. We have a global elliptic curve, prime p, and "generator" G. Alice picks a private signing key X_A and forms the public verifying key $Y_A = X_AG$. To sign a message M: Alice picks a value k. Alice sends Bob M, k and the signature $S = MkX_AG$. Bob verifies that $M = S + kY_A$.
   a. Show that this scheme works. That is, show that the verification process produces equality if the signature is valid.
   b. Show that the scheme is unacceptable by describing a simple technique for forging a user's signature on an arbitrary message.

Course Outcome 2 (CO2):

1. Explain design principles of Bitcoin and Ethereum.
2. Compare Blockchain, Crypto-currency and Token.
3. How to find a transaction in Blockchain and compare the types on blockchains.

Course Outcome 3 (CO3):

1. Design and deploy a distributed application.
2. Distinguish between proof-of-work and proof-of-stake consensus and write their security implications.
3. Explain the process of mining and how do miners make money?

Course Outcome 4 (CO4):

1. Write smart contracts for various transactions and explain why this is revolutionary and different from legal documents?
2. Develop a simple application using Solidity.
3. Develop projects using Hyperledger fabric platform, Plug-and-play platform

Course Outcome 5 (CO5):

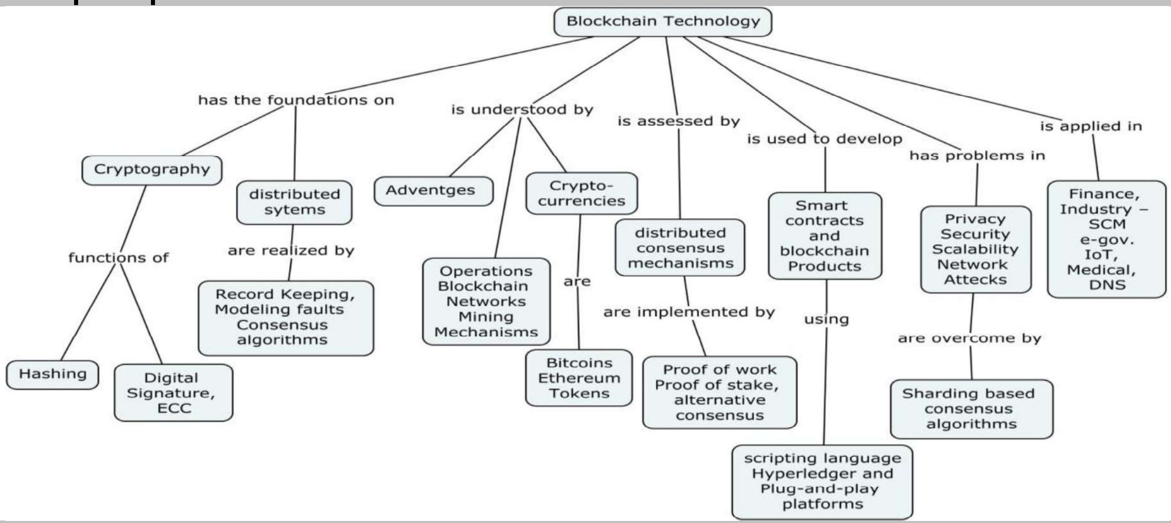
1. How is scalability problem resolved?
2. Examine the security issues, failed currencies & blockchains and protection from attackers.

3. Evaluate security, privacy, and efficiency of a given blockchain system.

Course Outcome 6 (CO6):

1. How will you create your own blockchain and explain the necessary steps needed.
2. Design a use case for blockchain in a business case or area of interest. What problem is this trying to solve? What is the value proposition of solving this problem? How will a blockchain be applied to this use case? Which component pieces will be utilized?
3. Design Blockchain use cases for the following:
   i. Digital Rights - ownership and accessibility, education
   ii. Industry - healthcare, identity, finance
   iii. Paradigm shift/future/big picture
   iv. Elections and Voting: Auto execution of contracts, escrow, etc.

Concept Map



Syllabus

Cryptographic primitives in Blockchain: Secure, Collision-resistant hash functions, digital signature, public key cryptosystems - encryption schemes and elliptic curve cryptography, verifiable random functions, zero-knowledge proof systems **Distributed System concepts:** Need for Distributed Record Keeping, Modeling faults and adversaries, Consensus algorithms - scalability problems and distributed consensus **Blockchain 1.0:** Advantages over conventional distributed database, Blockchain Network, private and public, Mining Mechanism, Bitcoin blockchain, the challenges, operations and solutions, contemporary proof-of-work based consensus mechanisms, Proof of stake, alternatives to Bitcoin consensus, crypto-currency, Bitcoin scripting language and their use **Blockchain 2.0:** Ethereum and smart contracts and Turing complete blockchain scripting – Solidity, issues of correctness and verifiability, Ethereum platform and its smart contract mechanism **Blockchain 3.0:** Hyperledger fabric platform, Plug-and-play platform and mechanisms for consensus and smart contract evaluation engines **Beyond Crypto-currency:** Privacy, Security issues in Blockchain: Pseudo-anonymity vs. anonymity, Zcash and Zk-SNARKS for anonymity preservation, attacks on Blockchains – Sybil attacks, selfish mining and Sharding based consensus algorithms **Blockchain Use Cases:** Finance, Industry – supply chain management, e-governance, Land Registration, Internet of Things, Medical Record Management System, and Domain Name Service

Learning Resources

- Arvind Narayanan, Joseph Bonneau, Edward Felten, Andrew Miller, and Steven Goldfeder, “Bitcoin and Cryptocurrency Technologies: a comprehensive introduction”, Princeton University Press, 2016.
- S.Shukla, M.Dhawan, S.Sharma, S.Venkatesan, “Blockchain Technology: Cryptocurrency and Applications”, Oxford University Press, 2019.

- Josh Thompson, "Blockchain: The Blockchain for beginners guide to Blockchain technology and Blockchain programming", Create Space Independent Publishing Platform, 2017.
- Andreas M. Antonopoulos, "Mastering Bitcoin: Unlocking Digital Cryptocurrencies", O'Reilly Media, 2014.
- Gavin Wood, "ETHEREUM: A Secure Decentralized Transaction Ledger", Yellow paper, 2014.
- Nicola Atzei, Massimo Bartoletti, and Tiziana Cimoli, "A survey of attacks on Ethereum smart contracts" IACR Cryptology ePrint Arch., 2016.
- NPTEL Course on Blockchain architecture design and use cases:
- https://nptel.ac.in/courses/106/105/106105184/
- NPTEL Course on Introduction to Blockchain technology and applications: https://nptel.ac.in/courses/106/104/106104220/#
- Virtual Lab: http://vlabs.iitb.ac.in/vlabs-dev/labs/blockchain/

Course Contents and Lecture Schedule

No.	Topic	No. of Hours	COs
1	**Primitives in Blockchain**		
1.1	Secure, Collision-resistant hash functions, Properties	1	CO1
1.2	Hash Algorithms	1	CO1
1.3	Digital Signature, public key cryptosystems - encryption schemes	2	CO1
1.4	Elliptic Curve Cryptography	1	CO1
1.5	verifiable random functions, zero-knowledge proof systems	1	CO1
1.6	Distributed System concepts - Need for Distributed Record Keeping,	2	CO1
1.7	Modeling faults and adversaries,	1	CO1
1.8	Consensus algorithms - scalability problems and distributed consensus	1	CO1
2	**Blockchain 1.0**		
2.1	Blockchain Networks - private and public	1	CO2
2.2	Mining Mechanism, Bitcoin blockchain, the challenges, operations and solutions	2	CO2
2.3	contemporary proof-of-work based consensus mechanisms, Proof of stake	2	CO3
2.4	alternatives to Bitcoin consensus, crypto-currency	1	CO2
2.5	Bitcoin scripting language and their use	1	CO2
3	**Blockchain 2.0**		
3.1	Ethereum and smart contracts	1	CO3
3.2	Turing complete blockchain scripting – Solidity	2	CO3
3.3	Issues of correctness and verifiability	1	CO3
3.5	Ethereum platform and its smart contract mechanism	1	CO3
4	**Blockchain 3.0**		
4.1	Hyperledger fabric platform	2	CO4
4.2	Plug-and-play platform	1	CO4
4.3	mechanisms for consensus and smart contract evaluation engines	1	CO4
5	**Beyond Crypto-currency**		
5.1	Privacy, Security issues in Blockchain, Pseudo-anonymity vs. anonymity	1	CO5
5.2	Zcash and Zk-SNARKS for anonymity preservation	1	CO5
5.3	Attacks on Blockchains – Sybil attacks, selfish mining	1	CO5
5.4	Sharding based consensus algorithms	2	CO5

6.	**Blockchain Use Cases**		
6.1	Finance, Industry – supply chain management	2	CO6
6.2	e-governance, Land Registration	1	CO6
6.3	IoT, Medical Record Management System, and Domain Name Service	2	CO6
	Total Hours	36	

Course Designers:

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- Dr. M.S.K. Manikandan manimsk@tce.edu
- Dr. S. Ponmalar spmece@tce.edu

18ECEE0	5G WIRELESS NETWORKS	Category	L	T	P	Credit
		ES	3	0	0	3

Preamble

The objective of this course is to introduce the students with a comprehensive understanding of current and 5G wireless Networks that includes 5G Fundamentals with its architecture, small cells, 5G Internets with Internet of Things and Software Defined Network. This course also includes cloud network and Security challenges in 5G network

Prerequisite

NIL

Course Outcomes

On the successful completion of the course students will be able to

CO#	Course Outcome Statement	Weightage in %
CO1	Discuss the concepts of current mobile networks and 5G networks	10
CO2	Demonstrate the ten pillars of 5G	10
CO3	Use the role play of Internet of Things and Software Defined Network and Resource Provisioning in 5G Technology	30
CO4	Determine capacity limits and Data Demands to identify the characteristics of small cells in 5G Networks.	20
CO5	Describe the concepts behind Mobile clouds and Mobile cloud enablers	15
CO6	Examine the Security Issues and Challenges in 5G Systems	15

CO Mapping with CDIO Curriculum Framework

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS2	Understand	Respond	-	1.3, 2.1.1, 2.1.5
CO2	TPS3	Apply	Value	-	1.3, 2.1.1, 2.2.2, 2.1.5, 3.2.6
CO3	TPS3	Apply	Value	-	1.3, 2.1.1, 2.2.2, 2.1.5, 3.2.6
CO4	TPS3	Apply	Value	-	1.3, 2.1.1, 2.2.2, 2.1.5, 3.2.6
CO5	TPS2	Understand	Respond	-	1.3, 2.2.2, 2.3.1
CO6	TPS4	Analyze	Organise	-	1.3, 2.1.1, 2.1.5, 3.2.6

Mapping with Programme Outcomes and Programme Specific Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	M	L	-	-	-	-	-	-	-	-	-	-	L	-	-
CO2	S	M	L	-	-	-	-	-	-	L	-	-	M	-	-
CO3	S	M	L	-	-	-	-	-	-	L	-	-	M	-	-
CO4	S	M	L	-	-	-	-	-	-	-	-	-	M	-	-
CO5	M	L	-	-	-	-	-	-	-	-	-	-	L	-	-
CO6	S	S	M	L	-	-	-	-	-	L	-	-	S	-	-

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

Cognitive Levels	Continuous Assessment Tests			Assignment			End Semester Examination
	1	2	3	1	2	3	
Remember	30	20	0	0	0	0	0
Understand	40	40	50	0	0	0	40
Apply	30	40	30	100	100	70	40
Analyse	0	0	20	0	0	30	20
Evaluate	0	0	10	0	0	0	10
Create	0	0	0	0	0	0	0

Assessment Pattern: Psychomotor

Psychomotor Skill	Assignment-1	Assignment-2	Assignment-3
Perception	-	-	-
Set	-	-	-
Guided Response	-	-	-
Mechanism	-	-	-
Complex Overt Responses	-	-	-
Adaptation	-	-	-
Origination	-	-	-

Sample Questions for Course Outcome Assessment

Course Outcome 1(CO1):

1. Determine the challenges posed by these 5G wireless systems?
2. Discuss the specifications of different generation of wireless Systems.
3. Explain how cellular systems evaluate towards 5G communication systems?

Course Outcome 2(CO2):

1. Explain the ten pillars of 5G wireless Networks
2. Discuss the evolution of Existing RATs.
3. How Self organizing networks work in 5G Networks?

Course Outcome 3(CO3):

1. Using IoT, how 5G network is enabled?
2. Discuss the operation of SDN with example
3. How Network function virtualization works in 5G Networks?

Course Outcome 4 (CO4):

1. Compare different small cells types
2. Based on deployments, how cells are works in 5G networks?
3. Why Wi-Fi and Femto cells as candidates for 5G technology?

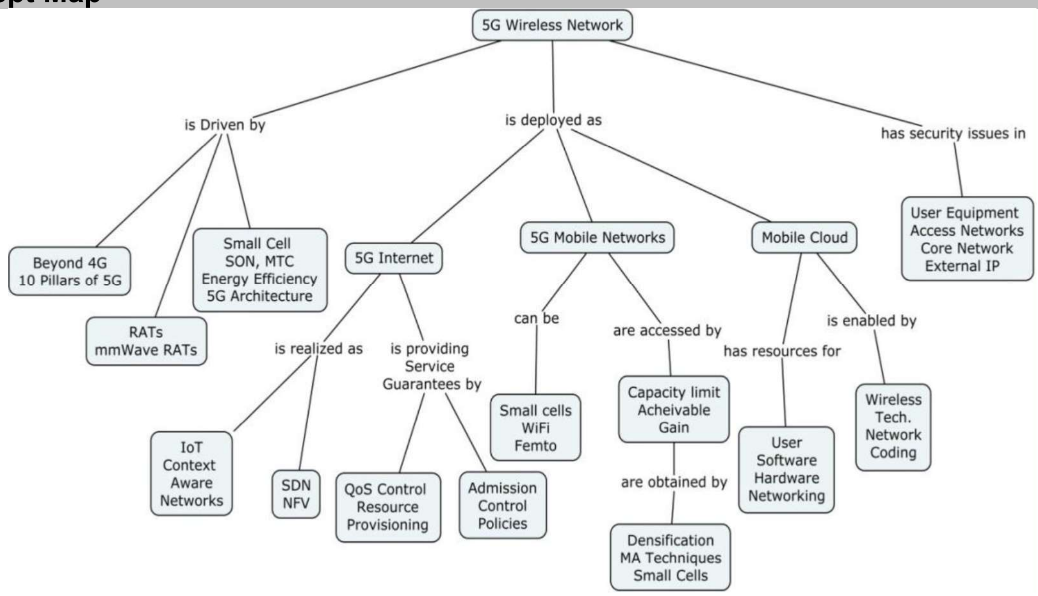
Course Outcome 5 (CO5):

1. How cooperation modes work in mobile user domain?
2. Examine wireless technologies from short range to wide area.
3. Explain with example, how mobile cloud participants share their resources in 5G Networks?

Course Outcome 6(CO6):

1. Discuss the security challenges in 5G Networks
2. How Mobile Botnets are functioning in 5G Networks?
3. How Femto cells attacks are overcome in 5G Networks?

Concept Map



Syllabus

Drivers for 5G: Historical Trend of Wireless Communications, Evolution of LTE Technology to Beyond 4G 5G Roadmap, 10 Pillars of 5G- Evolution of Existing RATs, Hyperdense Small Cell Deployment, Self Organising Network, Machine Type Communication, Developing Millimetre Wave RATs, Redesigning Backhaul Links, Energy Efficiency, Allocation of New Spectrum for 5G, Spectrum Sharing, 5G Architecture. **The 5G Internet:** Internet of Things - Context Awareness Networking Reconfiguration and Virtualisation Support -Software Defined Networking ,Network Function Virtualisation , Mobility-An Evolutionary Approach from the Current Internet, A Clean Slate Approach Quality of Service Control-Network Resource Provisioning, Aggregate Resource Provisioning, Emerging Approach for Resource Over• Provisioning -Control Information Repository, Service Admission Control Policies ,Network Resource Provisioning ,Control Enforcement Functions Network Configurations , Network Operations **Small Cells for 5G Mobile Networks:** Small Cells- Wi-Fi and Femto cells as Candidate Small Cell Technologies, Wi-Fi and Femto Performance – Indoors Vs. Outdoors, Capacity Limits and Achievable Gains with Densification- Gains with Multi Antenna Techniques, Gains with Small Cells, Mobile Data Demands-Approach and Methodology, Demand vs Capacity, Small Cell Challenges **Mobile Clouds: Technology and Services for Future Communication Platforms:** The Mobile Cloud-User Resources, Software Resources, Hardware Resources, Networking Resources, Mobile Cloud Enablers-The Mobile User Domain, Wireless Technologies Software and Middleware, Network Coding. **Security for 5G Communications:** Overview of a Potential 5G Communications System Architecture , Security Issues and Challenges in 5G Communications Systems- User Equipment, Access Networks, Mobile Operator's Core Network , External IP Networks

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Learning Resources

- Jonathan Rodriguez, Fundamentals of 5G Mobile Networks, Wiley,2015
- Stefan Rommer, Peter Hedman, Magnus Olsson, Lars Frid, Shabnam Sultana, Catherine Mulligan, 5G Core Networks, Elsevier, 2020.
- Savo Glisic, Advanced Wireless Networks, Technology and Business Models, Wiley 2012
- Fei Hu, "Opportunities in 5G Networks", CRC press 2016.
- Hrishikesh Venkatarman and Ramona Trestian, "5G Radio Access Networks: Centralized RAN, Cloud-RAN, and Virtualization of Small Cells", CRC press 2017.
- Yang Yang, Jing Xu, Guang Shi, Cheng-Xiang Wang, "5G Wireless Systems Simulation and Evaluation Techniques", Springer International Publishing AG 2018.
- Sassan Ahmadil, "LTE-Advanced: A Practical Systems Approach To Understanding 3gpp LTE Releases 10 And 11 Radio Access Technologies", Academic Press 2013.

Course Contents and Lecture Schedule

Module No.	Topic	No. of Hours	Course Outcome
1.	**Drivers for 5G**		
1.1	Historical Trend of Wireless Communications, Evolution of LTE Technology to Beyond 4G	1	CO1
1.2	Roadmap, 10 Pillars of 5G- Evolution of Existing RATs, Hyperdense Small Cell Deployment, Self Organising Network	1	CO1
1.3	Machine Type Communication, Developing Millimetre Wave RATs	1	CO1
1.4	Redesigning Backhaul Links, Energy Efficiency, Allocation of New Spectrum for 5G	1	CO1
1.5	Spectrum Sharing, 5G Architecture	2	CO1
2.	**The 5G Internet**		
2.1	Internet of Things - Context Awareness Networking Reconfiguration and Virtualisation Support	2	CO2

2.2	Software Defined Networking ,Network Function Virtualisation, Mobility-An Evolutionary Approach from the Current Internet	3	CO2
2.3	A Clean Slate Approach Quality of Service Control-Network Resource Provisioning	1	CO3
2.4	Aggregate Resource Provisioning, Emerging Approach for Resource Over• Provisioning	2	CO3
2.5	Control Information Repository, Service Admission Control Policies ,Network Resource Provisioning	1	CO3
2.6	Control Enforcement Functions ,Network Configurations , Network Operations	1	CO3
3.	**Small Cells for 5G Mobile Networks**		
3.1	Small Cells- Wi-Fi and Femtocells as Candidate Small Cell Technologies,	1	CO4
3.2	Wi-Fi and Femto Performance – Indoors vs Outdoors,	1	CO4
3.3	Capacity Limits and Achievable Gains with Densification- Gains with Multi Antenna Techniques,	1	CO4
3.4	Gains with Small Cells, Mobile Data Demands - Approach and Methodology, Demand vs Capacity, Small Cell Challenges	1	CO4
4.	**Mobile Clouds: Technology and Services for Communication Platforms**		
4.1	The Mobile Cloud-User Resources, Software Resources, Hardware Resources	1	CO5
4.2	Networking Resources, Mobile Cloud Enablers-	1	CO5
4.3	The Mobile User Domain, Wireless Technologies	1	CO5
4.4	Software and Middleware, Network Coding	1	CO5
5	**Security for 5G Communications**		
5.1	Overview of a Potential 5G Communications System Architecture	1	CO6
5.2	Security Issues and Challenges in 5G Communications Systems	2	CO6
5.3	User Equipment, Access Networks, Mobile Operator's Core Network	2	CO6
5.4	External IP Networks	1	CO6
	Total Hours	**36**	

Course Designers:

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18EC710	CONSUMER ELECTRONICS	Category	L	T	P	Credit
		PC	1	0	0	1

Preamble

Consumer Electronics includes a broad set of electronic devices that provide one or more functionalities in a home or for a particular individual. It is referred to electronic devices that are installed or used specifically inside a home/house. However, they also now incorporate mobile and computing devices, which can easily be carried by an individual outside the home, such as a cell phone or a tablet PC. The objective is to acquaint the students with the fundamental principles of operation of these devices.

Prerequisite

NIL

Course Outcomes

On the successful completion of the course students will be able to

CO#	Course Outcome Statement	Weightage in %
CO1	Understand the elctronic control of domestic appliances	30
CO2	Explore various audio-video systems.	50
CO3	Explore the architecture of commnunication gadgets ensuring safety and standards	20

CO Mapping with CDIO Curriculum Framework

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS2	Understand	Respond	-	1.3, 2.4.6
CO2	TPS2	Apply	Value	-	1.3, 3.2.4, 3.3.1, 4.1.2,
CO3	TPS2	Apply	Value	-	1.3, 3.2.4, 3.3.1, 4.1.2,4.5.3

Mapping with Programme Outcomes and Programme Specific Outcome

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	M	L	-	-	-	-	-	-	-	-	-	-	L	-	-
CO2	S	M	L	-	-	-	-	-	-	-	-	-	M	-	-
CO3	S	M	L	-	-	-	-	-	-	-	-	-	M	-	-

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

Cognitive Levels	Continuous Assessment Test – 3*	End Semester Examination*
Remember	0	0
Understand	80	80
Apply	20	20

***Continuous Assessment Test – 3 and End Semester Examination shall be for 50 marks with 90 minutes duration.**

Assessment Pattern: Psychomotor

Psychomotor Skill	Miniproject/Assignment/Practical Component
Perception	-
Set	-
Guided Response	-
Mechanism	-
Complex Overt Responses	-
Adaptation	-
Origination	-

Sample Questions for Course Outcome Assessment

Course Outcome 1 (CO1):

1. Draw the Block diagram of Washing Machine. State and Justify type of Washing machine having more advantages.
2. List any two wiring and safety instructions for use of microwave oven.
3. How the temperature is controlled in Refrigerator
4. Explain the working of microwave oven and give its four electrical specifications.

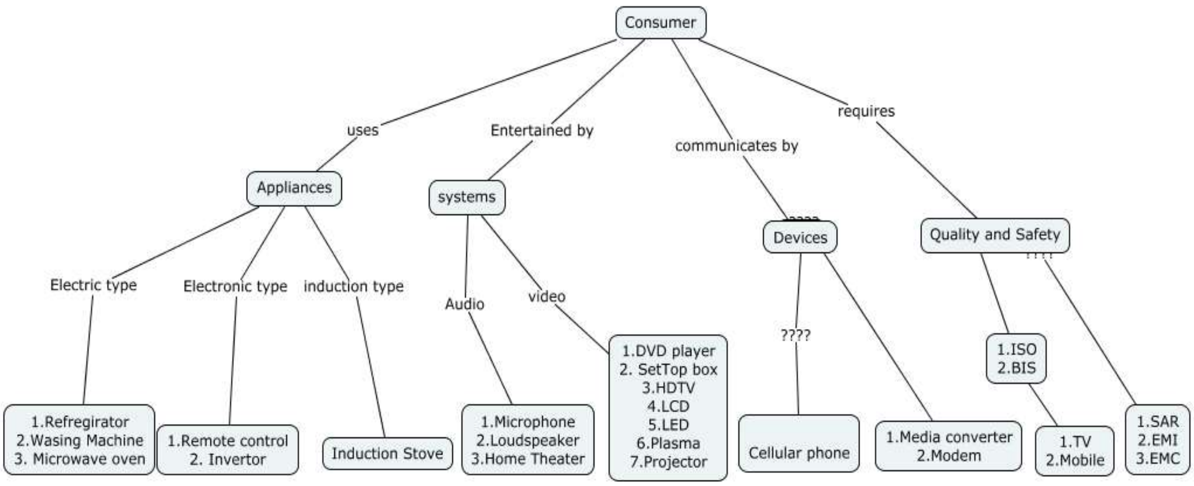
Course Outcome 2 (CO2):

1. Differentiate between Moving coil Microphone and Velocity Microphone.
2. An audio amplifier produces 20watt output across and 8 ohm resistance When a 5 millivolts signal is applied to its input across a 1 mega ohm resistor. Determine the decibel gain.
3. Differentiate LED and LCCD Standards.
4. Draw the hardware architecture of Digital Set top Box and explain its operation.
5. List the significance of LCD display and explain its operation

Course Outcome 3 (CO3):

1. Give CCIR-B standards for colour signal transmission and reception.
2. We feel electric shock at times, when we touch TV and Computer monitors. Give the reason.
3. Summarize the effect of EMI on secured communications.
4. Consider the past historical facts. Criticize on the impact of radio communication
5. Identify the three criteria to be satisfied by any system to become electromagnetically compatible.

Concept Map



Syllabus

Domestic Appliances: Electronic controls in Micro-wave oven, Refrigerator, Washing Machine, Inverter, Remote control. **Audio, Video Systems:** Mics and Speakers Home Theatre System –DVD player, Amplifiers. LCD –LED OLED TVs, PLASMA, LCD, DLP projectors, set top box. **Communication Devices:** Principle of operation of Phones, Cellular Phones, Smart Phone, Internet systems: Media converter, Modem. **Standards and safety:** Bureau of Indian Standards (BIS), International Standards Organisation (ISO), Concept of Reliability, TV and Mobile Phone Standards, Specific Absorption Rate, EMC,EMI compatibility

Learning Resources

- Bali S.P, “Consumer Electronics”, Pearson Education, 2017.
- B. R. Gupta, Vandana Singhal, “Consumer Electronics”, S. K. Kataria & Sons, 2006
- The Digital Consumer Technology Handbook A Comprehensive Guide to Devices, Standards, Future Directions, and Programmable Logic Solutions by Amit Dhir, Xilinx Inc., Elsevier 2004.

Course Contents and Lecture Schedule

Module No.	Topic	No. of Hours	Course Outcome
1	**Domestic Appliances**		
1.1	Electronic controls in, Refrigerator, Washing Machine	1	CO1
1.2	Remote control, Micro-wave oven	1	CO1
1.3	Inverter, Induction stove	1	CO1
2	**Audio –Video Systems**		
2.1	Microphones, Carbon, condenser	1	CO2
2.2	Loud Speaker**:** Direct radiating, horn loaded woofer	1	CO2
2.3	Home theatre systems: Stereo Amplifier, DVD player, DTH, Set top Box	2	CO2
2.4	TV systems: HDTV, LCD, LED, Organic LED, Plasma TV	2	CO2
2.5	LCD, DLP projectors	1	
3.	**Communication Devices**		
3.1	Architecture of Cellular Phones	1	CO3
3.2	Internet systems- Media converter, Modem	1	CO3
3.3			CO3
4	**Standards and safety**		
4.1	Bureau of Indian Standards (BIS), International Standards Organisation (ISO), Concept of Reliability	2	CO3
4.2	T.V. and Mobile Phone Standards	1	CO3
4.3	SAR, EMC-EMI compatibility	1	CO3
	Total No. of Hours	16	

Course Designers:

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18ES790	**CAPSTONE DESIGN PROJECT** (COMMON TO B.E./B.TECH PROGRAMMES)

Category	L	T	P	Credit
Project	0	0	6	3

Preamble

Capstone Design Project is a culminating course where students work in teams to design, build, and test prototypes with real world applications. The Capstone Design course provides students an opportunity to work with real-world, open-ended, interdisciplinary challenges proposed by industrial and research project sponsors. They learn and apply the engineering design process: defining functional requirements, conceptualization, analysis, identifying risks and countermeasures, selection, and physical prototyping. Student teams design and build working, physical prototypes to validate their solutions. The course reemphasizes teamwork, project management, research and development.

Prerequisite

NIL

Course Outcomes

On the successful completion of the course students will be able to

CO#	Course Outcome Statement
CO1	Apply prior knowledge, independent research, published information, patents, and original ideas in addressing complex engineering problems and generating solutions.
CO2	Make design decisions based on product design requirements, product lifecycle considerations, resource availability, and associated risks
CO3	Develop design solutions in addressing performance requirements while satisfying relevant societal/industrial and professional constraints.
CO4	Demonstrate effective use of contemporary tools for engineering analysis, fabrication, testing, and design communication.
CO5	Plan, monitor, and manage project schedule, resources, and work assignments to ensure timely and within-budget completion.
CO6	Test and defend performance of a design product with respect to at least one primary design requirement.
CO7	Perform professionally—exhibiting integrity, accepting responsibility, taking initiative, and providing leadership necessary to ensure project success.
CO8	Use formal and informal communications with team, advisor, and clients to document and facilitate progress

* *Weightage needs to be assigned based on the customized domain-specific rubrics*

CO Mapping with CDIO Curriculum Framework

CO#	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS3	Apply	Value	Mechanism	1.1, 1.2,1.3, 2.1, 2.2, 2.4, 3.1, 3.2, 4.1, 4.2, 4.3, 4.4, 4.5
CO2	TPS5	Evaluate	Organise	Adaptation	4.1.1, 4.1.2, 4.1.3, 4.1.4, 4.1.5, 4.1.6, 4.2.1, 4.2.2, 4.2.3, 4.2.4
CO3	TPS3	Apply	Value	Mechanism	4.4.1, 4.4.2, 4.4.3, 4.4.4, 4.4.5
CO4	TPS4	Analyse	Organise	Complex Overt Response	4.5.1, 4.5.2, 4.5.3, 4.5.4, 4.5.5
CO5	TPS4	Analyse	Organise	Complex Overt Response	4.3.1, 4.3.2, 4.3.3, 4.3.4
CO6	TPS4	Analyse	Organise	Complex Overt Response	4.5.1, 4.5.2, 4.5.3, 4.5.4, 4.5.5
CO7	TPS3	Apply	Value	Mechanism	2.5.1, 2.5.2

CO8	TPS3	Apply	Value	Mechanism	3.2.1, 3.2.2, 3.2.3, 3.2.4, 3.2.5, 3.2.6

Mapping with Programme Outcomes and Programme Specific Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S	M	L	-	-	M	M	S	S	M	M	S
CO2	S	S	M	L	S	M	M	M	S	M	M	S
CO3	S	M	L	-	-	M	M	M	S	M	M	S
CO4	S	S	M	L	M	M	M	M	S	M	M	S
CO5	S	S	M	L	M	M	M	M	S	M	S	S
CO6	S	S	M	L	M	M	M	M	S	M	M	S
CO7	S	M	L	-	-	M	M	S	S	S	M	S
CO8	S	M	L	-	-	M	M	S	S	S	M	S

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

Phases	Deliverables	Marks	Course Outcomes
Continuous Assessment			
Comprehensive Test on disciplinary knowledge*	MCQ format	20	CO1
Review 1 – Capstone Project Selection, functional decomposition and Technical Specification	Technical Report & Presentation	25	CO1, CO2, CO7, CO8
Review 2 – Evaluation of Design Approaches, Project planning and modern tool usage	Technical Report & Presentation	30	CO3, CO4, CO5, CO7, CO8
Review 3 – Evaluation of Testing and Validation, Documentation	Technical Report & Presentation	25	CO5, CO6, CO7, CO8
End-Semester Examination			
Demonstration of the product	Presentation & Viva -voce	60	CO1, CO2, CO3, CO4 CO5, CO6, CO7, CO8
Poster Presentation	Poster	40	

- Reports are to be submitted at each review. The report and presentation will be evaluated based on customized domain-specific rubrics for periodic reviews.
- Demonstration and Poster presentation will be evaluated by two faculty members nominated by their respective Head of the Department.

* The content for comprehensive test on disciplinary knowledge shall be decided by the committee at department level.

Course Designers:

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18ECPA0	COMPUTER VISION AND APPLICATIONS

Category	L	T	P	Credit
PE	3	0	0	3

Preamble

This course focuses on how computer treats vision as a process to understand human visual world. It deals with the construction of explicit meaningful descriptions of physical objects or other observable phenomena from images and how they are visualized by a computer and its applications. It focuses theoretical and algorithmic basis by which useful information about the world can be automatically extracted and visualized from a single image or a set of images. Since images are two-dimensional projections of the three-dimensional world, knowledge about the objects in the scene and projection as well as photometric geometries are required for low-level vision process. In mid-level, it describes that how the feature points such as interest points, corner points are detected, matched and the alignment of matched feature points. Subsequently, it deals various clustering and segmentation algorithms to obtain meaningful segments using similarity and discontinuity properties for further analysis. The higher-level vision encompasses object recognition and categorization which includes various classifiers. Finally, it explores applications such as face detection and recognition for visual authentication, Optical Character Recognition (OCR) for automatic number plate recognition, Image stitching, medical image segmentation and augmented reality.

Prerequisite

18EC560 Digital Image Processing

Course Outcomes

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

CO	Course Outcome Statement	Weightage %
CO1	Illustrate image formation using projective and photometric geometry with the relationship between world coordinates and image coordinates.	10
CO2	Measure the similarity between two images by applying rotation, scale invariant and oriented gradient feature detectors with Euclidean distance matching and least squares alignment method.	20
CO3	Obtain meaningful segments using similarity based K Means clustering segmentation algorithm and discontinuity based active contour segmentation algorithm.	15
CO4	Recognize the detected objects by applying supervised algorithms like K-nearest neighbour and SVM.	15
CO5	Recognize the detected objects by applying PCA, an unsupervised algorithm and deep learning algorithms such as Convolutional Neural Networks (CNN), and Region-based CNN.	20
CO6	Develop computer vision applications such as face detection and recognition, visual authentication, Optical Character Recognition (OCR) for automatic number plate recognition, Image stitching, medical image segmentation and Augmented Reality.	20

CO Mapping with CDIO Curriculum Framework

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS2	Understand	Respond	Guided Response	1.3, 2.4.6
CO2	TPS3	Apply	Value	Mechanism	1.3, 3.2.3, 3.2.4, 3.3.1, 4.1.2, 4.5.3
CO3	TPS3	Apply	Value	Mechanism	1.3, 3.2.3, 3.2.4, 3.3.1, 4.1.2, 4.5.3
CO4	TPS3	Apply	Value	Mechanism	1.3, 3.2.3, 3.2.4
CO5	TPS2	Apply	Value	Mechanism	1.3, 3.2.3, 3.2.4

CO6	TPS3	Apply	Value	Mechanism	1.3, 2.1.1, 2.3.1, 2.4.3, 2.4.4, 2.4.6, 2.5.1, 3.1, 3.2.3, 3.2.4, 3.2.6, 3.3.1, 4.1.1, 4.1.2, 4.5.3

Mapping with Programme Outcomes

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	M	L	-	-	-	-	-	-	L	-	-	M	L	L	L
CO2	S	M	L	-	M	-	-	-	M	-	-	M	M	M	M
CO3	S	M	L	-	M	-	-	-	M	-	-	M	M	M	M
CO4	S	M	L	-	L	-	-	-	M	L	-	M	M	L	L
CO5	S	M	L	-	M	-	-	-	M	-	-	M	L	L	M
CO6	S	M	L	-	M	M	-	M	M	M	-	M	L	L	M

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

Cognitive Levels	Continuous Assessment Tests			Assignment			End Semester Examination
	1	2	3	1	2	3	
Remember	10	10	0				0
Understand	10	10	10				10
Apply	80	80	90	50	50	50	90
Analyse	0	0	0				0
Evaluate	0	0	0				0
Create	0	0	0				0

Assessment Pattern: Psychomotor

Psychomotor Skill	Assignment-I	Assignment-II	Assignment-III
Perception	-	-	-
Set	-	-	-
Guided Response	-	-	-
Mechanism	50	50	50
Complex Overt Responses	-	-	-
Adaptation	-	-	-
Origination	-	-	-

Sample Questions for Course Outcome Assessment

Course Outcome 1 (CO1):

1. Consider a vector (7,5,3) which is rotated around the Z axis by $45^{0,}$ and then rotated around the Y axis by 45^{0} and finally translated by (6, -5,9). Find the new coordinates of the vector. All rotations are counter clockwise.
2. An ideal pinhole camera has focal length 5mm. Each pixel is 0.02 mm · 0.02 mm and the image principal point is at pixel (500, 500). Pixel coordinates start at (0, 0) in the upper-left corner of the image. Obtain the 3 · 3 camera calibration matrix, K, for this camera configuration.
   Hint: The first two vertices of the cube, the ones with world coordinates (X,Y,Z) = (0,0,0) and (1,0,0), project to pixel locations (x,y) = (252, 240) and (301,255), rounded to the nearest pixel.
3. Obtain the transformation matrix for an object translation of 50 pixels in X, Y, Z direction, an object rotation of 60^{0}around the Z axis in clockwise direction.

Course Outcome 2 (CO2):

1. Use SIFT features and propose solution for matching and alignment Describe how this algorithm could be used to detect the orientation of the plane in the scene from

the scene points. Illustrate the term 'scale-space' and describe how SIFT achieves scale and rotation invariance.

2. Develop an algorithm using Harris corner detection and describe one feature alignment technique for the two matched points captured in our TCE Dome.
3. Illustrate various matching strategies and error rates. Compare the results by fixing the false positive rates.

Course Outcome 3 (CO3):

1. Assume the following dataset is given: (3,3), (4,4), (6,6), (7,7), (8,8), (9,9), (0,6), (6,0). K-Means is used with k=3 to cluster the dataset. Moreover, Euclidean distance is used as the distance function to compute distances between centroids and objects in the dataset. K-Means' initial clusters C1, C2, and C3 are as follows:
   C1: {(4,4), (6,6), (9,9)}
   C2: {(0,6), (6,0)}
   C3: {(3,3), (7, 7), (8,8)}
   If K-means is run fo two iterations; what are the new clusters and what are their centroids? Illustrate how K-Means form the cluster with this example.
2. Develop an algorithm to group the scattered nodules in a mammogram image using K-means clustering algorithm.
3. Illustrate active contour model algorithm to segment tumour in MRI.

Course Outcome 4 (CO4):

1. Develop an algorithm to recognize the detected object is car or a human being when this frame is captured by a single static camera. Write the complexities for such classification for the given scenario.
2. Illustrate K nearest neighbor classifier to categorize the objects in the given image.
3. Develop an algorithm to recognize objects based on shape in a clutterd environment, for example an office table comprises of penstand, stapler, cup and water bottle etc.

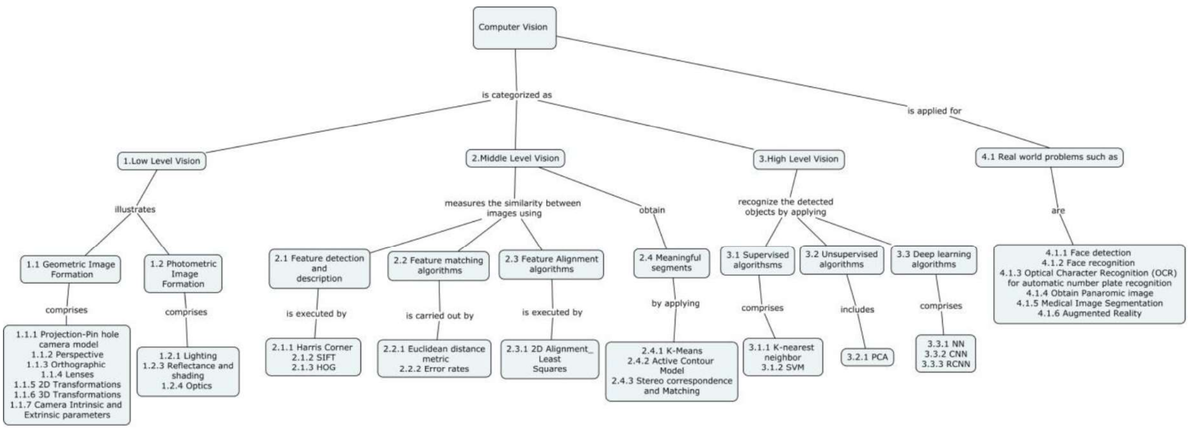
Course Outcome 5 (CO5):

1. Illustrate the architecture of CNN and write the significance of different layers.
2. Demonstrate the training and testing process by convolutional neural networks to recognize the face in the given image.
3. Distinguish traditional vs deep learning algorithms.

Course Outcome 6 (CO6):

1. Develop an algorithm to localize the license plate and recognize the vehicle number for intelligent traffic surveillance system to capture the vehicles which are not following the traffic rules.
2. Develop a face recognition system using PCA subspace approach for authentication system to enter into the restricted zone.
3. How Augmented reality is helpful in cricket sports for example to display the batsman's performance, ball height and lbw review.

Concept Map



Syllabus

Computer Vision: Low Level Vision: Introduction to computer vision and its applications. Image formation: Geometric image formation, projection, Pinholes, Lenses, perspective, orthographic projections, 2D Transformations, 3D Transformations, camera intrinsic and extrinsic parameters, Photometric image formation, Lighting, reflectance and shading, optics. **Middle Level Vision:** Feature detection, matching and alignment: Feature detectors and descriptors, Interest points, Harris corner detection, Scale Invariant Feature Transform (SIFT), Histogram of Oriented Gradients (HOG), Feature matching algorithms, Euclidean distance metric, Error rates, Feature alignment algorithms, 2D alignment using least squares. Clustering and Segmentation: K-Means Clustering, Active Contour Model based segmentation, Stereo correspondence, Epipolar geometry, Stereo matching. **High Level Vision:** Classifiers-Machine Learning**:** Supervised, K-nearest neighbour, SVM, Unsupervised, PCA, Deep Learning: Neural networks, Convolutional Neural Networks (CNN), Region-based CNN (R-CNN). **Applications:** Face detection using R-CNN and recognition using PCA and RCNN for visual authentication, Optical Character Recognition (OCR) for automatic number plate recognition, Image stitching, Medical Image Segmentation and augmented reality.

Learning Resources

- R Szeliski, “Computer vision: algorithms and applications”, Springer Science & Business Media, 2010.
- David A. Forsyth, Jean Ponce, “Computer Vision – A Modern Approach”, Prentice Hall, 2003, ISBN: 0130851981.
- Richard Hartley and Andrew Zisserman, “Multiple View Geometry in Computer Vision”, Second Edition, Cambridge University Press, March 2004.
- Al Bovik, “Handbook of Image & Video Processing”, Academic Press, 2000, ISBN: 0121197905.
- Prince, S.J.D, “Computer Vision: Models, Learning, and Inference”, Cambridge University Press, 2012.
- Ragav VenRagav Venkatesan and Baoxin Li, “Convolutional Neural Networks in
    - Visual Computing A Concise Guide”, CRC Press, Taylor and Francis Group, LCCN
    - 2017029154| ISBN 9781498770392 (hardback : alk. paper), 2017.
- http://www.ius.cs.cmu.edu/demos/facedemo.html
- https://nptel.ac.in/courses/106105216/Course on Computer Vision by Jayanta Mukhopadhyay.
- https://www.coursera.org/courses?query=computer%20vision.

Course Contents and Lecture Schedule

No.	Topic	No. of Lectures	CO
1.	Introduction to the Course and course outcomes **Computer Vision and Applications**	1	1
2.	**Low Level Vision –** Introduction -Pinholes	1	1
3.	**Image formation**-Geometric image formation-projection	1	1
4.	Lenses-perspective-orthographic	1	1
5.	Camera intrinsic and extrinsic parameters	1	1
6.	2D Transformations	1	1
7.	3D Transformations	1	1
8.	Photometric image formation	1	1
9.	Lighting-reflectance and shading	1	1
10.	Optics	1	1
11.	**Middle Level Vision- Feature detection, matching and alignment**	1	2
12.	Feature detectors and descriptors-Interest points-Harris corner	1	2

	detection		
13.	Scale Invariant Feature Transform (SIFT)	1	2
14.	Histogram of Oriented Gradients (HOG)	1	2
15.	Feature matching algorithms	1	2
16.	Euclidean distance metric-Error rates	1	2
17.	Feature alignment algorithms	1	2
18.	2D alignment using least squares	1	2
19.	Clustering and Segmentation- K-Means Clustering	1	3
20.	Active Contour Model	1	3
21.	Stereo correspondence, Epipolar geometry, Stereo matching.	2	3
22.	**Assignment 1: Feature Extraction and Segmentation**		
23.	**High Level Vision-Classifiers-Machine Learning: Supervised**	1	4
24.	K-nearest neighbour	1	4
25.	SVM	2	4
26.	**Unsupervised**- PCA	1	5
27.	Deep Learning		
28.	Neural networks	1	5
29.	Convolutional Neural Networks (CNN)	1	5
30.	Region-based CNN	1	5
31.	**Assignment II: PCA/ RCNN classifiers**		
32.	**Applications:** Face detection using RCNN	1	6
33.	Face recognition using PCA for visual authentication	1	6
34.	Face recognition using RCNN for visual authentication		
35.	Optical Character Recognition (OCR) for automatic number plate recognition	1	6
36.	Image stitching	1	6
37.	Medical Image Segmentation	1	6
38.	Augmented reality	1	6
39.	**Assignment III: Mini Project on CV Applications**		
	Total	36	

Course Designers:

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18ECPB0	DATA COMPRESSION	Category	L	T	P	Credit
		PE	3	0	0	3

Preamble

Data compression is a key part of almost every aspect of computer and communications technology. Irrespective of large storage systems, the concern of space optimization and the algorithmic aspects of the efficiency appear large. Developing techniques to achieve better transmission rates is paramount importance today. Data compression is grounded in information theory, and there are many fundamental algorithms that one must deal with daily in information transmission and storage tasks. This course provides an overview of classical and modern techniques and algorithms of various types of data compression. It covers statistical and dictionary methods, lossless and lossy compression algorithms in graphics, video and Big data compression.

Prerequisite

18EC520 Analog and Digital Communication Systems

Course Outcomes

On the successful completion of the course students will be able to

CO Number	Course Outcome Statement	Weightage*** in %
CO1	Outline the basics of Data Compression and its performance measure	10
CO2	Analyse various lossless Compression Algorithms to data	25
CO3	Analyse various lossy Compression Algorithms to data	20
CO4	Demonstrate different Image Compression Standards	15
CO5	Illustrate the principles of basic video and Big data compression techniques	15
CO6	Demonstrate the principles of various Video coding standards	15

CO Mapping with CDIO Curriculum Framework

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS2	Understand	Respond	Guided Response	1.1.1,2.1.1, 2.1.2
CO2	TPS4	Analyse	Organise	Mechanism	2.1.2, 2.1.2,2.1.3,2.1.4,2.1.5 2.4.1,3.1.1, 3.2.3, 3.2.4,3.2.5 4.5.3, 4.6.1,4.6.2
CO3	TPS4	Analyse	Organise	Mechanism	2.1.2, 2.1.2,2.1.3,2.1.4,2.1.5 2.4.1,3.1.1, 3.2.3, 3.2.4,3.2.5 4.5.3, 4.6.1,4.6.2
CO4	TPS3	Apply	Value	Mechanism	2.1.2, 2.1.2,2.1.3,2.1.4,2.1.5 2.4.6,3.1.1,3.2.3, 3.2.4,3.2.6,3.2.7, 4.5.3
CO5	TPS3	Apply	Value	-	2.1.2, 2.1.2,2.1.3,2.1.4,2.1.5 2.4.6,3.1.1,3.2.3, 3.2.4,3.2.6,3.2.7, 4.5.3
CO6	TPS3	Apply	Value	-	2.1.2, 2.1.2,2.1.3,2.1.4,2.1.5 2.4.6,3.1.1,3.2.3, 3.2.4,3.2.6,3.2.7, 4.5.3

Mapping with Programme Outcomes and Programme Specific Outcomes

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	M	L	-	-	-	L	-	-	-	L	-	-	L	-	-
CO2	S	S	M	L	M	L	L	-	L	M	-	-	S	-	L
CO3	S	S	M	L	M	L	L	-	L	M	-	-	S	-	L
CO4	S	M	L	L	L	M	L	M	L	M	L	L	S	L	M
CO5	S	M	L	L	L	M	L	L	L	M	L	L	S	L	M
CO6	S	M	L	L	L	M	L	M	L	M	L	L	S	L	M

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

Cognitive Levels	Continuous Assessment Tests			Assignment			End Semester Examination
	1	2	3	1	2	3	
Remember	20	-	-	0	0	0	0
Understand	20	20	30	0	0	0	20
Apply	40	60	70	100	60	60	60
Analyse	20	20	0	0	0	0	20
Evaluate	0	0	0	0	0	0	0
Create	0	0	0	0	0	0	0

Assessment Pattern: Psychomotor

Psychomotor Skill	Assignment-1	Assignment-2	Assignment-3
Perception	-	-	-
Set	-	-	-
Guided Response	-	-	-
Mechanism	-	40	40
Complex Overt Responses	-	-	-
Adaptation	-	-	-
Origination	-	-	-

Sample Questions for Course Outcome Assessment

Course Outcome1 (CO1):

1. State entropy
2. Discuss redundancies
3. What is the term “compression Ratio” in compression?

Course Outcome2 (CO2):

1. Consider a source alphabet with probabilities A={a1, a2, a3, a4, a5} with P(a1)= P(a3)=P(a4)=0.2, P(a2)=0.3 and P(a5)=0.1. Will the Human and minimum variance Huffman code have the same average length?
2. Encode the word ‘DANCE’ using Adaptive Huffman procedure which is produced from a source consists of 26 upper case English alphabet.
3. In a transmission of an English book the following tongue twister ‘Freezy breeze made these three trees freeze’, **is** sent. Encode it by LZ77.The first 21 characters without space are kept it in the search buffer and the remaining 16 are in look ahead buffer.

Course Outcome3 (CO3):

1. Explain Rate control in multimedia transmission by quantizer step size adaptation.
2. Explain LBG Algorithm for vector quantization.
3. For an image the seven-level decomposition shown below:

   21 6 15 12

-6	3	6	3
3	-3	0	-3
3	0	0	0

Find the bit stream generated by EZW coder.

Course Outcome 4 (CO4):

1. Is the JPEG2000 bit stream SNR scalable? If so, explain how it is achieved using the EBCOT algorithm.
2. Could we use wavelet-based compression in ordinary JPEG? How?
3. You are given a computer cartoon picture and a photograph. If you have a choice of using either JPEG compression or GIF, which compression would you apply for these two images? Justify your answer.

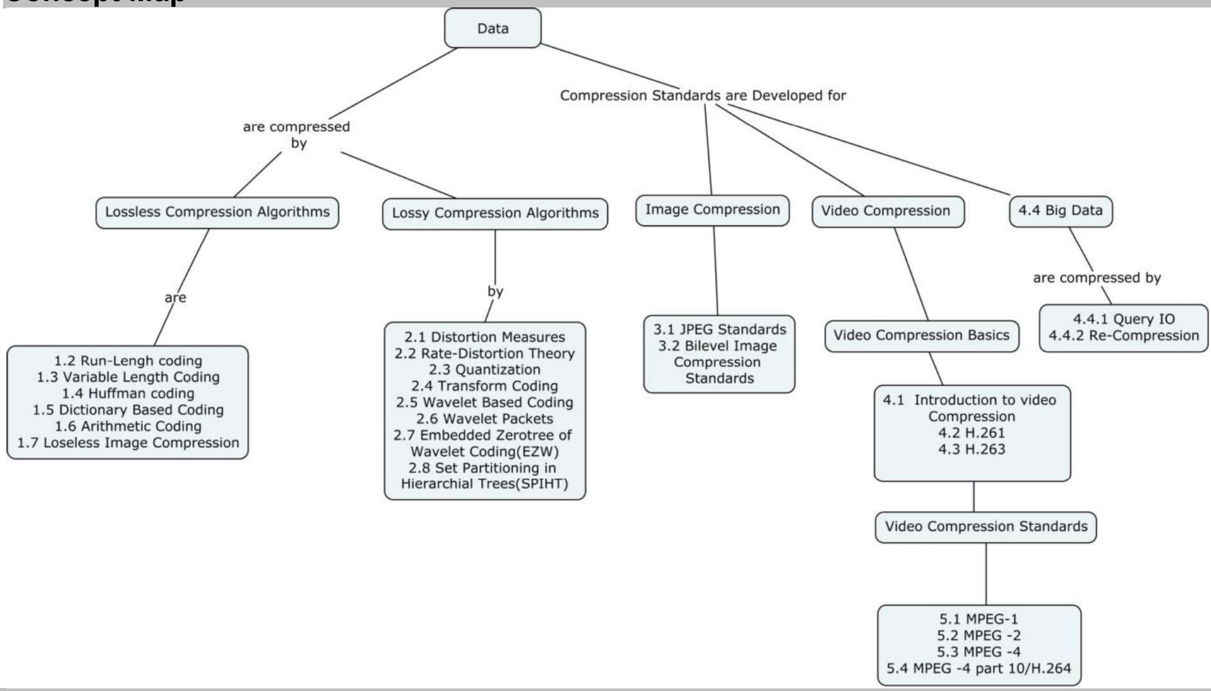
Course Outcome 5 (CO5):

1. Discuss in detail about the motion vector search methods.
2. Demonstrate I-Frame and P- Frame coding of H.261 with neat block diagram.
3. Discuss how the advanced prediction mode in H.263 achieves better compression ?

Course Outcome 6(CO6):

1. Demonstrate the method of estimating motion vectors with searching procedures in MPEG 1 video coding.
2. Explain Spatial interleaving of block-wise picture coding with neat diagram
3. Demonstrate Object oriented hierarchical description used in MPEG 4 video coding.

Concept Map



Syllabus

Introduction to Compression Techniques - Lossless- Lossy Compression Schemes - Measures of Performance - Modeling and coding.

Lossless Compression and Algorithms: Basics of Information Theory-Run length coding-Variable-Length coding(VLC)-Shannon-Fano Algorithm-Huffman coding-Variations of Huffman coding- Adaptive Huffman coding-Dictionary-Based coding-Arithmetic Coding- Lossless Image Compression-Differential Coding of Images-Lossless JPEG

Lossy Compression Algorithms: Distortion measures-The Rate-Distortion Theory-Quantization-Uniform Scalar Quantization-Nonuniform Scalar Quantization-Vector Quantization-Transform Coding-Discrete Cosine Transform(DCT)-Karhunenloeve Transform-Wavelet Based Coding-Continuous Wavelet Transform-Discrete Wavelet Transform-Wavelet

Packets-Embedded Zero tree of Wavelet Coding (EZW) -Set Partitioning in Hierarchical Trees(SPIHT)
Image Compression Standards: The JPEG Standard - JPEG 2000 -Comparison of JPEG and JPEG 2000 Performance- JPEG-LS standard- Bilevel Image Compression Standards- The JBIG Standard-The JBIG 2 Standard
Basic Video Compression and Big Data Compression Techniques: Fundamental Concepts of Video- Introduction to Video Compression-Video Compression Based on Motion Compensation-Search for Motion Vectors-H.261- H.263 .Compression of Big Data – Query IO-Recompression
Videos Coding:MPEG-1-MPEG-2-MPEG-4-Object-Based Visual Coding in MPEG-4-Synthetic Object Coding in MPEG-4-MPEG-4 Object types,Profiles and Levels-H.264

Learning Resources

- Li, Ze-Nian, Mark S. Drew, and Jiangchuan Liu, “Fundamentals of multimedia” Upper Saddle River (NJ):: Pearson Prentice Hall, 2004.
- Khalid Sayood, “Introduction to Data Compression” Fourth Edition, Morgan Kauffmann Publishers, Inc, Newnes, 2012.
- David Salomon, “A Guide to Data Compression Methods” Fourth Edition Springer Science & Business Media, 2013.
- http://queryio.com/hadoop-big-data-docs/hadoop-big-data-admin-guide/

Course Contents and Lecture Schedule

Module No.	Topic	No. of Hours	Course Outcome
1	**Introduction to Compression Techniques**	2	CO1
1.1	**Lossless Compression Algorithms**	1	CO2
1.1.1	Basics of Information Theory		
1.2	Run-length Coding		
1.3	**Variable Length Coding (VLC)**		
1.3.1	Shannon-Fano Algorithm	1	
1.4	**Huffman coding**		
1.4.1	Variations of Huffman Coding	1	
1.4.2	Adaptive Huffman Coding	2	
1.5	**Dictionary-Based Coding**	2	
1.6	**Arithmetic Coding**	1	
1.7	**Lossless Image Compression**		
1.7.1	Differential Coding of Images	1	
1.7.2	Lossless JPEG	1	
2	**Lossy Compression Algorithms**		CO3
2.1	Distortion measures	1	
2.2	The Rate-Distortion Theory	1	
2.3	**Quantization**		
2.3.1	Uniform Scalar Quantization	1	
2.3.2	Non-uniform Scalar Quantization	1	
2.3.3	Vector Quantization	1	
2.4	**Transform Coding**		
2.4.1	Discrete Cosine Transform(DCT)	1	
2.4.2	Karhunenloeve Transform	1	
2.5	**Wavelet Based Coding**		
2.5.1	Continuous Wavelet Transform	1	
2.5.2	Discrete Wavelet Transform		
2.6	Wavelet Packets	1	
2.7	Embedded Zero tree of Wavelet Coding (EZW)	1	

2.8	Set Partitioning in Hierarchical Trees(SPIHT)	1	
3	**Image Compression Standards**		CO4
3.1	**The JPEG Standard**	2	
3.1.1	JPEG 2000		
3.1.2	Comparison of JPEG and JPEG 2000 Performance		
3.1.3	The JPEG-LS standard		
3.2	**Bilevel Image Compression Standards**	2	
3.2.1	The JBIG Standard		
3.2.2	The JBIG 2 Standard		
4	**Basic Video Compression Techniques**		CO5
4.1	**Introduction to Video Compression**	1	
4.1.1	Video Compression Based on Motion Compensation		
4.1.2	Search for Motion Vectors		
4.2	**H.261**	1	
4.2.1	Intra-Frame (I-Frame) Coding		
4.2.2	Inter-Frame (P-Frame) Predictive Coding		
4.2.3	Quantization in H.261		
4.2.4	H.261 Encoder and Decoder		
4.3	**H.263**	1	
4.3.1	Motion Compensation in H.263		
4.4	**Big Data Compression**	1	CO5
4.4.1	Query IO		
4.4.2	Re-Compression		
5	**Video Coding**		CO6
5.1	**MPEG-1**	1	
5.1.1	Motion Compensation in MPEG-1		
5.2	**MPEG-2**	1	
5.2.1	Supporting Interlaced Video		
5.2.2	MPEG-2 scalabilities		
5.2.3	Other Major Differences from MPEG-1		
5.3	**MPEG-4**	2	
5.3.1	Object-Based Visual Coding in MPEG-4		
5.3.2	Synthetic Object Coding in MPEG -4		
5.3.3	MPEG-4 Object Types, Profiles and Levels		
5.4	**H.264**	1	
	Total Hours	36	

Course Designers:

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18ECPC0	DSP ARCHITECTURE AND PROGRAMMING	Category	L	T	P	Credit
		PE	2	0	2	3

Preamble

This course describes the architecture and instruction set of fixed point DSP processor to design and implement digital filters for real world applications such as audio coding, audio effects and speech processing.

Prerequisite

18EC440 Signal processing

Course Outcomes

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

CO Number	Course Outcome Statement	Weightage*** in %
CO1	Explain the architecture and instruction set of fixed point DSP processor	10
CO2	Represent signal samples in fixed point format to perform arithmetic operations based on this format	10
CO3	Write and simulate programs in assembly language and C language.	10
CO4	Develop ALP and C coding to implement FIR/IIR filter and their frequency domain analysis	25
CO5	Develop ALP and C code for audio signal processing applications	25
CO6	Apply code optimization and power management for efficient embedded system in fixed point processor	20

*** Weightage depends on Bloom's Level, number of contact hours

CO Mapping with CDIO Curriculum Framework

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS2	Understand	Respond	-	1.1.3
CO2	TPS2	Apply	Value	Mechanism	2.1.1, 2.1.2, 2.1.3, 2.1.5, 2.4.1, 2.4.2
CO3	TPS3	Apply	Value	Mechanism	2.1.1, 2.1.2, 2.1.3, 2.1.5, 2.4.1, 2.4.2
CO4	TPS4	Apply	Value	Mechanism	2.1.1, 2.1.2, 2.1.3, 2.1.4, 2.1.5, 2.4.1, 2.4.2, 2.4.3, 2.4.4, 2.4.6, 3.1.1, 3.1.2, 3.2.1, 3.2.2, 3.2.6, 4.4.1, 4.4.2, 4.4.3
CO5	TPS4	Apply	Value	Mechanism	2.1.1, 2.1.2, 2.1.3, 2.1.4, 2.1.5, 2.4.1, 2.4.2, 2.4.3, 2.4.4, 2.4.6, 3.1.1, 3.1.2, 3.2.1, 3.2.2, 3.2.6, 4.4.1, 4.4.2, 4.4.3
CO6	TPS3	Apply	Value	Mechanism	2.1.1, 2.1.2, 2.1.3, 2.1.4, 2.1.5, 2.4.1, 2.4.2, 2.4.3, 2.4.4, 2.4.6, 3.1.1, 3.1.2, 3.2.1, 3.2.2, 3.2.6, 4.4.1, 4.4.2, 4.4.3

Mapping with Programme Outcomes

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	M	L		-	-	-	-	L	L	L	-	L	L	-	L
CO2	S	M	L	-	S	-	-	L	L	L	-	L	L	L	L
CO3	S	M	L	-	S	-	-	L	L	L	-	L	M	L	L
CO4	S	M	L	-	S	-	-	M	M	M	L	L	M	M	M
CO5	S	M	L	-	S	-	-	M	M	M	L	L	M	M	M
CO6	S	M	L	-	S	-	-	M	M	M	L	L	M	M	M

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

Bloom's Category	Continuous Assessment Tests			End Semester Examination
	1	2	3	
Remember	20	0	0	Lab Examination
Understand	20	20	20	
Apply	60	80	80	
Analyse	0	0	0	
Evaluate	0	0	0	
Create	0	0	0	

Assessment Pattern: Psychomotor

Psychomotor Skill	**Practical**
Perception	-
Set	-
Guided Response	50
Mechanism	50
Complex Overt Responses	-
Adaptation	-
Origination	-

Sample Questions for Course Outcome Assessment

Course Outcome 1 (CO1):

1. Mention the computational units available in Blackfin processor.
2. Lists the flags and their positions in ASTAT register.
3. Let $R4 = \mathrm{0xA5A5C3AA,\ R3.L{=}0x0D09}$, Find the result in R7 after executing the instruction R7=extract (R4, R3.L) (x);

Course Outcome 2 (CO2):

1. Represent -0.01171875 in 1.15 format.
2. Find the largest positive value represented by 4.12 format.
3. Write the difference between truncation and rounding. What are the types of rounding? Give examples for types of rounding.

Course Outcome 3 (CO3):

1. Write an assembly language program in DSP processor to find 5!
2. Write an Assembly language program in DSP processor to arrange the number in ascending order for the given array.
   $Input = \{0x2828,\quad 0x4444,\quad 0x1234,\quad 0x2F02,\quad 0x7777,\quad 0x4FFE\}$
3. Write an Assembly language program in DSP processor to arrange the number in descending order for the given array.
   $Input = \{0x2828,\quad 0x4444,\quad 0x1234,\quad 0x2F02,\quad 0x7777,\quad 0x4FFE\}$

Course Outcome 4 (CO4):

1. A dc signal generator fluctuate between 1Volt to 10 Volt in an observation interval of T seconds is given by $\{1,5,8,2,4,9,3\}$. Choose appropriate FIR filter to smooth the variation in the output voltage and implement in DSP processor simulator.

2. Compute the gain $|H(\omega_0)|$ of moving average filters with length L=5, L=10, and L=20 at frequency $\omega_0 = 0.1\pi$.
3. Develop C code to implement moving average filter in DSP processor to remove a 1,000 Hz tone that muffles the speech signal.

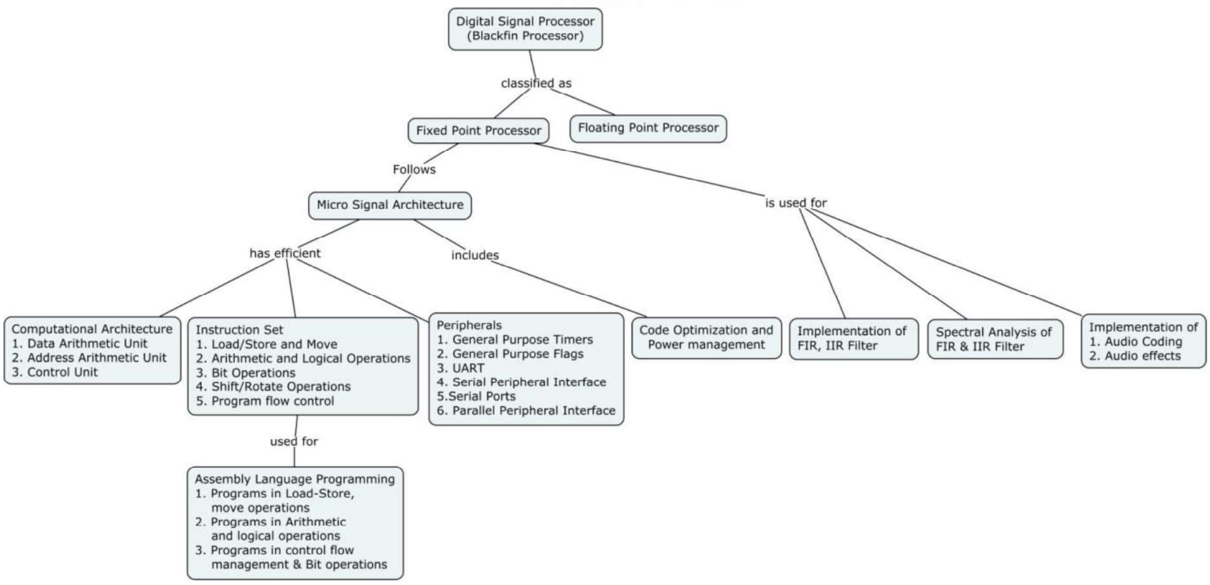
Course Outcome 5 (CO5):

1. A noisy speech signal, noisy.wav is recorded offline. This signal contains band limited noise that can be removed with the graphic equalizer. Analyze the band limited noise in order to design a suitable graphic equalizer to remove the band limited noise with the EZ-KIT.
2. Develop C code in DSP processor to implementing FIR graphic equalizer.
3. Develop C code in DSP processor to implementing IIR graphic equalizer.

Course Outcome 6 (CO6):

1. Determine the cycle count and processing MIPS in implementing a 256- tap FIR filter (with 16-bit arithmetic) using sample and block processing modes. The FIR filter is sampled at 48 kHz.
2. The cycle count for performing FIR filter in linear assembly code without branch prediction is [28 × *N*c +22] × *N*b + 66 cycles, where *N*c is the number of coefficients in the FIR filter and *N*b is the number of samples per block. The 66 cycles are overhead for setting up the FIR filter. Compute the cycle count/input sample and processing time/input sample in implementing a 32-tap FIR filter with different data samples per block. The Blackfin processor is operating at 270 MHz.
3. Implement a symmetric FIR filter in C with intrinsic functions on the Blackfin processor. Build the project by enabling the optimization in the Visual DSP++ compiler. Benchmark on the cycle count, data, and code size of the symmetric FIR filter and compare the results with the direct-form FIR filter. Does the symmetric FIR filter always result in a better performance as compared to the direct-form FIR filter? If not, why?

Concept Map



Syllabus

Theory:

Core Architecture: Introduction to Signal Processing Algorithms, Architecture of fixed point DSP processor, Data Arithmetic Unit, Address Arithmetic Unit, Control Unit, Memory map, Peripherals: General purpose Timers, General purpose flags, UART, serial peripheral interface, serial ports, parallel peripheral interface.

Instruction Set: Load/Store, move, Arithmetic and Logical operations, Bit operations, Shift/Rotate operations, Program flow control **Number Format:** Fixed point format, fixed point extended format, fixed point data types, dynamic range, precision and quantization error, Comparison between fixed point and floating point data types. **Assembly Language Programming:** Programs for working on Load-Store – Move – Buffers - Loops, Programs for working on Arithmetic and Logical instructions, Programs for working on Program flow – CC management – Bit operations. **Implementation in EZ-KIT:** Convolution, FIR filter, IIR filter, Spectral analysis of FIR and IIR filter. **Applications:** Audio coder, Audio effects, **Code Optimization and Power Management:** C optimization techniques, Assembly coding for efficient programming, Cycle count and Code size, Power consumption and management.

Practical:

1. Assembly Language Programming in fixed point DSP processor
   a) Working on Load-Store-Move-Buffers-Loops
   b) Working on Arithmetic and Logical Instructions
   c) Working on Program Flow - CC management – Bit operations
2. Implementation of moving average filter in EZ-KIT platform.
3. Frequency analysis in EZ-KIT platform.
4. Implementation of FIR/IIR based graphic equalizer in EZ-KIT.
5. Implementation of A-law and μ-law companding algorithm in EZ-KIT.
6. Sample rate conversion in EZ-KIT

Learning Resources

- ADSP Blackfin Processor Hardware Reference, Revision 3.6, 2013.
- Blackfin Processor Programming Reference, Revision 2.2, 2013.
- Woon-Seng Gan, Sen.M.Kuo, Embedded Signal Processing with Micro Signal Architecture, John Wiley Sons, 2007
- Richard Newbold, "Practical applications in Digital Signal Processing, Pearson Prentice Hall, 2012.

Course Contents and Lecture Schedule

Module No.	Topic	No.of Lectures	CO
1	**Core Architecture**		
1.1	Introduction to Signal Processing algorithms	1	CO1
1.2	Micro signal architecture Blackfin processor	1	CO1
1.3	Data Arithmetic Unit, Address Arithmetic Unit	1	CO1
1.4	Control Unit, memory map	1	CO1
1.5	Peripherals: General purpose Timers, General purpose flags,	1	CO1
1.6	UART, serial peripheral interface,	1	CO1
1.7	serial ports, parallel peripheral interface	1	CO1
2	**Instruction Set**		
2.1	Arithmetic and Logical operations	1	CO1
2.2	Bit operations	1	CO1
2.3	Shift/Rotate operations, Program flow control	1	CO1
3	**Number Format:**		
3.1	Fixed point format, fixed point extended format	1	CO2
3.2	fixed point data types, dynamic range, precision and quantization error	1	CO2
3.3	Comparison between fixed point and floating point data types	1	CO2
4	**Assembly Language Programming**		
4.1	Programs for working on Load-Store – Move – Buffers - Loops	1	CO3
4.2	Programs for working on Arithmetic and Logical	1	CO3

	instructions		
4.3	Programs for working on Program flow – CC management – Bit operations	1	CO3
5	**Implementation in EZ-KIT**		
5.1	Convolution	1	CO4
5.2	FIR filter, IIR filter	1	CO4
5.3	Spectral analysis of FIR and IIR filter.	1	CO4
6	**Applications**		
6.1	Audio coder	1	CO5
6.2	Audio effects	1	CO5
7	**Code Optimization and Power Management**		
7.1	C optimization techniques	1	CO6
7.2	Assembly coding for efficient programming, cycle count and code size.	1	CO6
7.3	Power consumption and management	1	CO6
	Theory	24	
	Practical	24	
	Total	48	

Course Designers:

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18ECPD0	WIRELESS COMMUNICATION SYSTEMS	Category	L	T	P	Credit
		PE	2	1	0	3

Preamble

The objective of the course on "Wireless Communication systems" is to present the techniques in the physical layer aspects of wireless communication systems and determine the performance of wireless systems in terms of capacity and probability of error.

Prerequisite

18EC520 Analog and Digital Communication Systems

Course Outcomes

On the successful completion of the course students will be able to

CO#	Course Outcome Statement	Weightage in %
CO1	Describe the fundamentals of cellular concepts in Wireless communication systems.	15
CO2	Characterize the wireless channel in terms of small scale and large-scale fading parameters.	15
CO3	Determine the BER and outage performance of wireless systems in fading environments.	15
CO4	Calculate the Capacity of SIMO, MISO and MIMO Wireless channels.	15
CO5	Determine the BER performance of SIMO, MISO and MIMO Wireless communication systems in fading environments.	20
CO6	Determine the capacity region of the given interference channels.	20

CO Mapping with CDIO Curriculum Framework

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS2	Understand	Respond	-	1.2.3, 2.4.6, 3.2.3
CO2	TPS3	Apply	Value	-	1.2.1, 2.1.1, 2.1.2, 2.1.3, 2.5.1
CO3	TPS3	Apply	Value	-	1.2.1, 2.1.1, 2.1.2, 2.4.2, 2.4.6, 2.5.1, 3.1.1, 3.2.3, 4.5.5, 4.6.2
CO4	TPS3	Apply	Value	Mechanism	1.2.1, 2.1.1, 2.1.2, 2.4.2, 2.4.6, 2.5.1, 3.1.1, 3.2.3, 4.5.5, 4.6.2
CO5	TPS3	Apply	Value	Mechanism	1.2.1, 2.1.1, 2.1.2, 2.4.2, 2.4.6, 2.5.1, 3.1.1, 3.2.3, 4.5.5, 4.6.2
CO6	TPS3	Apply	Value	-	1.2.1, 2.1.1, 2.1.2, 2.4.2, 2.4.6, 2.5.1, 3.1.1, 3.2.3, 4.5.5, 4.6.2

Mapping with Programme Outcomes and Programme Specific Outcomes

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	M	L	-	-	-	-	-	-	-	-	-	-	L	-	L
CO2	S	M	L	-	-	-	-	-	-	-	-	-	M	-	L
CO3	S	M	L	-	-	-	-	-	-	-	-	-	M	L	L
CO4	S	M	L	-	S	-	-	-	S	S	-	-	M	L	L
CO5	S	M	L	-	S	-	-	-	S	S	-	-	M	L	L
CO6	M	M	L	-	-	-	-	-	-	-	-	-	L	-	L

S- Strong; M-Medium; L-Low

AssessmentPattern: Cognitive Domain

Cognitive Levels	Continuous Assessment Tests			Assignment			End Semester Examination
	1	2	3	1	2	3	
Remember	20	0	0	0	0	0	0
Understand	20	20	20	0	0	0	20
Apply	60	80	80	100	100	100	80
Analyse	0	0	0	0	0	0	0
Evaluate	0	0	0	0	0	0	0
Create	0	0	0	0	0	0	0

Assessment Pattern: Psychomotor

Psychomotor Skill	Assignment-1	Assignment-2	Assignment-3
Perception	-	-	-
Set	-	-	-
Guided Response	-	-	-
Mechanism	-	30	30
Complex Overt Responses	-	-	-
Adaptation	-	-	-
Origination	-	-	-

Sample Questions for Course Outcome Assessment

Course Outcome 1 (CO1):

1. If a total of 33MHz of bandwidth is allocated to a particular FDD Cellular telephone system which uses two 25KHz simplex channels to provide full duplex voice and control channels, compute the number of channels available per cell for four cell reuse system.
2. Show that the frequency reuse factor for a cellular system is given by k/s,where k is the average number of channels per cell, and s is the total number of channels available to the cellular service provider.
3. Find the far field distance for an antenna with maximum dimension of 1m and operating frequency of 900MHz.

Course Outcome 2 (CO2):

1. Classify the following as slow or fast and frequency selective or frequency flat. Justify your answers. Assume that the system occupies the full bandwidth listed.
   (a) A cellular system with carrier frequency of 2GHz, bandwidth of 1.25MHz, that provides service to high-speed trains. The RMS delay spread is 2μ*s*.
   (b) A vehicle-to-vehicle communication system with carrier frequency of 800MHz and bandwidth of 100kHz. The RMS delay spread is 20ns.
   (c) A 5G communication system with carrier frequency of 3.7GHz and bandwidth of 200MHz.
   (d) A 60GHz wireless personal area network with a bandwidth of 2GHz and an RMS delay spread of 40ns. The main application is high-speed multimedia delivery.
   (e) Police-band radio. Vehicles move at upwards of 100mph and communicate with a base station. The bandwidth is 50kHz at 900MHz carrier.
2. Consider the LOS/NLOS path-loss model with $P_{los}(d) = e^{-d/200}$, free space for the LOS path loss, log distance without shadowing for the NLOS with β = 4, reference distance of 1m, $G_t = G_r$ = 0dB, and λ = 0.1m. Plot the path loss in decibels for distances from 1 to 400m.
3. Compute the maximum Doppler shift for the following sets of parameters:
   (a) 40MHz of bandwidth, carrier of 2.4GHz, and supporting 3km/h speeds
   (b) 2GHz of bandwidth, carrier of 64GHz, and supporting 3km/h speeds

Course Outcome 3 (CO3):

1. The received signal model in wireless communication system is given by $y = hx + n$, where magnitude of *h* is Rayleigh distributed, *x* is a unit energy BPSK symbol and *n* is complex Gaussian noise with variance σ_n^2. Derive the probability of occurrence for deep fade event.
2. Consider a voice system with acceptable BER when the received signal power is at or above half its average value. If the BER is below is acceptable level for more than 120ms, users will turn off their phone. Find the range of Doppler values in a Rayleigh fading channel such that the average time duration when users have unacceptable voice quality is less than $t = 60ms$.
3. Determine the capacity of slow fading channel and prove that the outage probability is $P_{out}(R) = \dfrac{2^R - 1}{SNR}$ where R is the data rate.

Course Outcome 4 (CO4):

1. Consider a SIMO System with flat fading described by
   $$y[n] = hs[n] + v[n]$$
   Suppose that $v[n]$ is zero mean and covariance R_v, determine the receive beamforming vector $\mathbf{w}$ that maximizes the signal to noise ratio. Assume that R_v is invertible.
2. Consider the Alamouti code with two transmit and two receive antennas with an optimum combiner. Write the equations for the received signal on each antenna. Stack them together and perform the spatial matched filter. Then, show how the observations on each antenna can be combined to get better performance. Determine the diversity order.
3. Derive the maximum likelihood decoder for a spatial multiplexing system with N_t = 2 and where different constellations C_1 and C_2 are used.

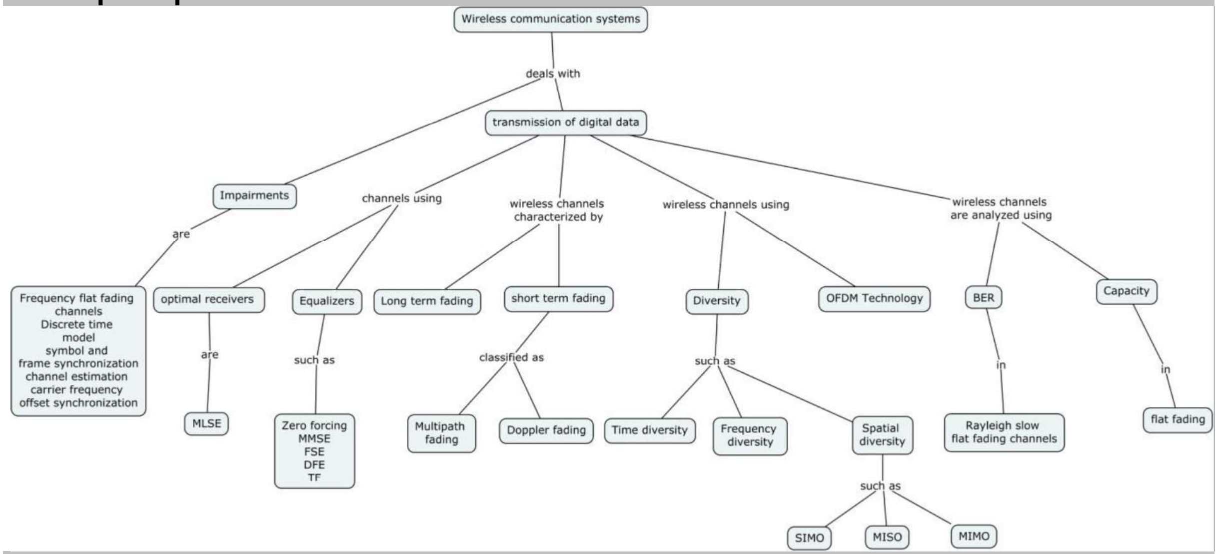
Course Outcome 5 (CO5):

1. Consider the groundbreaking space-time code devised by Alamouti, used in a MIMO system with $N_t = 2$and Nr receive antennas. Derive the pairwise error probability for the Alamouti code and show that the diversity order is 2Nr.
2. Three well-known diversity combining methods are maximum ratio combining (MRC), selection combining (SC), and switch-and-stay combining (SSC). Compare and contrast these techniques. In a flat-fading channel, what is the impact of each method on the symbol error rate; that is, how is the probability of symbol error different from the symbol error rate for a SISO channel?
3. Look up cyclic delay diversity as used in IEEE 802.11n and explain how it works.

Course Outcome 6 (CO6):

1. What is the capacity region of the Gaussian Interference channel with weak interference?
2. Is the Han-Kobayashi Inner bound tight in general?
3. What is the capacity region of the 3 user pair injective deterministic interference channels?

Concept Map



Syllabus

Wireless Fundamentals: Cellular concept, Path loss and shadowing: Radio Wave Propagation, Transmit and Receive Signal Models, Free-Space Path Loss **Wireless Propagation:** Statistical Multipath models, Time varying channel Impulse response, Calculating Impulse response from Power Delay Profile, Large scale channel models, Friis free space model, Log distance path loss model, LoS and NLoS path loss models, Small scale fading selectivity: Frequency selective fading, Time selective fading, Signal models for channel selectivity, Small scale channel models: Flat fading channel models, Frequency selective channel models, Link Budget analysis **Performance analysis with fading channel models**: **Capacity Analysis:** Capacity of Flat fading Channels, Capacity of frequency selective fading Channels **BER Analysis:** SISO Flat fading channels, **Multi-antenna Communications:** Single Input and Multiple output(SIMO), Multiple input and Single output (MISO),Multiple Input and Multiple Output (MIMO), Receiver diversity for Flat fading SIMO Systems: Antenna selection, Maximum Ratio Combining, Transmit diversity for MISO Systems: Transmit Beamforming, Alamouti code, Space Time Coding, MIMO Transceiver techniques, Spatial Multiplexing **Interference channels:** Discrete Memoryless Interference channel, Simple coding scheme, strong Interference, Gaussian Interference channel, Han-Kobayashi Inner bound, Capacity region, Gaussian vector channels **Case studies:** RF over Optics, 5G wireless systems.

Learning Resources

- Robert W. Heath Jr. “Introduction to Wireless Digital Communication: A Signal processing perspective”, 1st Edition, Prentice Hall,2017.
- Aditya.K.Jegannatham, “Principles of Modern Wireless Communication Systems”,Tata McGraw Hill, 2016.
- E.Gamal,Y-H.Kim, Network Information Theory, First Edition, Cambridge University Press, Cambridge,UK,2011.
- Andrea Goldsmith, “ Wireless Communications”, Cambridge University Press, 2005
- David Tse and Pramod Viswanath, “Fundamentals of Wireless Communications”, Cambridge University Press, 2006.
- A.Paulraj, R. Nabar and D Gore, “Introduction to Space-Time Wireless Communications”, Cambridge University Press, 2003.
- Hueber, G., and Niknejad, A. (Eds.). (2019), Millimeter-Wave Circuits for 5G and Radar (The Cambridge RF and Microwave Engineering Series), Cambridge: Cambridge University Press.
- Ranjan Bose, Wireless Communication, NPTEL Video lectures: https://nptel.ac.in/courses/117102062/#

Course Contents and Lecture Schedule

No.	Topic	No. of Hours	COs
1	**Wireless Fundamentals**		
1.1	Cellular concept, Path loss and shadowing	1	CO1
1.2	Radio Wave Propagation, Transmit and Receive Signal Models	1	CO1
1.3	Free-Space Path Loss	1	CO1
2	**Wireless Propagation**		
2.1	Statistical Multipath models, Time varying channel Impulse response	1	CO2
2.2	Calculating Impulse response from Power Delay Profile	1	CO2
2.3	Large scale channel models,Friis free space model	1	CO2
2.4	Log distance path loss model, LoS and NLoS path loss models	1	CO2
2.5	Small scale fading selectivity, Frequency selective fading	1	CO2
2.6	Time selective fading, Signal models for channel selectivity	1	CO2
2.7	Small scale channel models, Flat fading channel models	1	CO2
2.8	Frequency selective channel models,	1	CO2
3	**Performance analysis with fading channel models**		
3.1	Capacity of Flat fading Channels	2	CO3
3.2	Capacity of frequency selective fading Channels	1	CO3
3.3	**BER Analysis**		
4.1	SISO Flat fading channels	1	CO3
4	**Multi antenna Communications**		
4.1	Multi antenna communication, Single Input and Multiple output(SIMO)	2	CO4
4.2	Multiple input and Single output (MISO),Multiple Input and Multiple Output (MIMO)	2	CO4
4.3	Receiver diversity for Flat fading SIMO Systems, Antenna selection	2	CO5
4.4	Maximum Ratio Combining, Transmit diversity for MISO Systems	2	CO5
4.6	Reciprocity based beamforming, Alamouti code	2	CO5
4.7	Spatial Multiplexing	2	CO5
4.8	MIMO Transceiver techniques	2	CO5
5	**Interference channels**		
5.1	Discrete Memoryless Interference channel, Simple coding scheme	1	CO6
5.2	strong Interference, Gaussian Interference channel	1	CO6
5.3	Han-Kobayashi Inner bound, Capacity region	1	CO6
5.4	Gaussian vector channels	1	CO6
6	**Case studies**		
6.1	RF over Optics, 5G wireless systems		

Course Designers:

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18ECPE0	BIOMEDICAL SIGNAL PROCESSING

Category	L	T	P	Credit
PE	2	0	2	3

Preamble

The first objective of this course is to present signal processing techniques/algorithms to process biomedical signals for removal of artifacts and event detection in both time domain and frequency domain. The second objective is to simulate the signal processing algorithms using MATLAB for detecting events in the available biomedical data files which helps in diagnosis.

Prerequisite

18EC440 Signal Processing

Course Outcomes

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

CO#	Course Outcome Statement	Weightage*** in %
CO1	Explain the nature of biomedical signals and their artifacts.	10
CO2	Remove artifacts in biomedical signals with time domain and frequency domain filters and implement the filters using simulation tool.	20
CO3	Identify the discrete signal epochs in a biomedical signal and correlate them with events in the related physiological process and develop programs for the same.	20
CO4	Perform spectral analysis of biomedical signals and systems with suitable signal processing methods and implement the methods.	20
CO5	Diagnose the abnormality in biomedical signals using Aurdino	20
CO6	Describe the basic building blocks of healthcare IoT	10

*** Weightage depends on Bloom's Level, number of contact hours

CO Mapping with CDIO Curriculum Framework

CO#	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	**Affective**	**Psychomotor**	
CO1	TPS2	Understand	Respond	-	1.1.4, 2.1.1, 2.2.3, 2.3.1
CO2	TPS3	Apply	Value	Mechanism	1.2, 2.1.1, 2.2.3, 2.4.2, 3.1.1, 3.1.5, 3.2.3, 3.2.5, 4.4.1, 4.4.4, 4.5.1, 4.6.2
CO3	TPS3	Apply	Value	Mechanism	2.1.1, 2.1.2, 2.2.1, 2.2.3, 2.3.1, 2.4.2, 3.1.1, 3.1.5, 3.2.3, 4.4.1, 4.4.4, 4.5.1, 4.6.2
CO4	TPS3	Apply	Value	Mechanism	2.1.1, 2.1.5, 2.2.1, 2.2.3, 2.3.1, 2.4.2, 3.1.1, 3.1.5, 3.2.3, 4.4.4, 4.5.1, 4.6.2
CO5	TPS3	Apply	Value	Mechanism	2.4.2, 3.1.1, 3.1.5, 3.2.3, 3.2.5, 4.4.4, 4.5.1, 4.6.2
CO6	TPS2	Understand	Respond	-	2.4.2, 3.1.1, 3.1.5, 3.2.3, 4.4.4, 4.5.1, 4.6.2

Mapping with Programme Outcomes

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	M	L		-	-	-	-	-	-	-	-	L	L	-	L
CO2	S	M	L	-	S	-	-	L	M	L	-	L	S	M	L
CO3	S	M	L	-	S	-	-	L	M	L	-	L	S	M	L
CO4	S	M	L	-	S	-	-	L	M	L	-	L	S	M	L
CO5	S	M	L	-	S	-	-	L	M	L	-	L	S	M	L
CO6	M	L	-	-	-	-	-	-	-	-	-	L	L	-	L

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

Bloom's Category	Continuous Assessment Tests			End Semester Examination
	1	2	3	
Remember	20	0	0	0
Understand	20	20	20	20
Apply	60	80	80	80
Analyse	0	0	0	0
Evaluate	0	0	0	0
Create	0	0	0	0

Assessment Pattern: Psychomotor

Psychomotor Skill	Practical
Perception	-
Set	-
Guided Response	-
Mechanism	100
Complex Overt Responses	-
Adaptation	-
Origination	-

Sample Questions for Course Outcome Assessment

Course Outcome 1 (CO1):

1. Draw a typical ECG waveform over one cardiac cycle indicating the important component waves their typical durations and the typical intervals between them.
2. Draw the waveform corresponding to two cycles of a typical ECG and indicate the following waves and periods: a)the P,QRS, and T waves b) the RR interval c) atrial contraction d) atrial relaxation
3. Explain why the P and T waves are low-frequency signals whereas the QRS complex is a high-frequency signal.

Course Outcome 2 (CO2):

1. Explain how you would apply synchronized averaging to remove noise in a) ECG signals b) event-related potentials c) heart sound (PCG) signals d) EMG signals?
2. Draw a typical ECG waveform over one cardiac cycle indicating the important component waves. How is the waveform affected by passage through
   a) alowpass filter with a cutoff frequency of 40Hz?
   b) ahighpass filter with a cutoff frequency of 5Hz?
3. A biomedical signal sampled at 500Hz was found to have a significant amount of 60Hz interference. a)Design a notch filter with two zeros to remove the interference. b)What is the effect of the filter if a signal sampled at 100Hz is applied at the input?

Course Outcome 3 (CO3):

1. Explain Pan-Tompkins algorithm for QRS detection.
2. Prove that autocorrelation $\boldsymbol{\phi_{xx}(\tau)}$ of any function is maximum at $\boldsymbol{\tau = 0}$.
3. Propose an algorithm to detect the P wave in the ECG signal.

Course Outcome 4 (CO4):

1. Two real signals $x_1(n)$ and $x_2(n)$ are combined to form a complex signal defined as $y(n) = x_1(n) + jx_2(n)$. Derive a procedure to extract the DFTs $X_1(k)$ and $X_2(k)$of $x_1(n)$ and $x_2(n)$ from the DFT $Y(k)$of $y(n)$.
2. Two signals with sample values: {3,1,-1} and {4,4,2,1} are given. Implement the convolution of these two signals using FFT.
3. A signal $x(t)$ is transmitted through a channel. The received signal $y(t)$ is obtained as $y(t) = \alpha x(t - t_0) + \eta(t)$ where α is a scale factor, t_0 is the time delay and $\eta(t)$ is noise. Derive expressions for the Power Spectral Density (PSD) of $y(t)$ in terms of PSDs of $x$and η.

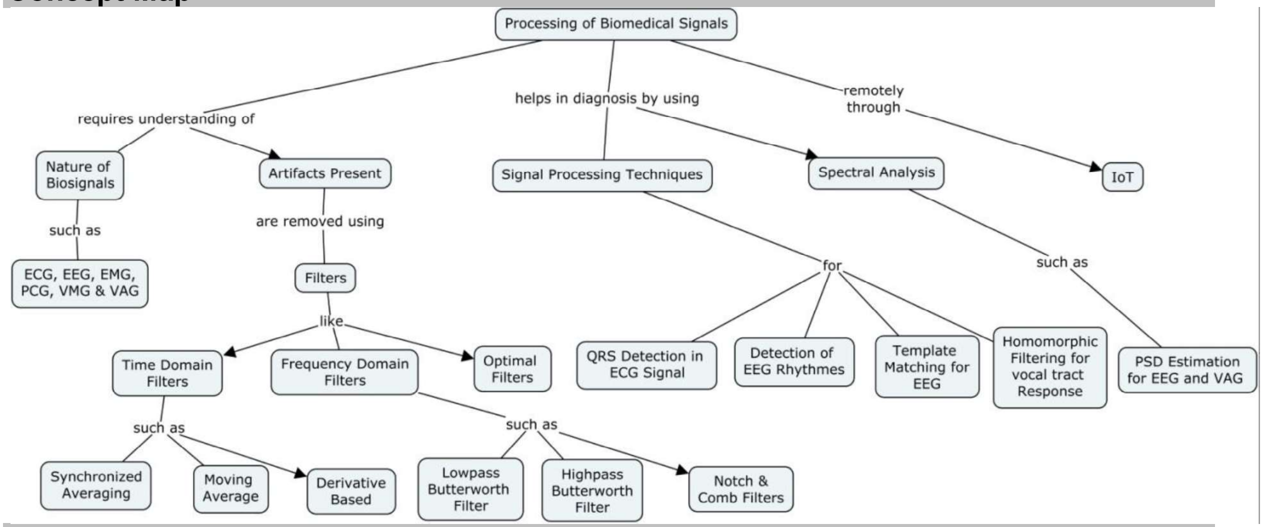
Course Outcome 5 (CO5):

1. Develop an algorithm using time domain technique to remove base-line drift in the ECG signal.
2. Using Arduino kit, filter the noisy ECG signal using Butterworth highpass filters with orders 2-8 and cutoff frequencies 0.5-5 Hz.
3. Detect the presence of the alpha rhythm in the given EEG signal using Arduino kit.

Course Outcome 6 (CO6):

1. List the most important physiological data for the development of a ubiquitous IoT healthcare system that can ensure more accurate diagnosis, real-time evidence based treatment, lower hospital visits, and optimal utilization of resources.
2. List the the protocols employed in the IoT cloud in order to provide visual and timely data to users.
3. Explain the basic building blocks of healthcare IoT.

Concept Map



Syllabus

Theory:

Introduction to Biomedical Signals: Nature of Biomedical Signals, Examples of Biomedical Signals-Action Potential, Electromygraphy (EMG), Electrocardiography (ECG), Electroencephalography (EEG), Event Related Potentials (ERPs), Electrogastrogtam (EGG), Phonocardiogram (PCG), Carotid Pulse (CP), Vibromyogram (VMG) and Vibroarthrogram (VAG), Objectives of Biomedical Signal Analysis **Filtering for Removal of Artifacts:** Time Domain Filters –Synchronized averaging, Moving-average filters, Derivative based operators to remove low-frequency artifacts, Frequency-domain Filters –Removal of high-frequency noise using Butterworth low pass filters, Removal of low-frequency noise using Butterworth high pass filters, Removal of periodic artifacts using Notch and Comb filters, Optimal filtering, Removal of artifacts using Arduino **Event Detection:** Derivative based methods for QRS detection, The Pan-Tompkins algorithm for QRS detection, Detection of the dicrotic notch, Detection of EEG rhythms, EEG spike-and-wave detection, Detection of the P wave, Homomorphic filtering, Event detection using Arduino **Frequency domain characterization of biomedical signals:** Estimation of power spectral density function: The periodogram, Averaged periodogram, Use of windows: Spectral resolution and leakage. **Basic building blocks of healthcare IoT**

Practical:

Filtering for Removal of Artifacts:

1. Removal of power line artifacts in biosignals.
2. Removal of noise using IIR filters.
3. Removal of random noise using synchronized averaging.
4. Removal of baseline drift using derivative based Filter.

Event Detection:

5. QRS Complex Detection using Pan Tompkin Algorithm.
6. Detection of alpha rhythm using cross-correlation coefficients.
7. Detection of s1 and s2 onset in PCG signal.

Spectral Analysis of Biomedical Signals:

8. Analysis of power spectral density of EEG and VAG signals for diagnosis.

Learning Resources

- R.M.Rangayan, "Biomedical Signal Analysis: A Case Study Approach" John Wiley & Sons. Inc, 2005.
- Willis J.Tompkins, "Biomedical Signal Processing", EEE, PHI,2004.
- D.C.Reddy, "Biomedical Signal Processing: Principles and Techniques", Tata McGraw Hill Publishing Co. Ltd, 2005.
- NPTEL course on Biomedical Signal Processing: https://onlinecourses-archive.nptel.ac.in/noc19_ee23/.
- Balas, V.E., Solanki, V.K., Kumar, R., Ahad, M.A.R, "A Handbook of Internet of Things in Biomedical and Cyber Physical System", Intelligent Systems Reference Library, Springer, 2020.

Course Contents and Lecture Schedule

Module No.	Topic	No. of Lectures	CO
1	**Introduction to Biomedical Signals:**		
1.1	Nature of Biomedical Signals	1	CO1
1.2	Examples of Biomedical Signals-Action Potential, EMG, ECG, EEG, ERPs, EGG, PCG, CP, Speech Signals, VMG and VAG	2	CO1
1.3	Objectives of Biomedical Signal Analysis	1	CO1
2	**Filtering for Removal of Artifacts:**		
2.1	Time Domain Filters –Synchronized averaging	1	CO2
2.2	Moving-average filters	1	CO2
2.3	Derivative based operators to remove low-frequency artifacts	1	CO2
2.4	Frequency-domain Filters – Removal of high-frequency noise using Butterworth lowpass filters	2	CO2
2.5	Removal of low-frequency noise using Butterworth high pass filters	1	CO2
2.6	Removal of periodic artifacts using Notch and Comb filters	1	CO2
2.7	Optimal filtering	2	CO2
2.8	Practical – Filtering for Removal of Artifacts using MATLAB	4	CO2
2.9	Practical – Filtering for Removal of Artifacts using Arduino	4	CO5
3	**Event Detection:**		
3.1	Derivative based methods for QRS detection	1	CO3
3.2	The Pan-Tompkins algorithm for QRS detection	3	CO3
3.3	Detection of the dicrotic notch	1	CO3
3.4	Detection of EEG rhythms	1	CO3

3.5	EEG spike-and-wave detection	1	CO3
3.6	Detection of the P wave	1	CO3
3.7	Homomorphic filtering	1	CO3
3.8	Practical: Event Detection using MATLAB	4	CO3
3.9	Practical: Event Detection using Arduino	4	CO5
4	**Frequency domain characterization of biomedical signals:**		
4.1	Estimation of power spectral density function: The periodogram	1	CO4
4.2	Averaged periodogram	2	CO4
4.3	Use of windows: Spectral resolution and leakage	1	CO4
4.4	Practical: Spectral analysis of Biomedical signals using MATLAB	4	CO4
5	**Basic building blocks of healthcare IoT**	2	CO6
	Total	48	

Course Designers:

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18ECPF0	FPGA BASED DIGITAL SYSTEM DESIGN	Category	L	T	P	Credit
		PE	3	0	0	3

Preamble

FPGA based Digital System Design aims at analyse the different architecture and organisation of Field Programmable Gate Arrays. Initially the different elements like Programmable logic cell, interconnect and Input/Output cells of the FPGA are explored and analysed. The subject focuses on the procedure for the design of sequential digital circuits and their mapping with the fixed platform of FPGA. It also analyses the timing issues related with the digital circuits of major concern and the alternate to overcome the timing issues in FPGA. Finally the learner is exposed with some reference case studies for FPGA implementation of both combinational and sequential digital circuits.

Prerequisite

18EC270 Digital System Design

Course Outcomes

On the successful completion of the course students will be able to

CO#	Course Outcome Statement	Weightage in %
CO1	Describe the FPGA design flow, architecture, programming technologies.	15
CO2	Analyse the configurable logic elements of Xilinx and altera FPGAs	10
CO3	Map the combinational and sequential circuits in the preferred FPGA hardware platform.	20
CO4	Analyse the Input / Output cells of FPGA for interfacing with external peripherals.	20
CO5	Understand the interconnect architectures of different vendors of FPGA	10
CO6	Analyse the timing parameters of combinational and sequential digital circuits.	15
CO7	Demonstrate the functioning of a digital system in a FPGA hardware platform	10

CO Mapping with CDIO Curriculum Framework

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS3	Apply	Value	Mechanism	2.1.1, 2.1.2, 2.4.2, 2.5.1, 3.1.1, 3.2.3, 4.5.5, 4.6.2
CO2	TPS3	Apply	Value	Mechanism	2.1.1, 2.1.2, 2.5.1, 3.1.1, 3.2.3, 4.5.5, 4.6.2
CO3	TPS3	Apply	Value	Mechanism	2.1.1, 2.1.2, 2.5.1, 3.1.1, 3.2.3, 4.5.5, 4.6.2
CO4	TPS4	Analyse	Organise	Complex Overt Response	2.1.1, 2.1.2, 2.1.3, 2.5.1
CO5	TPS2	Understand	Respond	Guided Response	2.5.4, 3.2.6
CO6	TPS5	Evaluate	Organise	Adaptation	2.1.1, 2.1.2, 2.1.3, 2.5.1
CO7	TPS5	Evaluate	Organise	Adaptation	2.1.1, 2.1.2, 2.1.3, 2.5.1

Mapping with Programme Outcomes and Programme Specific Outcomes

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	S	M	L	-	L	-	-	L	L	L	-	L	M	-	L
CO2	S	M	L	-	L	-	-	L	L	L	-	L	M	-	L
CO3	S	M	L	-	L	-	-	L	L	L	-	L	M	-	L
CO4	S	S	M	L	L	-	-	L	L	L	-	L	S	-	L
CO5	M	L	-	-	-	-	-	-	L	L	-	L	S	-	L
CO6	S	S	M	M	L	-	-	-	-	-	-	-	S	-	-
CO7	S	S	M	M	L	-	-	-	-	-	-	-	S	-	-

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

Cognitive Levels	Continuous Assessment Tests			Assignment			End Semester Examination
	1	2	3	1	2	3	
Remember	20	0	0	-	-	-	10
Understand	20	20	20	-	-	-	10
Apply	60	40	30	100	50		50
Analyse	0	40	30	0	50	40	20
Evaluate	0	0	10	0	0	20	10
Create	0	0	0	0	0	0	0

Assessment Pattern: Psychomotor

Psychomotor Skill	Assignment 3
Perception	
Set	
Guided Response	
Mechanism	40
Complex Overt Responses	
Adaptation	
Origination	

Sample Questions for Course Outcome Assessment**

Course Outcome 1(CO1):

1. Compare the coarse grained architecture and fine grained architecture of FPGA.
2. Draw and illustrate the process of storing information in an SRAM and DRAM cell.
3. Explain the method of programming and erasing the EPROM and EEPROM memory cell.

Course Outcome 2(CO2):

1. Draw the architecture of logic cells used in Altera MAX.
2. Draw the different elements present inside the Configurable Logic Block of Xilinx XC4000 series FPGA.
3. Compare the internal architecture, I/O and routing resources of CPLD and FPGA devices.

Course Outcome 3(CO3):

1. Implement the Mod-8 counter circuit using an FPGA whose logic block consist of 3 input and show the interconnection between the blocks to derive the complete circuit from primary input to output.
2. Implement the logic function F(a,b,c) = a.b'.c'+a'.b'.c+a'.b.c+a'.b'.c' using three input CPLD and draw the circuit.

3. Report the memory content of Look Up Table of Xilinx XC4000 series FPGA for implementing an MOD-4 counter.

Course Outcome 4 (CO4):

1. Draw the I/O cell structure of Xilinx FPGA and show the state of the programmable transistors to configure the cell.
2. Compare the I/O cells of Xilinx and Altera FPGA and conduct an investigation to find the scenario of limitation for implementation.
3. Illustrate an algorithm to interface the PS2 keyboard with the FPGA device present in an Development board.

Course Outcome 5 (CO5):

1. Draw the switch matrix used for changing the interconnect routing inside an FPGA.
2. With the help of neat diagram, show the interconnect architecture of Altera CPLD.
3. Describe the mapping process of interconnect for an specific application in FPGA and CPLD.

Course Outcome 6(CO6):

1. Consider a flip flop with a setup time of 3 ns and a hold time of 1ns. If the clock input rises at time *t*, is it ok for the data input to change at time *t*–2? What about *t*–4? What about *t*+1/2? What about *t*+2? Explain why it is not acceptable for the data input to change at certain times.
2. Consider a circuit in which there is a path from an input *x* to a flip flop that has a maximum possible delay of 7 ns, and there is also a path from *x* to another flip flop with a minimum delay of 3 ns. If the setup and hold times are 2 ns and 1 ns respectively and the clock input rises at time *t*, is it ok for *x* to change at time *t*–5? What about *t*–1? What about *t*? What about *t*–10?
3. Consider a flip flop with a setup time of 5 ns and a hold time of 3 ns. The clock input rises at time 20 ns. What it the latest time that the D input can change prior to the clock edge to ensure proper timing?

Course Outcome 7(CO7):

1. Consider the design of a sequential circuit that could control a vending machine. Suppose that a coin-operated vending machine dispenses candy under the following conditions:

    The machine accepts nickels and dimes.

    It takes 15 cents for a piece of candy to be released from the machine.

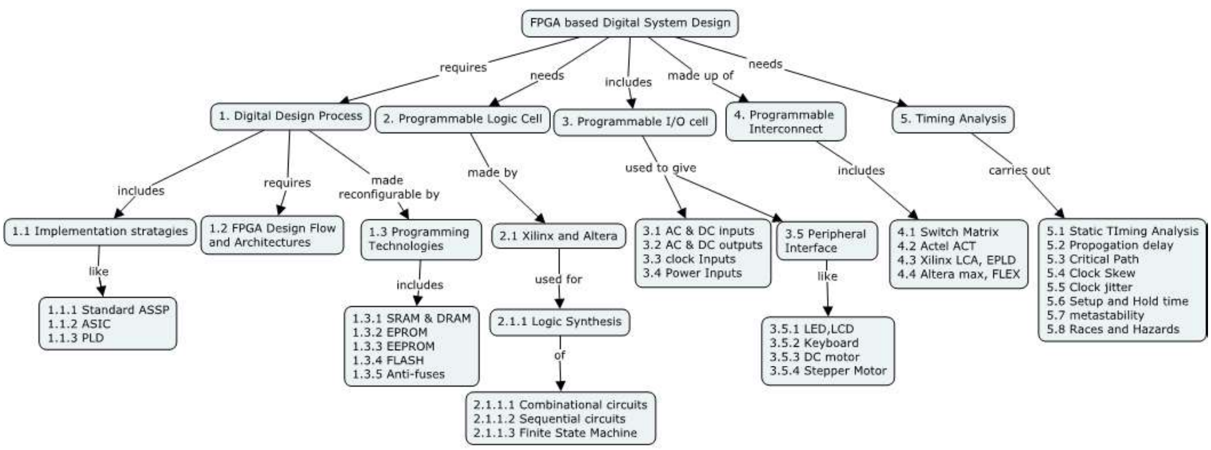
    If 20 cents is deposited, the machine will not return the change, but it will credit the buyer with 5 cents and wait for the buyer to make a second purchase. All electronic signals in the vending machine are synchronized to the positive edge of a clock.

2. The specification for the counter is

    The counting sequence is 0, 1, 2, . . . , 6, 7, 0, 1, . . .

    There exists an input signal *w*. The value of this signal is considered during each clock cycle. If *w* = 0, the present count remains the same; if *w* = 1, the count is incremented. The counter can be designed as a synchronous sequential circuit.

Concept Map



Syllabus

Digital Design process: Standard ICs, ASIC and FPGA design flow, Programmable Logic Devices, FPGA architectures, Programming technologies: SRAM, DRAM, EPROM, EEPROM FLASH and Anti-fuses.
Programmable Logic cells: Xilinx and Altera logic blocks, Logic synthesis for combinational circuits, sequential circuits - Synchronous and Asynchronous Sequential Circuit -Finite State Machine design, Design examples: SOP and POS implementation, Flip flops and registers.
Programmable I/O cells: AC, DC inputs and outputs, Clock inputs and power inputs Xilinx I/O cells and Altera I/O cells. Interfaces: LED, LCD, Keyboard, DC motor and Stepper motor.
Programmable interconnects: Switch matrix, Actel ACT, Xilinx LCA, EPLD, Altera Max and FLEX interconnect architectures.
Timing Analysis: Static Timing Analysis (STA) - Propagation delay, Critical path, Clock skew, Clock jitter, setup time and Hold time - violations, metastability, synchronisers, races and hazards.
Case studies: Vending machines, Counters, Arbiter, Arithmetic circuits.

Learning Resources

- M. Morris Mano and Michael D. Ciletti, "Digital Design: with an Introduction to the Verilog HDL", 5th Edition, Prentice Hall 2012.
- Jan M. Rabey, Anantha Chandrakasan and Borivoje Nikolic " Digital integrated circuits: A Design Perspective (2nd Edition) ", Pearson 2009
- M.J.S.Smith, "Application Specific Integrated Circuits", Pearson, 2003.
- Stephen D. Brown, and Zvonko Vranesic, "Fundamentals of Digital Logic with Verilog Design, 2nd Edition," McGraw Hill, June, 2007.
- Samir Palnitkar, "Verilog HDL: A guide to digital design and synthesis" Pearson Education India, 2010.

Course Contents and Lecture Schedule

Module No.	Topic	No. of Hours	Course Outcome
1.	**Digital Design process**		
1.1	Implementation Technologies		
1.1.1	Standard ICs, ASIC, Programmable Logic Devices	1	CO1
1.2	FPGA Design flow and architectures	1	CO1
1.5	Programming technologies:		
1.5.1	SRAM, DRAM	1	CO1
1.5.2	EPROM, EEPROM	1	CO1
1.5.3	FLASH and Anti-fuses.	1	CO1
2.	**Programmable Logic cells**:		
2.1	Xilinx and Altera logic blocks	2	CO2
2.1.1	Logic synthesis - combinational circuits,	2	CO2
2.1.1.1	Sequential circuits - Synchronous and Asynchronous	3	CO3
2.1.1.2	Finite State Machines	2	CO3
2.2	Design examples: SOP and POS implementation, Flip flops and registers.	2	CO3
3.	**Programmable I/O cells**:		
3.1	AC & DC inputs	1	CO4
3.2	AC & DC outputs.	1	CO4
3.3	Clock inputs and power inputs	1	CO4
3.4	Xilinx I/O cells and Altera I/O cells	1	CO4
3.5	Peripheral Interfaces	1	CO4
3.5.1	LED, LCD	1	CO4
3.5.2	Keyboard	1	CO4
3.5.3	DC motor, Stepper motor	1	CO4
4.	**Programmable interconnects:**		

4.1	Switch matrix,	1	CO5
4.2	Actel ACT interconnect	1	CO5
4.3	Xilinx LCA, EPLD interconnect	1	CO5
4.4	Altera Max and FLEX interconnect	1	CO5
5.	**Timing Analysis**		
5.1	Static Timing Analysis (STA)	1	CO6
5.2	Propagation delay, Critical path	1	CO6
5.3	Clock skew, Clock jitter	1	CO6
5.4	setup time and Hold time - violations,	1	CO6
5.5	metastability, synchronisers, races and hazards.	1	CO6
6	**Case studies:** Vending machines, Counters, Arbiter, Arithmetic circuits	3	CO7
	Total Hours	**36**	

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18ECPG0	ANALOG SYSTEM DESIGN	Category	L	T	P	Credit
		PE	2	0	2	3

Preamble

This course deals with the design and applications of JFET and MOSFET differential and operational amplifier circuits. Use of analog multipliers to build analog systems is emphasized. Much attention is given to PLL, VCO, linear and non-linear applications of op-amp and active filter synthesis, including switched capacitor configurations. It also deals with DC-DC converters and Low dropout regulators.

Prerequisite

18EC330 : Electronic Circuits

Course Outcomes

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

CO#	Course Outcome Statement	Weightage in %
CO1	Demonstrate the characteristics of JFET and MOSFET Differential amplifier and operational amplifier	10
CO2	Use analog multipliers to build analog systems	10
CO3	Demonstrate the operation of PLL, Automatic gain control, DC-DC converter, Low drop-out regulator and Switched capacitor filter IC MF10.	30
CO4	Experiment Instrumentation Amplifier and regenerative feedback systems	15
CO5	Experiment function generator, Voltage Controlled Oscillator and PLL	20
CO6	Experiment Automatic Gain Control and Low Dropout Regulator	15

CO Mapping with CDIO Curriculum Framework

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS3	Apply	Value	-	1.2.3, 2.4.6, 3.2.3
CO2	TPS3	Apply	Value	-	1.2.3,2.1.1, 2.3.4, 2.4.6, 2.5.1, 3.1.1, 3.2.3, 4.5.1, 4.6.1
CO3	TPS3	Apply	Value	-	1.2.3, 2.1.1, 2.3.4, 2.5.1, 3.1.1, 3.2.3, 4.5.1, 4.6.1
CO4	TPS3	Apply	Value	Mechanism	1.2.3, 2.1.1, 2.3.4, 2.5.1, 3.1.1, 3.2.3, 4.5.1, 4.6.1
CO5	TPS3	Apply	Value	Mechanism	1.2.3, 2.4.6, 3.2.3,
CO6	TPS3	Apply	Value	Mechanism	1.2.3, 2.1.1, 2.3.4, 2.5.1, 3.1.1, 4.5.1, 4.6.1

Mapping with Programme Outcomes

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	S	M	L	-	-	-	-	-	-	-	-	-	M	-	-
CO2	S	M	L	-	-	-	-	-	-	-	-	-	M	-	-
CO3	S	M	L	-	-	-	-	-	-	-	-	-	M	-	-
CO4	S	M	L	-	S	-	-	-	M	M	-	-	M	L	-
CO5	S	M	L	-	S	-	-	-	M	M	-	-	M	L	-
CO6	S	M	L	-	S	-	-	-	M	M	-	-	M	L	-

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

Bloom's Category	Continuous Assessment Tests			End Semester Examination
	1	2	3	
Remember	0	0	0	0
Understand	40	20	20	20
Apply	60	80	80	80
Analyse	0	0	0	0
Evaluate	0	0	0	0
Create	0	0	0	0

Assessment Pattern: Psychomotor

Psychomotor Skill	Practical
Perception	-
Set	-
Guided Response	-
Mechanism	100
Complex Overt Responses	-
Ad aptation	-
Origination	-

Sample Questions for Course Outcome Assessment

Course Outcome 1 (CO1):

1. Write note about TL082 wide bandwidth dual JFET input operational amplifier with necessary diagram.
2. A square wave peak-to-peak amplitude of 50mV has to be amplified to a peak-to-peak amplitude of 3V, with rise time of 4 μs or less. Can TL082 be used?
3. A op-amp whose slew rate is 0.5V/μs is used as an inverting amplifier with a gain of 50.The voltage gain Vs frequency curve is flat up to 20 kHz. What maximum peak to peak input signal can be applied without distorting the output?

Course Outcome 2 (CO2):

1. Assess the need of pre-distortion circuits in Gilbert analog multiplier.
2. How is the configuration of Gilbert multiplier done with pre-distortion circuits.

Course Outcome 3 (CO3):

1. A PLL has a free running frequency of 300 KHz and the bandwidth of the low pass filter is 50KHz. Check whether the loop acquires lock for an input signal of 320KHz.
2. Design a second order Butterworth low-pass filter having upper cut-off frequency of 2.1961 kHz.
3. Design an OP-AMP based first order active low pass filter.

Course Outcome 4 (CO4):

1. Design an instrumentation amplifier circuit to provide a gain that can be varied over the range of 5 to 500, utilizing a 47KΩ variable resistance. Draw the designed circuit.

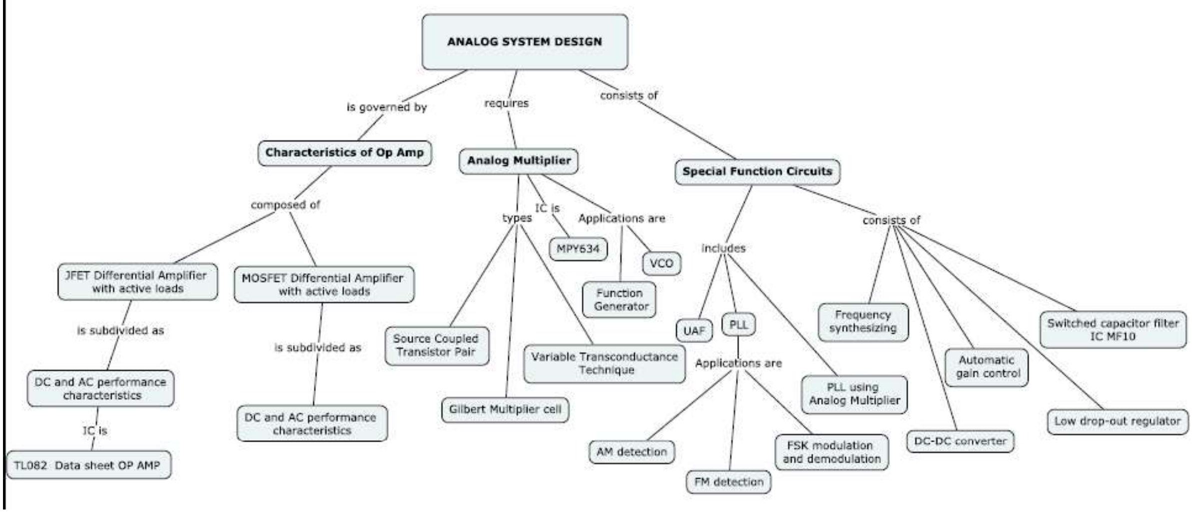
Course Outcome 5 (CO5):

1. Design a function generator to generate both square and triangular waveforms for a frequency of 50KHz. Draw the designed circuit diagram, generated square and triangular waveforms specifying the peak amplitude and time period. Assume that the operational amplifier saturates at ±10V.
2. Design a voltage controlled oscillator to generate triangular waveform. Assume that the operational amplifier saturates at ±10V.

Course Outcome 6 (CO6):

1. Plot the graphs of output characteristics, transfer characteristics and ripple rejection for a typical low dropout regulator.
2. Elaborate the steps for determining the lock range of AGC.

Concept Map



Syllabus

Theory:

Characteristics of Op Amp: JFET and MOSFET Differential amplifier with active loads, DC and AC performance characteristics, JFET Operational Amplifiers –TL082 Op Amp Data sheet **Analog Multiplier :** Analog Multiplier using Source Coupled Transistor Pair - Gilbert Multiplier cell – Variable transconductance technique, ICs - MPY634, function generator, Voltage controlled oscillator **Special Function Circuits:** Universal Active filters, Principles of PLL, PLL using analog multiplier **Application of PLL:** FM detection, FSK modulation and demodulation and Frequency synthesizing and clock synchronization, Automatic gain control, DC-DC converter, Low drop-out regulator, Switched capacitor filter IC MF10.

Practical:

1. Design and implement Instrumentation Amplifier.
2. Design and implement regenerative feedback systems – Schmitt trigger, Astable and Monostable multivibrators.
3. Design and implementation of Universal Active filters.
4. Design and implementation of function generator and Voltage Controlled Oscillator.
5. Design and implementation of Phase locked loop.
6. Design and implementation of Automatic Gain Control (AGC).
7. Design and implementation of a Low Dropout Regulator.

Learning Resources

- Adel S. Sedra, Kenneth C. Smith, “Microelectronic Circuits: Theory and Applications”, Oxford University Press, 2014.
- K.R.K.Rao, C.P. Ravikumar, “Analog Systems Lab Manual”, 2nd edition, Wiley, 2012.
- David A. Bell, “Operational Amplifiers and Linear ICs”, 3rd edition, OUP, 2013.
- Sergio Franco, “Design with operational amplifier and analog integrated circuits”, McGraw Hill, 1997
- Robert F. Coughlin, Frederick F. Driscoll, “Operational-Amplifiers and Linear Integrated Circuits”, 6th Edition, Prentice Hall, 2001.
- David A Bell, “Laboratory Manual for Operational Amplifiers & Linear ICs”, 2nd edition, D.A. Bell, 2001.
- Analog System Design using ASLK Kit by K.R.K. Rao, Video Lecture Link: https://www.youtube.com/watch?v=S_v70oFKmnw

Course Contents and Lecture Schedule

Module No.	Topic	No.of Lectures	CO
1	**Characteristics of Op Amp**		
1.1	JFET and MOSFET Differential amplifier with active loads	2	CO1
1.2	DC and AC performance characteristics	1	CO1
1.3	JFET Operational Amplifiers	1	CO1
1.4	TL082 Op Amp Data sheet	1	
1.5	Practical	2	CO4
2	**Analog Multiplier**		
2.1	Analog Multiplier using Source Coupled Transistor Pair	2	CO2
2.2	Gilbert Multiplier cell	1	CO2
2.3	Variable transconductance technique	1	CO2
2.4	ICs - MPY634, function generator	2	CO2
2.5	Voltage controlled oscillator	1	CO2
2.6	Practical	8	CO5
3	**Special Function Circuits**		
3.1	Universal Active filters	2	CO3
3.2	Principles of PLL	2	CO3
3.3	PLL using analog multiplier	1	CO3
3.4	Practical	6	CO5
4	**Application of PLL**		
4.1	FM detection	1	CO3
4.2	FSK modulation and demodulation	1	CO3
4.3	Frequency synthesizing and clock synchronization	1	CO3
4.4	Automatic gain control ,DC-DC converter	2	CO3
4.5	Low drop-out regulator, Switched capacitor filter IC MF10	2	
4.5	Practical	8	CO6
	Total	48	

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18ECPH0	ELECTRONIC MEASUREMENT AND INSTRUMENTS	Category	L	T	P	Credit
		PE	3	0	0	3

Course Outcomes

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

CO#	Course Outcome Statement	Weightage in %
CO1	Identify errors in different types of electrical measurements.	10
CO2	Determine resistance, capacitance and inductance using AC bridges.	30
CO3	Use Digital Measurement Concepts.	30
CO4	Analyze the characteristics of components used in Analog and Digital data acquisition systems.	15
CO5	Classify and employ the sensor for various applications.	15

CO Mapping with CDIO Curriculum Framework

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS3	Apply	Value	-	1.2.2, 2.1.1, 2.1.2, 2.4.2, 2.5.1, 3.1.1, 3.2.3, 4.5.5, 4.6.2
CO2	TPS3	Apply	Value	-	1.2.2, 2.1.1, 2.1.2, 2.5.1, 3.1.1, 3.2.3, 4.5.5, 4.6.2
CO3	TPS3	Apply	Value	-	1.2.2, 2.1.1, 2.1.2, 2.5.1, 3.1.1, 3.2.3, 4.5.5, 4.6.2
CO4	TPS4	Analyse	Organise	-	1.2.2, 2.1.1, 2.1.2, 2.1.3, 2.5.1
CO5	TPS2	Understand	Respond	-	1.2.2, 2.5.4, 3.2.6

Mapping with Programme Outcomes

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	S	M	L	-	-	-	-	-	-	-	-	-	M	-	-
CO2	S	M	L	-	-	-	-	-	-	-	-	-	M	-	-
CO3	S	M	L	-	-	-	-	-	-	-	-	-	M	-	-
CO4	S	S	M	L	-	-	-	-	-	-	-	-	S	-	-
CO5	M	L	-	-	-	-	-	-	-	-	-	-	L	-	-

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

Cognitive Levels	Continuous Assessment Tests			Assignment			End Semester Examination
	1	2	3	1	2	3	
Remember	10	0	10	0	0	0	0
Understand	10	20	20	0	0	0	20
Apply	80	40	30	100	50	0	50
Analyse	0	40	40	0	50	50	30
Evaluate	0	0	0	0	0	0	0
Create	0	0	0	0	0	0	0

Assessment Pattern: Psychomotor

Psychomotor Skill	Assignment 3
Perception	
Set	
Guided Response	
Mechanism	30
Complex Overt Responses	
Adaptation	
Origination	

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Mention the standards of measurement and errors.
2. Explain in detail about PMMC.
3. Calculate random error, systematic error, gross error for the given MI readings.

Course Outcome 2 (CO2)

1. What is the value of series resistance to be used to extent ‘0’to 200V range of 20,000Ω/volt voltmeter to 0 to 2000 volt?
2. Discuss about AC –Bridge to measure capacitance.
3. A 250V M.I. voltmeter has coil resistance of 500Ω, coil inductance of 1.04 H and series resistance of 2kΩ. The meter reads correctively at 250V D.C. What will be the value of capacitance to be used for shunting the series resistance to make the meter read correctly at 50HZ? What is the reading of voltmeter on A.C. without capacitance?

Course Outcome 3 (CO3)

1. What is Hysteresis effect?
2. Prove that for electrodynamometer type wattmeter true power = {cos Φ / [cos Φ cos (Φ – β]} x actual wattmeter reading Where cos Φ power factor of the circuit β = tan-1 ($\omega L/R$) where L and R are the inductance and resistance of the pressure coil of the circuit. Enumerate about the various testing methods on single phase energy meter.
3. Describe the measurement of frequency, phase angle and time delay using oscilloscope with suitable diagrams and mathematical expressions.

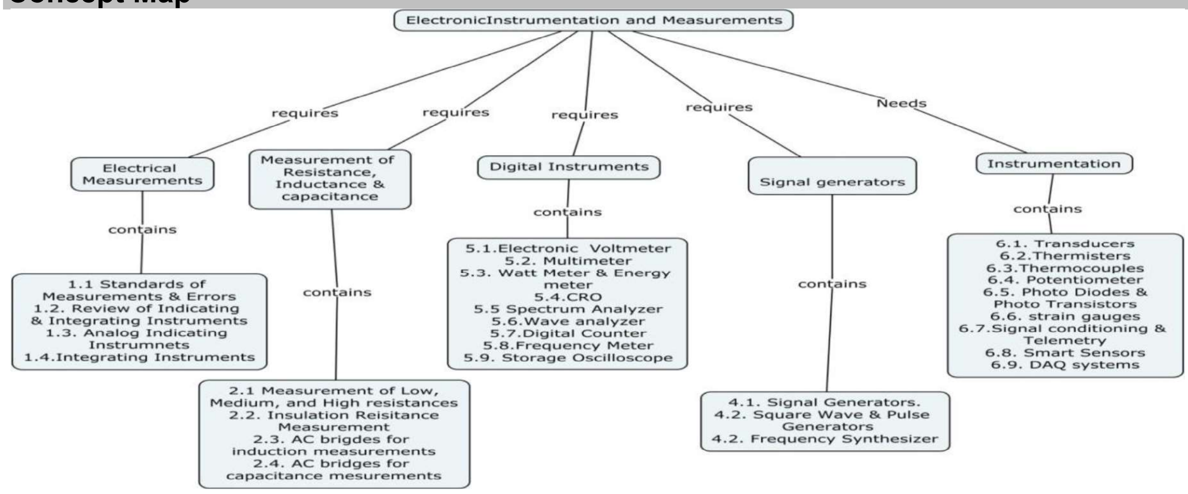
Course Outcome 4 (CO4)

1. List out the basic components in a function generator.
2. Illustrate the working of Basic Schmitt trigger used in Function generator.
3. Describe the Working of PLL and its use in Frequency synthesizer

Course Outcome 5 (CO5)

1. Analyze the effects of voltmeter calibrated with a potentiometer.
2. Design a smart sensor and mention its applications.
3. Illustrate about Data Acquisition System

Concept Map



Syllabus

Measurement Units, Measurement System Design, Review of Instrument Types: Active, Passive, Analog and Digital Instruments. **Static Characteristics**: Accuracy, Precision, Repeatability, Tolerance, range/Span, Linearity, Sensitivity, threshold, resolution, hysteresis, dead Space. **Dynamic Characteristics**: Zero-Order, First-Order, Second-Order Instrument. Measurement Error and source of error: Statistical analysis of error and Calibration. **Analog Meters**: Moving Coil, Moving Iron, Clamp-on Meters, Analog Multimeter, High-Frequency Signals analog Meters. **Digital Meters**: Voltage-to-Time Conversion Digital Voltmeter, Potentiometric Digital Voltmeter, Dual-Slope Integration Digital Voltmeter, Voltage-to-Frequency Conversion Digital Voltmeter, Digital Multimeter. **Bridges:** Resistance, inductance and capacitor measurement, DC bridges. Current, frequency, phase, power and energy measurements. **Sensor and actuator:** classification & selection of transducers-inductive & capacitive transducers- piezoelectric and Hall-effect transducers- encoder, thermisters, thermocouples, potentiometer, photo-diodes & photo-transistors, strain gauges, signal conditioning and telemetry, basic concepts of smart sensors and application. **Signal generators and oscilloscope**. Function generators- pulse and square wave generators- Frequency Synthesizer. Oscilloscopes: Analog, Digital CRO and DSO. **PC based virtual instrument**:RS232 and 4-20mA current loop, Field bus, safety and reliability.

Learning Resources

- Measurement and Instrumentation Theory and Application, Reza Langari Alan S. Morris Elsevier 2017.
- A.K.Sawhney, "A Course in Electrical and Electronic Measurements and Instrumentation (Nineteenth Revised Edition 2011 Reprint 2014), Dhanpatrai & co.
- Golding, E.W., "Electrical Measurement and Measuring Instruments", 3rd Edition, SirIssac Pitman and Sons, 1960.

Course Contents and Lecture Schedule

Module No.	Topic	No. of Lectures	Course outcome
1	**Measurement Units, Measurement system types:**		
1.1	Units, Active, and Passive	1	CO1
1.2	Analog and Digital Instruments	1	CO1
2	**Static and Dynamic Characteristics**:		
2.1	Accuracy, Precision, Repeatability, Tolerance, range / Span, Linearity, Sensitivity, threshold, resolution, hysteresis, dead Space.	2	CO1
2.2	Zero-Order, First-Order, Second-Order Instrument.	2	CO1
2.3	source of error: Statistical analysis of error	2	CO2
2.4	Calibration	1	CO2
3	**Analog and digital Meters**:		
3.1	Analog meters: Moving Coil , Moving Iron,	2	CO2
3.2	Clamp-on Meters, Analog Multimeter	1	CO2
3.3	High-Frequency Signals analog Meters.	1	CO2
3.4	Digital Meters: Voltage-to-Time Conversion Digital Voltmeter,	1	CO2
3.5	Potentiometric Digital Voltmeter,	1	CO2
3.6	Dual-Slope Integration Digital Voltmeter,	1	CO3
3.7	Voltage-to-Frequency Conversion	2	CO3
3.8	Digital Voltmeter, Digital Multimeter	1	CO3
4	**Bridges:**		CO3
4.1	Resistance, inductance and capacitor measurement	1	CO3
4.2	Current, frequency, phase, power and energy measurement	2	CO3
5	**Sensor and actuator:**		

5.1	Transducers- inductive & capacitive transducers	1	
5.2	piezoelectric and Hall-effect transducers- encoder,	1	CO4
5.3	Thermisters, thermocouples, potentiometer,	1	CO4
5.4	photo-diodes & photo-transistors, strain gauges,	1	
5.5	signal conditioning and telemetry, basic concepts of smart sensors and application	2	CO4
6	**Signal generators and oscilloscope:**		CO4
6.1	Function generators- pulse and square wave generator	2	CO4
6.2	Analog, Digital CRO and DSO.	2	CO5
7	**PC based virtual instrument**		
7.1	Building blocks of PC based instruments	1	CO5
7.2	RS232 and 4-20mA current loop,	2	CO5
7.3	Field bus, safety and reliability	1	CO5
	Total	**36**	

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18ECPJ0	NETWORK AND DATA SECURITY	Category	L	T	P	Credit
		PE	3	0	0	3

Preamble

The objectives of this course are to provide in-depth understanding of the underlying concepts of different classical and modern cryptographic techniques along with their network security applications like IP security, WEB security and System security

Prerequisite

NIL

Course Outcomes

On the successful completion of the course students will be able to

CO Number	Course Outcome Statement	Weightage*** in %
CO1	Identify the threats and security attacks in the networks and corresponding services and mechanisms	7
CO2	Use conventional encryption technique, classical encryption technique and modern encryption technique	18
CO3	Use Asymmetric encryption algorithm and Diffie-Hellman algorithm, Elliptic Curve Cryptography	20
CO4	Determine key management and distribution technique in IP Security.	20
CO5	Compare principles and practices of cryptography and network security technologies in financial sectors	15
CO6	Relate various system security attacks along with their countermeasures.	20

CO Mapping with CDIO Curriculum Framework

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS2	Understand	Respond	-	2.1.1, 2.1.2, 2.4.2, 2.4.6, 2.5.1, 3.1.1, 3.2.3, 4.5.5, 4.6.2
CO2	TPS3	Apply	Value	-	2.1.1, 2.1.2, 2.5.1, 3.1.1, 3.2.3, 4.5.5, 4.6.2
CO3	TPS3	Apply	Value	-	2.1.1, 2.1.2, 2.5.1, 3.1.1, 3.2.3, 4.5.5, 4.6.2
CO4	TPS3	Apply	Value	-	2.1.1, 2.1.2, 2.1.3, 2.5.1
CO5	TPS3	Apply	Value	-	2.1.1, 2.1.2, 2.1.3, 2.5.1
CO6	TPS4	Analyse	Organise	-	2.1.1, 2.1.2, 2.5.1

Mapping with Programme Outcomes and Programme Specific Outcomes

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	M	L	-	-	-	-	-	-	-	-	-	-	L		
CO2	S	M	L	-	-	-	-	-	-	-	-	-	L		
CO3	S	M	L	-	L	-	-	M	M	M	-	-	M	L	L
CO4	S	M	L	-	L	-	-	M	M	M	-	L	M	L	L
CO5	S	M	L	-	-	-	-	M	M	M	-	-	M	L	
CO6	S	S	M	L	M	-	-	M	M	M	-	-	M		

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

Cognitive Levels	Continuous Assessment Tests			Assignment			End Semester Examination
	1	2	3	1	2	3	
Remember	0	0	0	0	0	0	0
Understand	60	40	20	0	0	0	20
Apply	40	40	60	100	0	100	60
Analyse	0	20	20	0	100	0	20
Evaluate	0	0	0	0	0	0	0
Create	0	0	0	0	0	0	0

Assessment Pattern: Psychomotor

Psychomotor Skill	Assignment-1	Assignment-2	Assignment-3
Perception	-	-	-
Set	-	-	-
Guided Response	-	-	-
Mechanism	-	100	-
Complex Overt Responses	-	-	-
Adaptation	-	-	-
Origination	-	-	-

Sample Questions for Course Outcome Assessment

Course Outcome 1(CO1):

1. Discuss about the web security threats and the methods used to overcome the threats
2. What is digital immune system
3. Compare Active and Passive attacks

Course Outcome 2 (CO2):

1. Encrypt the term "EXAM" using playfair cipher
2. Encrypt and decrypt the term "Final Exam" using the Hill cipher with the key $k = \begin{bmatrix} 0 & 3 & 0 \\ 0 & 0 & 21 \\ 15 & 0 & 0 \end{bmatrix}$ such that kk^{-1}=I.
3. The plaintext 'letusmeetnow' and the corresponding 'HBCDFNOPIKLB'are given. The algorithm used is Hill cipher, but the key size is unknown. Identify the key matrix.

Course Outcome 3 (CO3)

1. For $E_{11}(1,6)$, consider the point G=(2,7). Compute the multiples of 2G through 13G.
2. List four general categories of schemes for the distribution of public keys
3. Consider a Diffie Hellmen scheme with a common prime q=11 and a primitive root alpha=2.
   a. show that 2 is the primitive root of 11.
   b. If user A has public key Y_A=9,what is a A's private key X_A.If user B has public key Y_B=3,what is the shared secret key K.

Course Outcome 4 (CO4):

1. Elaborate Key management operation in IPsec
2. Differentiate transport and tunnel mode of IP Security by its operation and header format for both IPv4 and IPv6.
3. Discuss in detail about the ISAKMP with its header format, payload and exchange type

Course Outcome 5 (CO5):

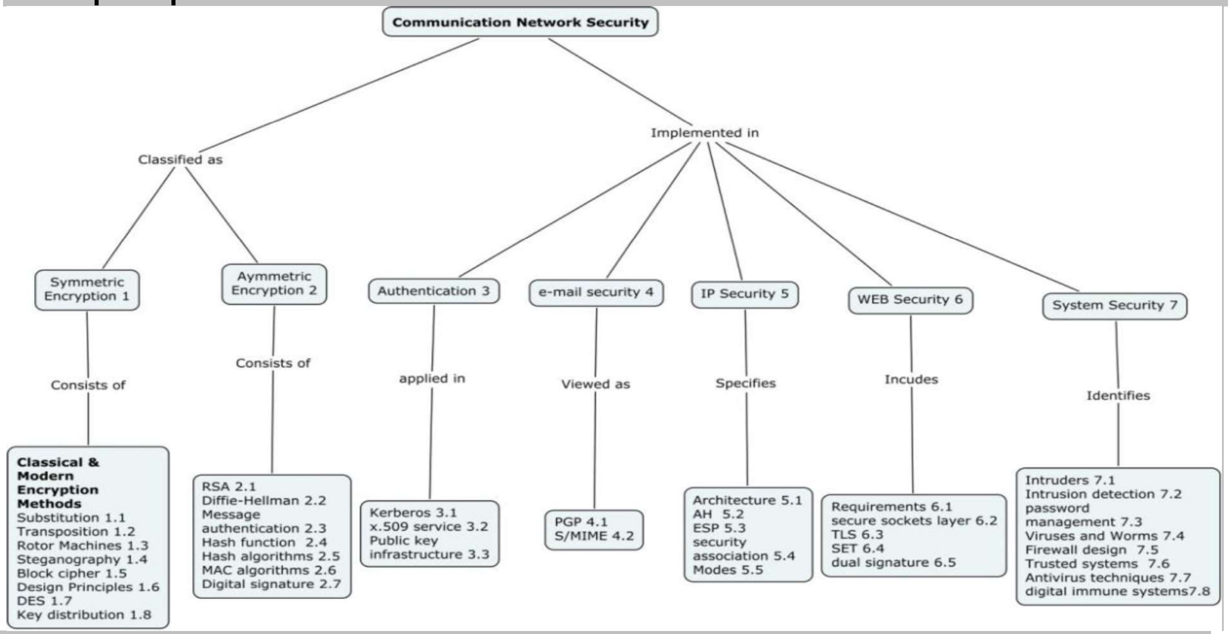
1. Explain about payment processing in SET

2. Discuss in detail about SSL handshake protocol along with its message type and corresponding associated parameters
3. What is the purpose of Dual signature?

Course Outcome 6 (CO6):

1. Explain Statistical anomaly detection and rule based detection techniques
2. Discuss in detail about different types of malicious programs.
3. Discuss about firewall design principles and its characteristics

Concept Map



Syllabus

Conventional Encryption: Introduction – Conventional Encryption model – Data Encryption Standard – block cipher – Encryption algorithms – confidentiality – Key distribution. **Public Key Encryption and Hashing**: Principles of Public key cryptosystems – Number Theory – Fermat's theorem and Euler's theorem, Discrete Logarithms RSA algorithm – Diffie-Hellman Key Exchange, Elliptic curve cryptography – Message authentication and Hash function – Hash MAC algorithms – Digital signatures. **IP Security**: IP security overview – IP security Architecture, authentication Header – Security payload – security association – key management. **WEB Security:** Web security requirement – secure sockets layer – transport layer security –secure electronic transaction – dual signature. **System Security:** Intruders – Intrusion detection-password management -Viruses – Viruses and related threats-Worms – Firewall design – Trusted systems – Antivirus techniques – digital immune systems. Case study – cloud security and embedded system security.

Learning Resources

- William Stallings. "Cryptography and Network Security", 4th Edition, Prentice Hall of India, New Delhi, 2012.
- C. Kaufmann, R. Perlman and M. Speciner, "Network Security: Private Communication in a Public World", Prentice Hall PTR, 2002.
- W.R. Cheswick, S.M. Bellovin and A.D. Rubin, "Firewalls and Internet Security", Addison- Wesley, 2003.
- NPTEL course on Cryptography and network security: https://nptel.ac.in/courses/106105031/

Course Contents and Lecture Schedule

Module No.	Topic	No. of Hours	Course Outcome
1	**Conventional Encryption**		
1.1	Introduction – Conventional Encryption model	2	CO1
1.2	Confidentiality, data integrity, authentication, Passive and active attacks	2	CO1
1.3	Data Encryption Standard – block cipher	2	CO2
1.4	Different Encryption algorithms	2	CO2
1.5	Key distribution	1	CO2
2	**Public Key Encryption and Hashing**:		
2.1	Principles of Public key cryptosystems	1	CO3
2.2	Number Theory – Fermat's theorem and Euler's theorem	2	CO3
2.3	Discrete Logarithms	2	CO3
2.4	RSA algorithm	2	CO3
2.5	Diffie-Hellman Key Exchange	2	CO3
2.6	Elliptic curve cryptography	2	CO3
2.7	Message authentication and Hash function	2	CO3
2.8	Hash MAC algorithms, Digital signatures.	2	CO3
3	**IP Security**		
3.1	IP security overview	1	CO4
3.2	IP security Architecture	1	CO4
3.3	Authentication Header Security Payload	1	CO4
3.4	Security association –key management.	1	CO4
4	**Web Security**		
4.1	Web security requirement	1	CO5
4.1	Secure sockets layer – transport layer security	2	CO5
4.3	Secure electronic transaction – dual signature	2	CO5
5	**System Security**		
5.1	Intruders – Intrusion detection-	1	CO6
5.2	Password management	1	CO6
5.3	Viruses – Viruses and Related threats-Worms	1	CO6
5.4	Firewall design – Trusted systems	1	CO6
5.5	Antivirus techniques – digital immune Systems.	1	CO6
5.6	Case study – cloud security and embedded system security	1	CO6
	Total Number of Hours	**39**	

Course Designers:

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- Dr S. Ponmalar spmece@tc e.edu

18ECPK0	OPTICAL COMMUNICATION NETWORKS

Category	L	T	P	Credit
PE	3	0	0	3

Preamble

The objective of this course is to provide a comprehensive understanding of optical communication systems and networks. This course provides coverage of basic optical technology including physical aspects of light propagation, fiber optic components and its characteristics and modulation/demodulation techniques and link design. It also covers enabling technologies for optical network including SONET/SDH, WDM network and future optical systems and Networks.

Prerequisite

NIL

Course Outcomes

On the successful completion of the course students will be able to

COs	Course Outcome Statement	Weightage in %
CO1	Determine the transmission characteristics of optical fiber and their measurement procedures.	25
CO2	Demonstrate the characteristics of optical sources and modulation techniques.	15
CO3	Demonstrate the characteristics of optical detectors and demodulation techniques	15
CO4	Demonstrate the characteristics of SONET, WDM network and network components. (Couplers, isolators, multiplexers, switches, filters, etc.)	15
CO5	Solve network survivability and wavelength routing and assignment problem in optical networks.	10
CO6	Design and analyze the performance of optical communication links.	20

CO Mapping with CDIO Curriculum Framework

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS3	Apply	Value	-	1.1, 1.2, 2.1.1, 2.1.3, 2.3.1
CO2	TPS3	Apply	Value	Mechanism	1.1, 1.2, 2.1.1, 2.1.3, 2.3.1, 3.2.4
CO3	TPS2	Apply	Value	Mechanism	1.1, 1.2, 2.1.1, 2.1.3, 2.3.1, 3.2.4
CO4	TPS3	Apply	Value	-	1.1, 1.2, 2.1.1, 2.1.3, 2.3.1,
CO5	TPS3	Apply	Value	-	1.1, 1.2, 2.1.1, 2.1.3, 2.3.1, 2.4.4
CO6	TPS3	Analyze	Organise	Complex Overt Responses	1.1, 1.2, 2.1.1, 2.1.2, 2.1.3, 2.3.1, 2.5.1, 4.1.1, 4.1.3

Mapping with Programme Outcomes and Programme Specific Outcomes

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	S	M	L	-	L	-	-	M	M	M	-	-	M	L	-
CO2	S	M	L	-	L	-	-	M	M	M	-	-	M	L	-
CO3	S	M	L	-	L	-	-	M	M	M	-	-	M	L	-
CO4	S	M	L	-	L	-	-	M	M	M	-	-	M	L	-
CO5	S	M	L	-	L	-	-	M	M	M	-	-	M	L	-
CO6	S	S	M	L	M	-	-	M	M	M	-	-	M	L	-

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

Cognitive Levels	Continuous Assessment Tests			Assignment			End Semester Examination
	1	**2**	**3**	1	2	3	
Remember	0	0	0	-	-	-	0
Understand	40	40	30	-	-	-	30
Apply	60	60	50	100	100	100	50
Analyse	0	0	20	-	-	-	20
Evaluate	0	0	0	-	-	-	0
Create	0	0	0	-	-	-	

Assessment Pattern: Psychomotor

Psychomotor Skill	Miniproject /Assignment/Practical Component
Perception	-
Set	-
Guided Response	-
Mechanism	100
Complex Overt Responses	-
Adaptation	-
Origination	-

Sample Questions for Course Outcome Assessment**

Course Outcome 1 (CO1):

1. Differentiate intermodal and intramodal dispersion.
2. How does dispersion limit the performance of a fibre optic system?
3. An optical fiber has the following data: n1 = 1.5, n2 = 1.45. Calculate: (a) Critical angle.(b) Numerical aperture (c) Acceptance angle.

Course Outcome 2 (CO2):

1. Explain the working principle of laser diode.
2. A *1550*-nm LED has an internal quantum efficiency η_{int} of 99% and external quantum efficiency η_{ext} of 20%. Calculate the output power P_{out} of the LED when it is driven by a current I of 80 mA.
3. A laser source of length 4cm with refractive index of 1.78. The peak emission wavelength from the device is 0.55um. Determine the number of longitudinal modes and their frequency separations.

Course Outcome 3 (CO3):

1. Explain the working principle of avalanche photo diode.
2. When 4×10^{11} photons each with a wavelength of 850 nm are incident on a photodiode, on average 2×10^{11} electrons are collected at the terminals of the device. Determine the quantum efficiency and the responsivity of the photodiode at the above wavelength.
3. A photodiode has a quantum efficiency of 65% when photons of energy 1.5×10^{-19} J are incident upon it. (i) What is the operating wavelength of the photodiode? (ii) Calculate the incident optical power required to obtain a photo current of 2.5μA?

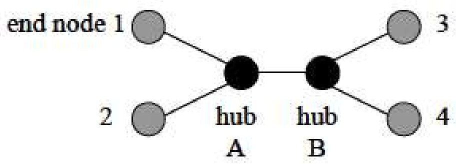
Course Outcome 4 (CO4):

1. Write down the features of SONET.
2. A product sheet of a 2×2 biconical tapered coupler with 40:60 splitting ratio shows a insertion loss of 2.5 dB for 60 percent port and 4 dB for 40 percent port
   a. If the input power P_0 = 150 μW, find the power at output port 1 and output port 2.
   b. From the calculated output power P_1 and P_2 , show that the splitting ratio is 40:60.
   c. Find the excess loss of the coupler.
3. Assume that wavelengths λ_1 = 1530nm λ_2 = 1534nm λ_3= 1538nm and λ_4=1542nm are transmitted through an optical add drop multiplexer. Construct a fiber bragg grating based add drop multiplexer to drop wavelength λ_1, λ_2 , λ_3 respectively at each stage and add

wavelength λ_5 (1550nm) at the last stage by properly designing the grating period. ($n_{eff} = 1.48$). Draw the OADM architecture.

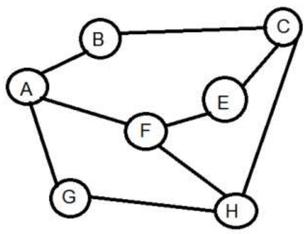
Course Outcome 5 (CO5):

1. Consider the network topology shown below. Each undirected link represents two fibers, one for the transmission in each direction. There are 4 end nodes and 2 hub nodes.



Consider the following s-d pairs each of which has 1 wavelength unit of traffic: 1-3, 1-4, 2-3, 2-4, 3-1, 3-2, 4-1, 4-2, 4-3. Specify the wavelength assignment (WA) that uses the minimum number of wavelengths.

2. Consider the network shown below. Assign wavelengths using first fit and random fit algorithm for the following lightpath requests: (i) C-F (ii) A-E (iii) H-E (iv) B-H (v) A-C (vi) G-B (vii) A-B.



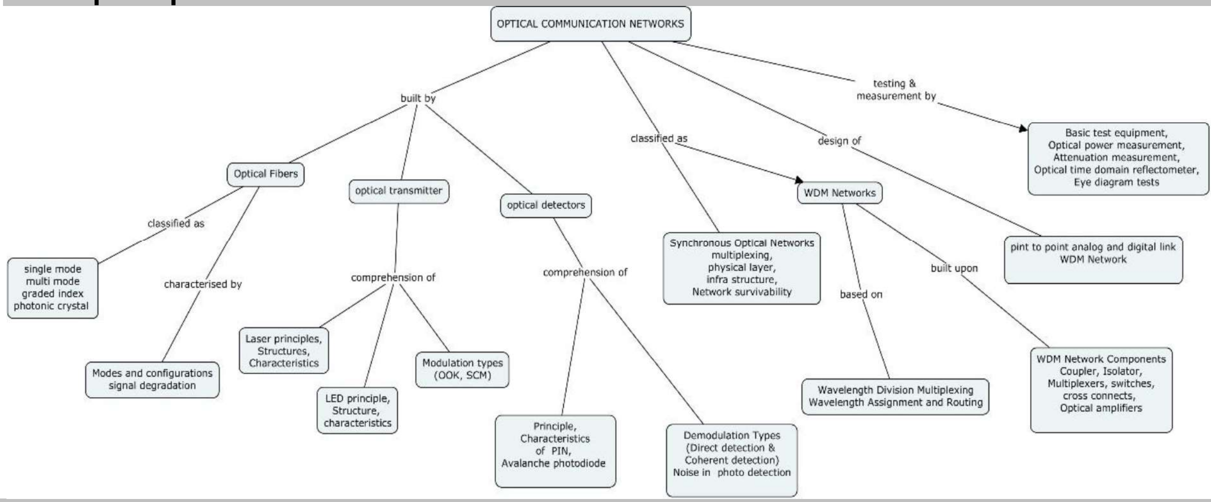
3. Consider a ring topology with 5 nodes. Find the ways by which the network can be protected against link failure.

Course Outcome 6 (CO6):

1. For an optical fiber link of 15km and B. W. of 100Mbps, receiver sensitivity is -50dBm, fiber loss is 2dB/km and power launch is 0dBm into the fiber by transmitter, detector coupling loss is 1dB and splicing loss of 0.4 dB/splice for 10 splices. Determine the feasibility of system.
2. A 100Mbit/s signal is to be sent through a 100m length of fiber with eight connector pairs to a receiver with sensitivity of -30dBm. The fiber loss is 4dB/km, and the average connector loss is 1.0dB. if the system margin is 5dB,what is the minimum power that the light source must launch into fiber?
3. Consider an optical transmission system operating at a wavelength of 1550 nm over an unrepeatered distance of 75km at the rate of 800 Mb/s. The transmitter available has a minimum coupled output power of 2mw, while the receiver has a worst case received power of 125μW. Two types of fibre with different specifications are available as shown in the table below. Two connectors are to be used in the system with a loss of 0.5 dB each, while the splice loss for both fibre types is 0.2 dB maximum. Assume a system margin of 3dB. Prepare a power budget for each system and decide which fibre type should be used and why.

Fibre type	Attenuation	Maximum distance between splices
A	0.5 dB/km	1500 metres
B	0.3 dB/km	1200 metres

Concept Map



Syllabus

Introduction: Motivation and evolution of fiber optic system, role of fiber optics in telecom, fiber backhaul network, Elements of optical fiber transmission link, bandwidth and spectral efficiency; Fiber Optic Links: power budget and rise time budget. **Optical Fibers:** Types: single mode fiber, multi-mode fiber, graded index fiber, photonic crystal fiber; Optical fiber modes and configurations, transmission characteristics of optical fiber: Attenuation, Dispersion; Test and Measurements: Basic test equipment, Optical power measurement, Attenuation and dispersion measurement, Optical time domain reflectometer, Eye diagram tests. **Optical Transmitters:** Light Emitting Diode: structure, LED characteristics: output power, quantum efficiency, modulation bandwidth**;** Laser: laser diode mode, threshold condition, rate equation, Laser characteristics: quantum efficiency, resonant frequency; Modulation/multiplexing: Direct modulation, sub carrier modulation/multiplexing, QPSK, QAM, OTDM, Optical OFDM. **Optical Receivers:** pin photo detector, characteristics; Avalanche photodiode, characteristics, Noise in Photo detector; demodulation: Direct detection, coherent detection. **Optical Networks:** Overview of Fiber Backhaul Network, SONET/SDH**:** multiplexing, physical layer, infra structure, Network survivability; WDM Networks, WDM Components : Coupler, Isolator, Multiplexers, switches, cross connects, Optical amplifiers; Wavelength Assignment and Routing problem; Future Optical Networks. **Fiber Optic Link Design:** Analog, digital and WDM link design

Sample Assignment:

Hands on with Light Runner Equipment:

1. Characterisation of optical sources, detectors, and numerical aperture measurement.
2. Characterisation of wavelength division multiplexer and de-multiplexer.
3. Voice and data transmission over optical fiber system.
4. Power budget and rise time budget of optical fiber link

Hands on with OptSim software

1. BER and eye pattern analysis of point to point optical communication link.
2. BER and eye pattern analysis of WDM link.
3. Simulation of free space optics system

Learning Resources

- Gerd Kaiser, "Optical fiber communications", McGraw Hill Int., 5^{th} edition, 2017.
- Rajiv Ramaswami, Kumar Sivarajan, Galen Sasaki, "Optical Networks: a practical perspective", Morgan Kaufmann Publishers, 3^{nd} edition, 2009.
- G.P. Agrawal, "Fiber-Optic Communication Systems", Wiley, 4^{th} edition, 2010
- John Senior, "Optical fiber communications-principles and practices", Prentice Hall of India, 3^{rd} edition, 2013.
- J.Gower, "Optical communication systems", Prentice Hall of India, 2^{nd} edition, 2001.
- Joseph C. Palais, "Fiber Optic Communication", Pearson Education, 5^{th} edition, 2011.

- Biswanath Mukherjee, “Optical WDM Network”, Springer, 1st edition, 2006.
- NPTEL course on “Introduction to Photonics” by Dr. Balaji Srinivasan
  Link: https://nptel.ac.in/courses/108106135/

Course Contents and Lecture Schedule

Module No	Topics	No. of Hours	COs
1	**Overview of Optical Fiber Communication**		
1.1	Motivation and evolution of fiber optic system, Elements of optical fiber transmission link, optics in telecom	2	CO1
1.2	bandwidth and spectral efficiency, power budget and rise time budget in fiber optic link	1	CO1
2	**Optical Fibers**		
2.1	Fiber Types: Step index, Graded index, Single mode, multimode, photonic crystal fiber	1	CO1
2. 2	Optical fiber modes and configurations	1	CO1
2. 3	Transmission characteristics of optical fiber: Attenuation, Dispersion	2	CO1
2.4	Basic test equipment, Optical power measurement, Attenuation measurement	2	CO1
2.5	Optical time domain reflectometer, Eye diagram tests	1	CO1
3	**Optical Transmitters**		
3.1	Light Emitting Diode: structure, Characteristics: Quantum efficiency, output power, modulation bandwidth	2	CO2
3.2	Laser: Structure, laser diode mode and threshold condition, rate equation, quantum efficiency and resonant frequency	2	CO2
3.3	Direct modulation, sub carrier modulation/multiplexing, QPSK, QAM, OTDM, Optical OFDM	2	CO2
4	**Optical Receivers**		
4.1	p-i-n photo detector - Avalanche photodiode	1	CO3
4.2	Noise in Photo detectors	2	CO3
4.3	Demodulation: Direct Detection, Coherent Detection	2	CO3
5	**Optical Networks**		
5.1	**SONET/SDH:** multiplexing, physical layer, infrastructure, Network Survivability	2	CO4, CO5
5.2	WDM Networks - WDM Network Components: Coupler, Isolator, Multiplexers, Filters, Switches, Cross connects, Optical Amplifiers	3	CO4
5.3	Wavelength Assignment and Routing problem	3	CO5
6	**Fiber Optic Link Design**		
6.1	Digital Systems: Power Budget , Rise time Budget	2	CO6
6.2	Analog systems: Carrier to Noise ratio	2	CO6
6.3	WDM link design	2	CO6
	Total	36	

Course Designers:

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18ECPL0	MEDICAL IMAGING AND PROCESSING	Category	L	T	P	Credit
		PEES	3	0	0	3

Preamble

The course is offered to provide the basic concepts of various medical imaging modalities and the use of analysis tools for medical image reconstruction. It involves three different levels. In the lower level, the course introduces the terminology of medical imaging and explains how X-ray, CT, MRI and ultrasound images are reconstructed. In the middle level, it addresses how to select the specific segmentation and classification methods for extracting meaningful information from the medical imaging modalities. In higher level, it addresses how to visualize and analyze the 3D images and some of the case studies.

Prerequisite

18EC560 Digital Image Processing

Course Outcomes

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

CO Number	Course Outcome Statement	Weightage in %
CO1.	Describe the various medical imaging modalities.	15
CO2.	Determine the resultant images with various reconstruction techniques	20
CO3.	Solve problems on various medical images by segmentation techniques and morphological operations	20
CO4.	Examine the classifier for the given medical images	15
CO5.	Examine the given 3-D images with visualization	15
CO6.	Distinguish case studies with segmentation and classification techniques	15

CO Mapping with CDIO Curriculum Framework

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS2	Understand	Respond	-	1.3, 2.3.1
CO2	TPS3	Apply	Value	Mechanism	1.3, 2.1.1, 2.1.4, 2.1.5, 3.2.3
CO3	TPS3	Apply	Value	Mechanism	1.3, 2.1.1, 2.1.5, 3.2.4
CO4	TPS4	Analyze	Organise	Complex Overt Responses	1.3, 2.1.1, 3.2.3
CO5	TPS4	Analyze	Organise	-	1.3, 2.2.1
CO6	TPS4	Analyze	Organise	-	1.3, 2.3.2

S- Strong; M-Medium; L-Low

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO 1	PSO 2	PSO3
CO1	M	L	-	--	-	--	-	-	-	-	-	-	L	-	-
CO2	S	M	L	--	S	--	-	-	-	L	-	-	M	-	L
CO3	S	M	L	--	M	--	-	-	-	L	-	-	M	-	L
CO4	S	S	M	L	M	--	-	-	-	L	-	-	M	-	L
CO5	S	S	M	L	-	--	-	-	-	-	-	-	M	-	-
CO6	S	S	M	L	-	--	-	-	-	-	-	-	M	-	-

Assessment Pattern - Cognitive

Cognitive Levels	Continuous Assessment Tests			Assignment			End Semester Examination
	1	2	3	1	2	3	
Remember	20	20	0	0	0	0	0
Understand	20	40	20	0	0	0	20
Apply	40	40	40	100	50	50	40
Analyze	0	0	40	0	0	0	40
Evaluate	0	0	0	0	0	0	0
Create	0	0	0	0	0	0	0

Assessment Pattern: Psychomotor

Psychomotor Skill	Assignment-1	Assignment-2	Assignment-3
Perception	-	-	-
Set	-	-	-
Guided Response	-	-	-
Mechanism	-	25	25
Complex Overt Responses	-	25	25
Adaptation	-	-	-
Origination	-	-	-

Sample Questions for Course Outcome Assessment

COURSE OUTCOME 1 (CO1):
1. How breast cancer is detected using Mammographic images?
2. What is the principle of X-ray Computer tomography?
3. How T1-weighted spin echo is generated in MRI?
4. Explain how M-mode images are useful in the display of moving structures

COURSE OUTCOME 2 (CO2):
1. What is central slice theorem? Explain
2. Demonstrate the role of Sinogram in medical imaging reconstruction
3. Consider the following image:

4	5	6	9
13	14	7	7
15	16	8	4
15	16	8	3

Apply iterative reconstruction method and obtain the resultant image.

COURSE OUTCOME 3 (CO3):
1. What is the use of Morphological Operation in medical image processing?
2. Illustrate how active contour model is useful in image segmentation
3. Demonstrate the performance of watershed segmentation algorithm in detail.

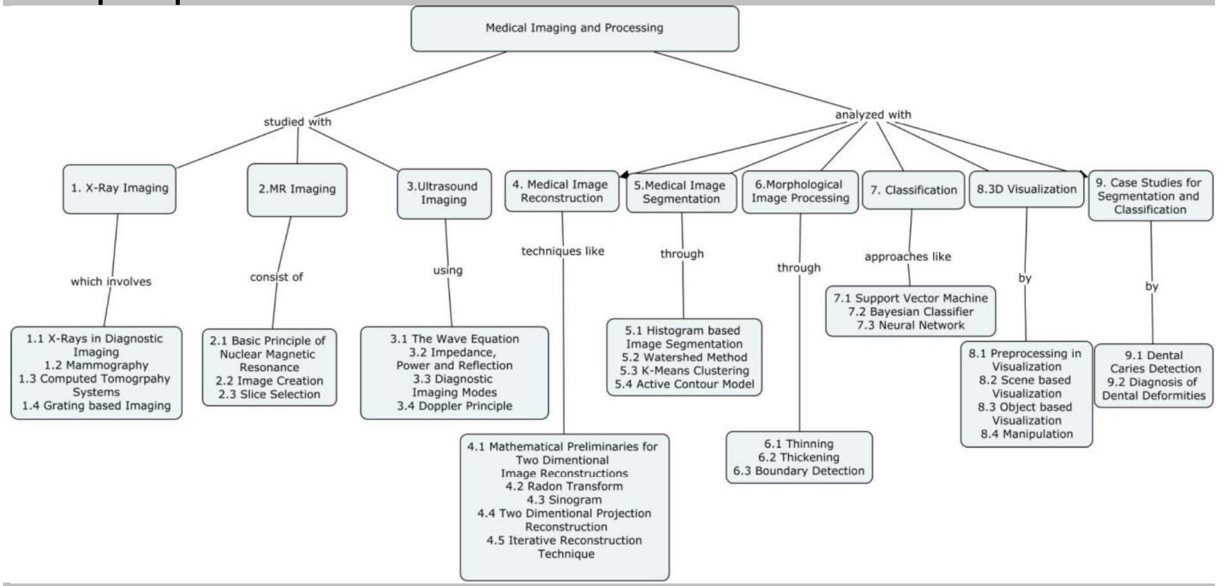
COURSE OUTCOME 4 (CO4):
1. Mention the use of Bayesian Decision Making
2. Calculate the weights and specify the structure of a neural network capable of performing exactly the same function as a Baye’s classifier for two pattern classes in n-dimensional space.
3. Demonstrate the basic concept of SVM Classifier

COURSE OUTCOME 5 (CO5):
1. List out the various 3-D imaging operations
2. Compare and contrast the scene based visualization with object based visualization
3. Interpret the necessity of manipulation and analysis in 3D visualization

COURSE OUTCOME 6 (CO6):
1. List out the various pre processing techniques which are suitable for the enhancement of dental X-Ray images

2. Experiment how image processing techniques will be Useful for identification of Dental caries
3. Contrast how automated system is better than manual diagnosis of Dental Deformities by Cephalometry X-ray images

Concept Map



Syllabus

X-Ray Imaging- X-rays in Diagnostic imaging-Mammography-Computed tomography systems- Grating based imaging **Magnetic Resonance Imaging–** Basic principles of nuclear magnetic resonance-Image creation-slice selection **Ultrasound Imaging**- The wave equation- Impedance, power and reflection – Diagnostic imaging modes- Doppler principle. **Medical Image Reconstruction:** Mathematical preliminaries for two dimensional image reconstructions-Radon transform – Sinogram - Two dimensional projection reconstruction-Iterative reconstruction techniques **Medical Image Segmentation:** Histogram based image segmentation –Watershed Method – K Means clustering – Active Contour Model **Morphological Image Processing –** Thinning- Thickening -Boundary detection. **Classification:–**Support vector machine- Bayesian classifier-Neural network **3D Visualization-** Preprocessing in Visualization – Scene based visualization- Object based visualization – Manipulation. **Case Studies for segmentation and Classification**: Dental caries detection - Diagnosis of Dental Deformities

Learning Resources

- Atam.P.Dhawan, "Medical Image Analysis", John Wiley and Sons ,2011
- Rafael.C.Gonzalez and Richard.E. Woods, "Digital Image Processing", 4th Edition, Pearson publication,2017
- William.R.Hendee and Russell Ritenour.E. Woods, "Medical Imaging Physics", A John Wiley & sons , Inc. publications, 2002
- P.Hariharan, "Basics of Interferometry" Academic Press,2012
- Geoff Dougherty, "Digital Image Processing for Medical Applications", Cambridge, 2009.
- G. R. Sinha, Bhagwati Charan Patel, " Medical Image Processing (Concepts and Applications)" PHI Learning private Limited, 2014.
- Issac Bankman and I.N.Bankman, " Handbook of Medical Imaging: Processing and Analysis", Academic press,2009
- Zang-Hee Cho, Joie P. Jones, Manbir Singh, "Foundations of Medical Imaging", A John Wiley & sons , Inc. publications, 2017
- Jacob Beutel and M.Sonka, "Handbook of Medical Imaging", volume 2. "Medical Image Processing and Analysis", SPIE press 2000.

Course Contents and Lecture Schedule

No.	Topic	No. of Lectures	COs
1.	**X-ray imaging**		
1.1	X-rays in Diagnostic imaging	1	CO1
1.2	Mammography	1	CO1
1.3	computed tomography	1	CO1
1.4	Grating based imaging	1	CO1
2.0	**MR imaging**		
2.1	Basic principles	1	CO1
2.2	Image creation	2	CO1
2.3	slice selection	1	CO1
3.0	**Ultra sound imaging**		
3.1	The wave equation	1	CO1
3.2	Impedance, power and reflection	1	CO1
3.3	Diagnostic imaging modes	2	CO1
3.4	Doppler principle	1	CO1
4.0	**Medical Image Reconstruction**		
4.1	Mathematical preliminaries for two dimensional image reconstructions	1	CO2
4.2	Radon transform	1	CO2
4.3	Sinogram	1	CO2
4.4	Two dimensional projection reconstruction	1	CO2
4.5	Iterative reconstruction techniques	2	CO2
5.0	**Medical Image Segmentation**		
5.1	Histogram based image segmentation	1	CO3
5.2	Watershed Method	1	CO3
5.3	K- Means clustering	1	CO3
5.4	Active Contour Model	1	CO3
6.0	**Morphological Image Processing**		
6.1	Thinning, Thickening	1	CO3
6.2	Boundary detection	1	CO3
7.0	**Classification**		
7.1	Bayesian classifier	1	CO4
7.2	Neural network	1	CO4
7.3	Support vector machine	1	CO4
8.0	**3-D Visualization**		
8.1	Preprocessing	1	CO5
8.2	Scene based visualization,	1	CO5
8.3	Object based visualization, Manipulation	2	CO5
9.0	**Case Studies for segmentation and Classification**:	1	
9.1	Dental caries detection	1	CO6
9.2	Diagnosis of Dental Deformities	2	CO6
	Total Number of Hours	36	

Course Designers:

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18ECPM0	PLANAR ANTENNAS FOR WIRELESS APPLICATIONS

Category	L	T	P	Credit
PE	2	1	0	3

Preamble

Planar antennas have a range of applications in both the military and commercial sectors, and are often mounted on the exterior of aircraft and spacecraft as well as incorporated into mobile radio communication devices. Furthermore, the development of new services and radio technologies demand for low cost, light weight, compact, efficient antennas for portable wireless devices. One of the main competencies that a present day antenna engineer has to posses is the capability to design basic antennas and evolve novel designs suitable for portable wireless devices that have good bandwidth, gain and radiation characteristics. This subject is essential to understand the need for designing broadband and miniaturized antennas for wireless applications such as Radio frequency identification, RADAR, 5G and Body centric communication. This course presents various types of antenna geometry suitable for the above mentioned wireless applications, the issues in respect of their design and development.

Prerequisite

18EC520 Antennas and Wave Propagation

Course Outcomes

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

CO #	Course Outcome Statement	Weightage in %
CO1.	Explain different wireless applications and requirements of an antenna in terms its parameters	10
CO2.	Identify, design antennas for RFID applications and BAN	15
CO3.	Simulate the radiation pattern of RFID and flexible antennas using EM CAD simulators	20
CO4.	Identify, design antennas for Radar and Communication Systems	15
CO5.	Simulate the characteristics of phased array and MIMO	20
CO6.	Develop prototype of a designed antenna and Measure its parameters	20

CO Mapping with CDIO Curriculum Framework

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS2	Understand	Respond	Guided Response	1.3, 2.1.1
CO2	TPS3	Apply	Value	Mechanism	1.3, 2.1.1, 2.1.5, 3.1, 4.4.1, 4.5.1 – 4.5.4
CO3	TPS3	Apply	Value	Mechanism	1.3, 2.1.1, 2.1.2, 2.5.1, 3.1.1, 3.2.3, 4.5.5
CO4	TPS3	Apply	Value	Mechanism	1.3, 2.1.1, 2.1.5, 3.1, 4.4.1, 4.5.1- 4.5.4
CO5	TPS3	Apply	Value	Mechanism	1.3, 2.1.1, 2.1.2, 2.5.1, 3.1.1, 3.2.3, 4.5.5
CO6	TPS5	Evaluate	Organize	Adaptation	1.3, 2.1.1, 2.1.5, 3.1, 4.4.1, 4.5.1- 4.5.4

Mapping with Programme Outcomes and Programme Specific Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	M	L	-	-	-	-	-	-	-	-	-	-	L	-	L
CO2	S	M	L	L	M	-	-	L	L	L	-	L	M	-	L
CO3	S	M	L	L	M	-	-	L	L	L	-	L	M	-	L
CO4	S	M	L	L	M	-	-	L	L	L	-	L	M	-	L
CO5	S	M	L	L	M	-	-	L	L	L	-	L	M	-	L
CO6	S	S	S	M	M	-	-	L	M	L	-	L	S	M	L

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

Cognitive Levels	Continuous Assessment Tests			Assignment			End Semester Examination
	1	2	3	1	2	3	
Remember	0	0	0	0	0	0	0
Understand	30	30	30	0	0	0	30
Apply	70	70	70	50	50	0	70
Analyse	0	0	0	0	0	0	0
Evaluate	0	0	0	0	0	50	0
Create	0	0	0	0	0	0	0

Assessment Pattern: Psychomotor

Psychomotor Skill	Assignment-1	Assignment-2	Assignment-3
Perception	-	-	-
Set	-	-	-
Guided Response	50	-	-
Mechanism	-	50	50
Complex Overt Responses	-	-	-
Adaptation	-	-	-
Origination	-	-	-

Sample Questions for Course Outcome Assessment

Course Outcome (CO1)

1. What are the features of 5G wireless systems?
2. Explain the standards of RFID applications.
3. List some of the antennas used in RADAR.
4. What are the effects of environment on RFID Tag antenna?

Course Outcome (CO2)

1. Design a suitable antenna used in RFID Tag for animal tracking?
2. Design a conformal, flexible E shaped antenna for wearable antenna application.
3. Suggest a suitable planar antenna system for the given specifications:
   Center Frequency-5GHz, Dielectric constant-3.38, Thickness - 1.52mm, VSWR-2:1
   Bandwidth > 500MHz

Course Outcome (CO3)

1. Propose simulation steps to facilitate the design of patch antenna on a multilayer substrate having effective dielectric constant of 5.5.
2. Evaluate the performance of compact antennas for wearable devices in health care.
3. Prepare a model chart for developing antenna for wearable devices considering different RF constraints.

Course Outcome (CO4)

1. Design a wide band antenna system operating in RADAR system?
2. Design a MIMO array for 5G mobile communication in sub 6GHz band?
3. Derive the specification and design antenna for wide band Radar operation

Course Outcome (CO5)

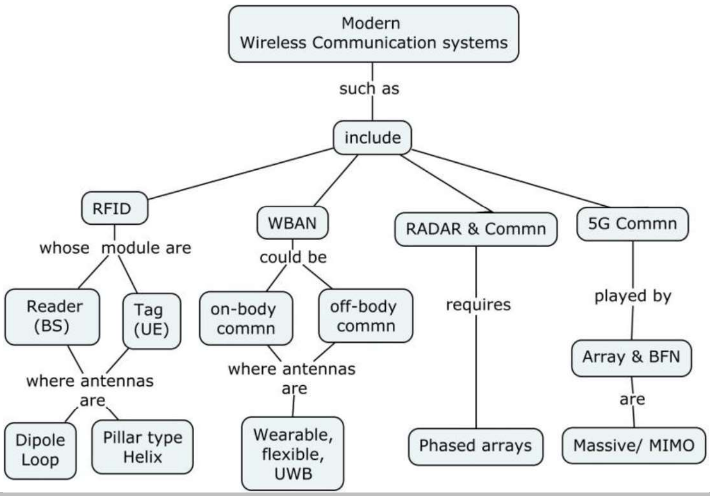
1. Simulate an antenna operating in the RADAR

2. Design and simulate the 2*2 array operating in the 3.3 to 3.5GHz band
3. Prepare a model chart for developing phased array used in Radar system

Course Outcome (CO6)

1. Prototype the given antenna simulated using EM simulator and validate the performance
2. Develop the prototype of RFID tag antenna used in library book management.
3. Evaluate the performance of MIMO array integrated with base band system.

Concept Map



Syllabus

Overview: Requirements and Typical Challenges antenna design for different wireless communication. RFID, BAN, RADAR and 5G.**Printed Antennas for RFID system:** Frequency, Regulations and Standardization, RFID antennas, Reader antennas, Tag architecture, Types of Tag antenna, Read range calculation, Design of reader and tag antenna. **Antennas for Wireless Body Area Network:** standards, on body, off body communication, antenna design challenges, Wearable Antennas, flexible antennas. **Phased Array for Radar and Communication Systems:** Transceiver, System requirements, Array characterization, Array design, Electronic Scanning techniques. **Array and BFN for 5G mobile communication system:** 5G technology,– Mobile communication, challenges, Massive MIMO, phased array and beam forming, antenna design, form factor and broadband performance, Antenna design. **Case Study:** Design, development of antennas for RFID, BAN, Radar and 5G Applications.

Learning Resources:

- "Handbook of RF and Wireless Technologies", Edited by Farid Dowla, Science Direct, 2004
- Anil Pandey, "Microstrip and Printed Antennas: Application-Based Designs" Artech House, 2019.
- Daniel M. Dobkin, "The RF in RFID UHF RFID in Practice", Elsevier, 2013.
- Peter von Butovitsch, Henrik Asplund, "Advanced Antenna Systems for 5G Network Deployments" Published by Elsevier 2020.
- ZhiHao Jiang,, Douglas H. Werner, "Electromagnetics of Body Area Networks" : John Wiley Publishers 2016.
- ZhiNing Chen, "Antennas for Portable devices" Wiley Publishers, 2007.
- R.Waterhouse" Printed antennas for wireless communications" John Wiley Publishers, 2007.
- Grishkumar and K.P. Ray, "Broadband Microstrip Antennas" Artech House, 2003.
- John D.Kraus, Ronald J. Marhefka "Antennas for all Applications" Fourth Edition, Tata McGraw-Hill, 2006.

Course Contents and Lecture Schedule

Module No.	Topic	No. of Hours	Course Outcome
1.	Introduction: Course CO,PO, PSO, Introduction to course with concept map	1	CO1
1.1	Overview of different wireless communication. RFID, BAN, RADAR and 5G. Requirements and Typical Challenges antenna design	1	CO1
2.	RFID Frequency, Regulations and Standardization	1	CO2
2.1	Reader antennas- Specifications, types	1	CO2
2.2	RFID Tag Antennas: Tag architecture- Tag, clip type,	1	CO2
2.3	Read range calculation, Design of reader and tag antenna.	1	CO2
3.	Tutorial: RFID reader and tag antenna design and simulation	3	CO3
3.1	Antennas for Wireless Body Area Network	1	CO3
3.2	Standards, on body, off body communication, antenna design challenges	1	CO3
3.3	Wearable Antennas, flexible antennas.	1	CO3
4	Tutorial: design, simulation of compact flexible antenna	3	CO4
4.1	Phased Array for Radar and Communication Systems:	1	CO4
4.2	Transceiver, System requirements,	1	CO4
4.3	Array characterization, Array design,	1	CO4
5	Electronic Scanning techniques.	1	CO5
5.1	Tutorial: Radar antenna design, simulation	3	CO5
5.2	Array and BFN for 5G mobile communication system	1	CO5
5.3	5G technology,– Mobile communication, challenges, Massive MIMO,	2	CO5
6	phased array and beam forming	1	CO6
6.1	form factor and broadband performance, ,	1	CO6
6.2	Tutorial : Design, simulation of 5G array Antenna	3	CO6
6.3	Assignment 3: Mini project- Design, development of antennas for RFID, BAN, Radar and 5G Applications, wearable and UWB antenna	4	CO6

Course Designers:

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18ECPN0	ELECTROMAGNETIC INTERFERENCE AND COMPATIBILITY	Category	L	T	P	Credit
		PE	3	0	0	3

Preamble

The objective of this course is to provide insight in to the different sources of EMI, basic EMC requirements for the electronic devices, EMI filters to mitigate the noise, and the measurement techniques for EMI/EMC.

Prerequisite

18EC320- RF Passive Devices and Circuits

Course Outcomes

On the successful completion of the course students will be able to

CO Number	Course Outcome Statement	Weightage*** in %
CO1	Comprehend the EMI regulations and EMC requirements for the commercial wireless applications	10
CO2	Determine the major sources of interference by applying the concepts of non-ideal passives and conducted interference	10
CO3	Design an EMI filter to suppress the common-mode noise for wireless applications	20
CO4	Determine the possible shielding and grounding mechanism for the given device in an EM environment	20
CO5	Analyse the near-end and far-end crosstalk noise in a high density printed circuit boards	20
CO6	Illustrate the impact of EMI/EMC effects through measurements	20

*** Weightage depends on Bloom's Level, number of contact hours,

CO Mapping with CDIO Curriculum Framework

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS2	Understand	Respond	-	1.3, 2.4.6, 3.2.3
CO2	TPS3	Apply	Value	-	1.3, 2.1.1, 2.3.4, 2.4.6, 2.5.1, 3.1.1, 3.2.3
CO3	TPS3	Apply	Value	-	1.3, 2.1.1, 2.3.4, 2.5.1, 3.1.1, 3.2.3
CO4	TPS3	Apply	Value	-	1.3, 2.1.1, 2.3.4, 2.4.6, 2.5.1, 3.1.1, 3.2.3
CO5	TPS4	Analyse	Organise	-	1.3, 2.1.1, 2.3.4, 2.5.1, 3.1.1, 3.2.3
CO6	TPS3	Apply	Value	-	1.3, 2.1.1, 2.3.4, 2.4.6, 2.5.1,3.1.1, 3.2.3

Mapping with Programme Outcomes and Programme Specific Outcomes

Cos	PO1	PO2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2	PSO 3
CO1	M	L	-	-	-	-	-	-	-	-	-	-	M	-	L
CO2	S	M	L	-	-	-	-	-	-	-	-	L	M	-	L
CO3	S	M	L	L	L	-	-	-	L	L	-	L	M	L	L
CO4	S	M	L	L	L	-	-	-	L	L	-	L	M	L	L
CO5	S	S	M	L	L	-	-	-	L	L	-	L	S	L	L
CO6	S	M	L	L	-	-	-	-	L	L	-	L	M	L	L

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

Cognitive Levels	Continuous Assessment Tests			Assignment			End Semester Examination
	1	2	3	1	2	3	
Understand	30	20	20	20	-	-	**20**
Apply	70	80	60	80	100	80	**60**
Analyse	0	0	20	0	0	20	**20**
Evaluate	0	0	0	0	0	0	0
Create	0	0	0	0	0	0	0

Sample Questions for Course Outcome Assessment

Course Outcome 1 (CO1):

1. Compare the MIL-STD-461E RE102 radiated emission limits for U.S. Air Force ground applications at 30 MHz and 1 GHz to the FCC Class A radiated emission limits. Is this a valid comparison?
2. The voltage induced at the terminals of an antenna V_{ant} is 5V for every V/m of incident field E_{ant}. What level in dBμV at the base of the antenna would correspond to the FCC Class B limit at 100MHz? Determine the reading of the spectrum analyzer if it is connected to the antenna with 200 ft of RG58U coaxial cable that has 4.5 dB/100 ft of loss at 100MHz.
3. The radiated emissions from a product are measured at 50 MHz at 15 m away and are found to be 21 mV/m. Does the product comply with the FCC Class B limit? [No] By how much does the product pass or fail?

Course Outcome 2 (CO2):

1. An inductor is to be placed in series with a 50-V load to block a 100 MHz noise current. Determine a value for the inductance that will reduce the 100-MHz noise signal across the load by 20 dB.
2. Determine the frequency where the internal inductance of a #32 AWG solid wire begins to decrease due to skin effect. Determine the internal inductance of this wire at 100 MHz.
3. Determine the effective dielectric constant and characteristic impedance of a coplanar stripline constructed of a glass epoxy board of thickness 47 mils supporting two 1-oz Cu lands 100 mils in width and separated (edge to edge) by 100 mils.

Course Outcome 3 (CO3):

1. Suppose that a common-mode choke has self-inductances of 28 mH and a coupling coefficient of 0.98. Determine the leakage inductance presented to differential-mode currents. Repeat this for a coupling coefficient of 0.95.
2. Suppose that a green-wire inductor has an inductance of 1 mH and a parasitic capacitance of 10 pF. Determine the resonant frequency of this inductance and its impedance at 30 MHz.
3. The Class B quasi-peak conducted emission limits at 150 kHz, 500 kHz, and 30 MHz are 66 dBμV, 56 dBμV, and 60 dBμV. Determine these in amperes and dBμA.

Course Outcome 4 (CO4):

1. A circular rod of diameter 3cm is inserted vertically into the ground up to a depth of 3 m. The resistivity of earth soil is 104 Ω-cm. If the resistances between the electrode and the adjacent soil and the contact resistance between the electrode and the soil are neglected, calculate the percentage of total resistance to earth of the electrode established within 3m of the rod inside the soil.
2. A 100-MHz plane wave is incident on a plane isolated double shield made of copper having same thickness with air between the two shields. Calculate the difference between the reflection losses and absorption losses for double and single shields.
3. Calculate the difference in total shielding effectiveness provided by two layers of aluminum sheets of thickness 1mm each separated by a 2mm air gap and a single aluminum sheet of thickness 2mm at a frequency of 10MHz.

Course Outcome 5 (CO5):

1. A printed circuit board (PCB) has inner planes surrounding the embedded lands. This resembles a coupled stripline illustrated in Fig. 9.3a. If the board length is 9 in., determine the propagation delay of voltage and current waves from one end to the other.
2. Use the SLEM method to calculate the effective even- and odd-mode impedances and propagation velocities for the coupled striplines whose capacitance and inductance matrices are shown below. Estimate the impacts of crosstalk on the propagation delay for a 0.5-m coupled length.

$$L = \begin{bmatrix} 3.480 \times 10^{-7} & 1.951 \times 10^{-8} \\ 1.951 \times 10^{-8} & 3.480 \times 10^{-7} \end{bmatrix} \quad \mathrm{H/m}$$

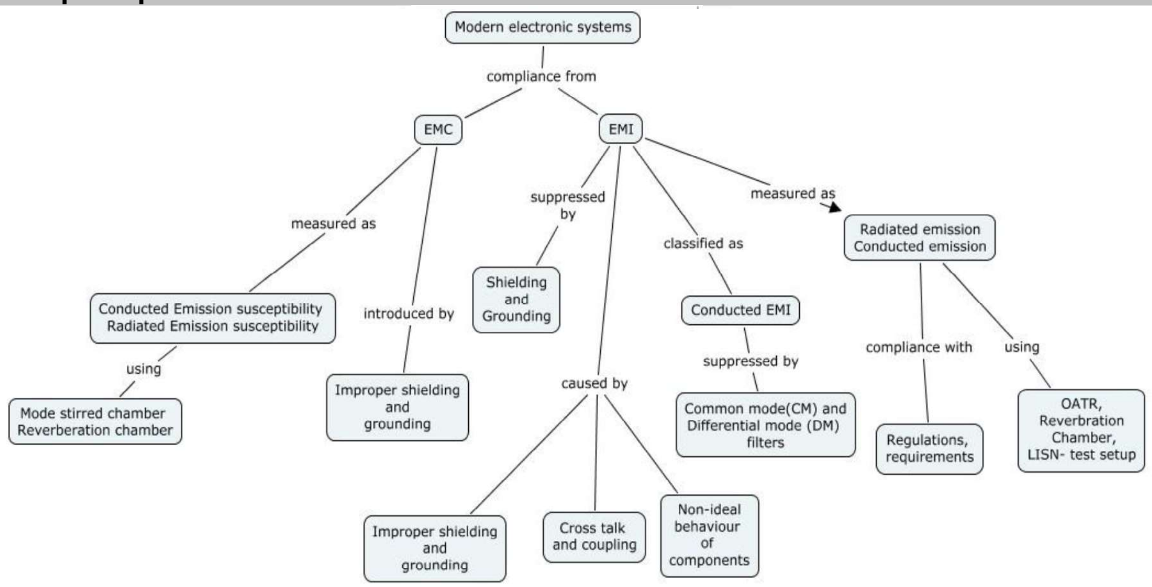
$$C = \begin{bmatrix} 1.271 \times 10^{-10} & -7.213 \times 10^{-12} \\ -7.213 \times 10^{-12} & 1.271 \times 10^{-10} \end{bmatrix} \quad \mathrm{F/m}$$

3. Sketch the far-end crosstalk pulse for a two-line case with no termination at the near end, and matched termination at the far end.

Course Outcome 6 (CO6):

1. Assume that 1-m radiated emission pre-compliance testing is being performed in a location where the closest metallic object is 5 m away from both the product and the antenna. How many decibels below the desired signal will the reflected signal be?
2. What will be the output voltage from an F-33-1 common-mode current clamp when it is placed around a cable with 100 mA of common-mode current?
3. At what voltage level (in dBmV) should the limit line be placed on a spectrum analyzer when using an F-61 common-mode current clamp on a 1/3-m long cable in order to pass FCC Class A radiated emission?

Concept Map



Syllabus

Introduction: Sources of EMI - International EMI regulations - EMC requirements - EMC standards – Need for standards – Civilian EMC standards – Military standards. **Non-ideal behaviour of components** – Wires - Printed Circuit Board - Effect of Component Leads – Resistors – Inductors - Capacitors. **Conducted Emissions and Susceptibility** - Measurement of Conducted Emissions – LISN - Common and Differential Mode Currents - Power Supply Filters - Power Supplies - Linear Power Supplies - SMPS - Power Supply and Filter Placement - Conducted Susceptibility. **Shielding** - Shielding Effectiveness - Far-Field Sources - reflection loss - absorption loss - Multiple- Reflection Loss – Near Field Sources - Electric Sources - Magnetic Sources – Magnetic field shielding - Effect of Apertures.

Grounding - Safety Ground - Signal Ground - Ground Bounce and Partial Inductance - Single-Point Grounding - Multipoint Grounding - Hybrid Grounding - Ground Loops - Subsystem Decoupling. **Crosstalk** - Mutual Inductance and Capacitance – Coupled line analysis - Near end and Far end cross talk - estimation of crosstalk – time and frequency domain analysis for different load terminations - crosstalk minimization. **EMC Tests and Measurements** – Risk Analysis in EMC Tests and Measurements - Emission Measurements - Immunity/Susceptibility Tests - Harmonic Measurements - Surge and Flicker Tests - Electrostatic Discharge Tests - Electrical Fast Transients - Measurements of Spurious - Error Analysis and Uncertainty.

Learning Resources

- Clayton R. Paul, Introduction to Electromagnetic Compatibility, Second Edition, John Wiley & Sons, 2006.
- Henry W. Ott, Electromagnetic Compatibility Engineering, John Wiley & Sons, 2009.
- Ralph Morrison, Grounding and Shielding: Circuits and Interference, Sixth Edition, John Wiley & Sons, 2016.
- Clayton R. Paul, Transmission Lines in Digital Systems for EMC Practitioners, John Wiley & Sons, 2012.
- Stephen H. Hall, Howard L. Heck, Advanced Signal Integrity for High-Speed Digital Designs, Wiley-IEEE Press, 2009.
- Mark I. Montrose, EMC and the Printed Circuit Board: Design, Theory, and Layout Made Simple, Wiley-IEEE Press, 2004.
- NPTEL Course: https://nptelmooc2013.appspot.com/noc19_ee17/preview

Course Contents and Lecture Schedule

Module No.	Topic	No. of Hours	Course Outcome
1.	**Introduction -** Sources of EMI - International EMI regulations	2	CO1
1.1	EMC requirements - EMC standards – Need for standards – Civilian EMC standards – Military standards	2	CO1
1.2	**Non-ideal behaviour of components** – Wires - Printed Circuit Board	2	CO2
1.3	Effect of Component Leads – Resistors – Inductors - Capacitors	2	CO2
2	**Conducted Emissions and Susceptibility** - Measurement of Conducted Emissions – LISN - Common and Differential Mode Currents	2	CO3
2.1	Power Supply Filters - Power Supplies - Linear Power Supplies	2	CO3
2.2	SMPS - Power Supply and Filter Placement - Conducted Susceptibility	2	CO3
3	**Shielding** - Shielding Effectiveness - Far-Field Sources - reflection loss - absorption loss - Multiple-Reflection Loss	2	CO4
3.1	Near Field Sources - Electric Sources - Magnetic Sources – Magnetic field shielding - Effect of Apertures	2	CO4
3.2	**Grounding** - Safety Ground - Signal Ground - Ground Bounce and Partial Inductance	2	CO4
3.3	Single-Point Grounding - Multipoint Grounding - Hybrid Grounding - Ground Loops - Subsystem Decoupling	2	CO4

4	**Crosstalk** - Mutual Inductance and Capacitance – Coupled line analysis	2	CO5
4.1	Near end & Far end cross talk - estimation of crosstalk	2	CO5
4.2	Time and frequency domain analysis for different load terminations - crosstalk minimization.	2	CO5
5	**EMC Tests and Measurements** – Risk Analysis in EMC Tests and Measurements	2	CO6
5.1	Emission Measurements - Immunity/Susceptibility Tests - Harmonic Measurements -	2	CO6
5.2	Surge and Flicker Tests - Electrostatic Discharge Tests - Electrical Fast Transients	2	CO6
5.3	Measurements of Spurious - Error Analysis and Uncertainty.	2	CO6

Course Designers:

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18ECPP0	RF MEMS DESIGN AND TECHNOLOGY	Category	L	T	P	Credit
		PEES	3	0	0	3

Preamble

MEMS has been identified as one of the most promising technologies for the 21st Century and has the potential to revolutionize both industrial and consumer products by combining silicon-based microelectronics with micromachining technology. The performance of current RF (Radio Frequency) systems can be enhanced by replacing critical components by their MEMS counterparts (Micro Electro Mechanical systems).This course starts with the glimpses of MEMS covering the introduction and origin of MEMS, driving force for MEMS development, commercial applications, fabrication process and packaging techniques. The latter half of the course will be devoted to provide a thumb rule in designing, modelling various RF MEMS components such as switches, capacitors, phase shifters, micromachined Transmission lines and antennas. They are also exposed to the MEMS CAD tools available in the Design center. Special weight is given to design circuits and do simulation with Comsol, Intellisuite and Coventorware. By taking this course, students can make good preparations for their research in relevant areas.

Prerequisite

18EC320- RF Passive Devices and Circuits

Course Outcomes

On the successful completion of the course students will be able to

CO Number	Course Outcome Statement	Weightage in %
CO1	Summarize the Concept of miniaturization, actuation mechanisms, packaging and micro fabrication techniques	10
CO2	Design RF MEMS Switch circuits for phase shifter applications	20
CO3	Design RF MEMS capacitors and inductors.	15
CO4	Design RF MEMS phase shifters for phased array antennas	20
CO5	Apply micromachining techniques to antennas	15
CO6	Acquire skills in computer aided design tools for modelling and simulating RF MEMS devices	20

CO Mapping with CDIO Curriculum Framework

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS2	Understand	Respond	-	1.3, 2.4.6
CO2	TPS3	Apply	Value	-	1.3, 2.1.1, 2.1.2, 2.1.3, 2.5.1
CO3	TPS3	Apply	Value	-	1.3, 2.4.6
CO4	TPS3	Apply	Value	-	1.3, 2.1.1, 2.1.2, 2.5.1
CO5	TPS3	Apply	Value	-	1.3, 2.4.6
CO6	TPS3	Apply	Value	-	1.3, 2.1.1, 2.1.2, 2.5.1

Mapping with Programme Outcomes and Programme Specific Outcomes

Cos	PO1	PO2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2	PSO 3
CO1	M	L	-	-	-	-	-	-	-	-	-	-	L	-	-
CO2	S	M	L	-	L	-	-	L	-	L	-	L	M	-	-
CO3	S	M	L	-	L	-	-	L	-	L	-	L	M	-	-
CO4	S	M	L	-	L	-	-	L	-	-	-	L	M	-	-
CO5	S	M	L	-	L	-	-	L	-	-	-	L	M	-	-
CO6	S	M	L	-	L	-	-	L	-	-	-	L	M	-	-

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

Cognitive Levels	Continuous Assessment Tests			Assignment			End Semester Examination
	1	2	3	1	2	3	
Remember	0	0	0	0	0	0	0
Understand	50	20	20	50	0	0	20
Apply	50	80	80	50	100	100	80
Analyse	0	0	0	0	0	0	0
Evaluate	0	0	0	0	0	0	0
Create	0	0	0	0	0	0	0

Assessment Pattern: Psychomotor

Psychomotor Skill	Assignment-1	Assignment-2	Assignment-3
Perception	-	-	-
Set	-	-	-
Guided Response	-	-	-
Mechanism	-	-	-
Complex Overt Responses	-	-	-
Adaptation	-	-	-
Origination	-	-	-

Sample Questions for Course Outcome Assessment

Course Outcome 1(CO1):

1. Tabulate the direct analogy of electrical and mechanical domains.
2. Classify MEMS packages. Based on the need for packaging of MEMS devices classify and differentiate various packaging methodologies.

Course Outcome 2(CO2):

1. 1 Design a RF MEMS shunt switch with an equivalent circuit approach operating at a frequency of 40 GHz.
2. i) Applying the concepts of direct analogy between electrical and mechanical domains Convert the mechanical model of a RF MEMS shunt switch to electrical model.
   ii) Derive the expression for pull down voltage of a switch.

Course Outcome 3 (CO3):

1. List the ways of designing RF MEMS capacitors and explain the draw backs present in two plate system. How three plate system provides better capacitance ratio.
2. How a planar inductor can be modelled and designed? Explain the various design issues for enhancing the performance of the MEMS inductors.

Course Outcome 4 (CO4):

1. Determine the Bragg frequency and the phase shift per unit length of a DMTL phase shifter at a frequency of 10 GHZ.
2. Design a DMTL phase shifter using LC model with the following design specifications.
   f = 30 GHz, Length of the membrane (L) = 300 μm, $wxW = 40*100\ \mu m^2$, g=4 μm,
   t = $2\,\mu m$, $Z_0 = 100$ ohms, $Z_{lu} = 60$ ohms, Z_{ld} = 42 ohms, $t_d = 1500\,A^0$.

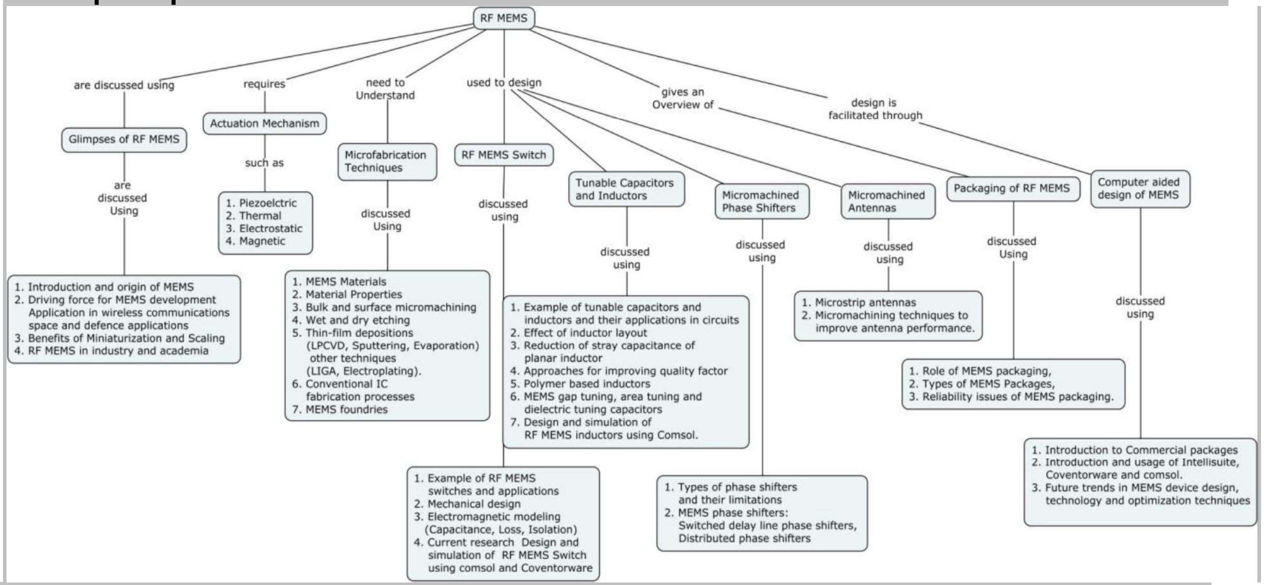
Course Outcome 5 (CO5):

1. How radiation occurs from micro strip antennas. Comment on the various choices of micromachining techniques for realizing micro strip antennas.
2. What do you mean by reconfigurability? How micromachining technique could be applied to build a Vee antenna for beam steering and beam shaping?

Course Outcome 6(CO6):

1. Compare and contrast the usage of Intellisuite and Coventorware MEMS CAD tools.
2. List the important features of Coventorware MEMS CAD tool.

Concept Map



Syllabus

Glimpses of MEMS: Overview of MEMS, driving force for MEMS development, Application in wireless communications, space and defence applications, Benefits of Miniaturization and Scaling, RF MEMS in industry and academia, Commercial packages. **Actuation Mechanisms in MEMS**: Electrostatic, Thermal and Magnetic. **Micro fabrication Techniques:** MEMS Materials, Material Properties, Bulk and surface micromachining, Wet and dry etching Thin-film depositions (LPCVD, Sputtering, Evaporation), other techniques (LIGA, Electroplating). Conventional IC fabrication processes. **Packaging of RF MEMS:** Role of MEMS packaging, Types of MEMS Packages, Reliability issues of MEMS packaging. **RF MEMS Components: Case study 1: RF MEMS Switch:** RF MEMS Series, Capacitive shunt switches, Electromagnetic modeling (Capacitance, Loss, Isolation), Current research, Examples of switches for various applications. **Case Study 2: Tunable Capacitors and Inductors:** Example of tunable capacitors and inductors and their applications in circuits, Effect of inductor layout, reduction of stray capacitance of planar inductor, Approaches for improving quality factor, Polymer based inductors, MEMS gap tuning, area tuning and dielectric tuning capacitors. **Case Study 3: Micromachined phase shifters:** Types of phase shifters and their limitations, MEMS phase shifters: Switched delay line phase shifters, Distributed phase shifters. **Case Study 4: Micromachined antennas:** Microstrip antennas, Micromachining techniques to improve antenna performance, Reconfigurable antennas. **Computer aided design of MEMS:** Commercial packages, usage of Intellisuite, Coventorware and Comsol CAD tools. Future trends in MEMS device design.

Learning Resources

- Vijay K Varadhan ,K.J.Vinoy “RF MEMS and their Applications”, John Wiley & Sons, 1998.
- K.J Vinoy, K.N Bhat, V.K Aatre “Micro and Smart Systems”, John Wiley & Sons, 2010
- http://care.iitd.ac.in/People/Faculty/bspanwar/teaching.html
- http://nptel.ac.in/courses/'MEMS and Micro Systems'
- http://www.mecheng.iisc.ernet.in/~suresh/memscourse/pcontent.html

Course Contents and Lecture Schedule

Module No.	Topic	No. of Hours	Course Outcome
1.	**Glimpses of MEMS**		
1.1	Overview of MEMS	1	CO1
1.2	Driving force for MEMS development, Application in wireless communications, space and defence	1	CO1

	applications		
1.3	Benefits of Miniaturization and Scaling	1	CO1
1.4	RF MEMS in industry and academia, Introduction to Commercial packages	1	CO1
2.	**Actuation Mechanisms in MEMS**		
2.1	Electrostatic Thermal and Magnetic	1	CO1
3.	**Micro fabrication Techniques**		CO1
3.1	MEMS Materials, Material Properties	1	CO1
3.2	Bulk and surface micromachining	0.5	CO1
3.3	Wet and dry etching	0.5	CO1
3.4	Thin-film depositions (LPCVD, Sputtering, Evaporation), other techniques (LIGA, Electroplating), Conventional IC fabrication processes	2	CO1
4	**Packaging of RF MEMS**		CO1
4.1	Role of MEMS packaging ,Types of MEMS Packages	1	CO1
4.2	Reliability issues of MEMS packaging.	1	CO1
5	**RF MEMS Components: Case study 1: RF MEMS Switch**		
5.1	RF MEMS Series , Capacitive shunt switches	1	CO2
5.2	Electromagnetic modelling (Capacitance, Loss, Isolation),	2	CO2
5.3	Current research ,Examples of switches for various applications	1	CO2
6	**Tunable Capacitors and Inductors**		
6.1	Example of tunable capacitors and inductors and their applications in circuits	0.5	CO3
6.2	Effect of inductor layout	1	CO3
6.3	Reduction of stray capacitance of planar inductor	1	CO3
6.4	Approaches for improving quality factor	0.5	CO3
6.5	MEMS gap tuning, Area tuning and dielectric tuning capacitors	2	CO3
7	**Micromachined phase shifters**		
7.1	Types of phase shifters and their limitations	1	CO4
7.2	MEMS phase shifters: Switched delay line phase shifters, Distributed phase shifters	2	CO4
8	**Micromachined antennas**		
8.1	Microstrip antennas	1	CO5
8.2	Micromachining techniques to improve antenna performance	1	CO5
8.3	Reconfigurable antennas	1	CO5
9	**Computer aided design of MEMS**		
9.1	Overview of Commercial packages	1	CO6
9.2	Usage of Intellisuite, Coventorware and Comsol CAD tools	8	CO6
9.3	Future trends in MEMS device design	1	CO6

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18ECPQ0	STATISTICAL SIGNAL PROCESSING	Category	L	T	P	Credit
		PE	2	1	0	3

Preamble

The objective of this course is to present the theory and applications of statistical signal processing methods. In this course, the key topics namely signal modelling, optimum linear filtering, spectral estimation and array processing are discussed in detail. The topics have been chosen based on the grounds of theoretical value and practical importance.

Prerequisite

18EC440 Signal Processing

Course Outcomes

On the successful completion of the course students will be able to

CO#	Course Outcome Statement	Weightage in %
CO1	Calculate the first and second order moments of the given sampling distributions	10
CO2	Determine system behaviour of All pole, All zero, and pole-zero models of systems with random signals	10
CO3	Design optimum linear systems for linear prediction and filtering of random signals	15
CO4	Determine the power spectrum of given random signal using non-parametric methods	15
CO5	Determine the power spectrum of given random signal using parametric methods	15
CO6	Determine the power spectrum of given random signal using Eigen Analysis method	20
CO7	Compute the Direction of Arrival information of information with the random samples collected using an array of sensors	15

CO Mapping with CDIO Curriculum Framework

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS3	Apply	Value	Mechanism	1.3, 2.1.1, 2.1.2, 2.4.1, 2.4.2
CO2	TPS3	Apply	Value	Mechanism	1.3, 2.1.1, 2.1.2, 2.4.1, 2.4.2
CO3	TPS3	Apply	Value	Mechanism	1.3, 2.1.1, 2.1.2, 2.4.1, 2.4.2, 3.2.5
CO4	TPS3	Apply	Value	Mechanism	1.3, 2.1.1, 2.1.2, 2.4.1, 2.4.2, 3.2.5
CO5	TPS3	Apply	Value	Mechanism	1.3, 2.1.1, 2.1.2, 2.4.1, 2.4.2, 3.2.5
CO6	TPS3	Apply	Value	Mechanism	1.3, 2.1.1, 2.1.2, 2.4.1, 2.4.2, 3.2.5
CO7	TPS3	Apply	Value	Mechanism	1.3, 2.1.1, 2.1.2, 2.4.1, 2.4.2, 3.2.5

Mapping with Programme Outcomes and Programme Specific Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	S	M	L	-	M	-	-	-	M	-	-	-	M	-	L
CO2	S	M	L	-	M	-	-	-	M	-	-	-	M	-	L
CO3	S	M	L	-	M	-	-	-	M	-	-	-	M	-	L
CO4	S	M	L	-	M	-	-	-	M	-	-	-	M	-	L
CO5	S	M	L	-	M	-	-	-	M	-	-	-	M	-	L
CO6	S	M	L	-	M	-	-	-	M	-	-	-	M	-	L
CO7	S	M	L	-	M	-	-	-	M	-	-	-	M	-	L

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

Cognitive Levels	Continuous Assessment Tests			Assignment			End Semester Examination
	1	2	3	1	2	3	
Remember	0	0	0	0	0	0	0
Understand	20	20	20	0	0	0	20
Apply	80	80	80	50	50	50	80
Analyse	0	0	0	0	0	0	0
Evaluate	0	0	0	0	0	0	0
Create	0	0	0	0	0	0	0

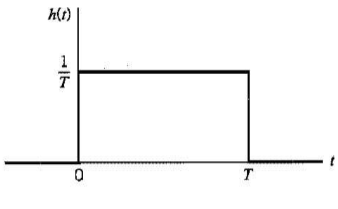
Assessment Pattern: Psychomotor

Psychomotor Skill	Assignment-1	Assignment-2	Assignment-3
Perception	-	-	-
Set	-	-	-
Guided Response	-	-	-
Mechanism	50	50	50
Complex Overt Responses	-	-	-
Adaptation	-	-	-
Origination	-	-	-

Sample Questions for Course Outcome Assessment

Course Outcome 1 (CO1):

1. The random process $X(t)$ is define by $X(t) = X\cos(2\pi f_0 t) + Y\sin(2\pi f_0 t)$ where X and Y are two zero mean independent Gaussian random variables each with variance σ^2. Find $\mu_X(t)$.
2. A zero-mean stationary process $X(t)$ is applied to a linear filter whose impulse response is defined by a truncated exponential: $h(t) = \begin{cases} ae^{-at}, & 0 \le t \le T \\ 0, & otherwise \end{cases}$. Show that the power spectral density of the filter output $Y(t)$ is defined by $S_Y(f) = \dfrac{a^2}{a^2 + 4\pi^2 f^2}\left(1 - 2\exp(-aT)\cos(2\pi fT) + \exp(-2aT)\right)S_X(f)$ Where $S_X(f)$ is the power spectral density of the filter input.
3. A stationary, Gaussian process $X(t)$ with zero mean and power spectral density $S_X(f)$ is applied to a linear filter whose impulse response $h(t)$ shown in Figure. A sample Y is taken of the random process at the filter output at time T.
   i) Determine the mean and variance of Y.
   ii) What is the probability density function of Y?



Course Outcome 2 (CO2):

1. Consider two linear random processes with systems function $H(z) = \dfrac{1 - 0.81z^{-1} - 0.4z^{-2}}{\left(1 - z^{-1}\right)^2}$.
   i) Find a difference equation that leads to a numerically stable simulation of each process.

ii) Generate and plot 100 samples from each process, and look for indications of non stationarity in the obtained records.
iii) Compute and plot the second difference of (i) and the first difference of (ii). Comment about the stationary of the obtained records.

2. Show that the spectrum of any PZ model with real coefficients has zero slope at $\omega = 0$ and $\omega = \pi$.
3. Find a minimum phase model with autocorrelation $\rho(0)=1, \rho(\pm)=1, and\, \rho(l)=0$ for $|l| \geq 2$.

Course Outcome 3 (CO3):

1. The Bartlett method is used to estimate the power spectrum of a signal $x[n]$. We know that the power spectrum consists of a single peak with a 3dB bandwidth of 0.01 cycles per sample, but we do not know the location of the peak.
   i) Assuming that N is large, determine the value of $M = N/K$ so that the spectral window is narrower that the peak.
   ii) Explain why it is not advantageous to increase M beyond the value obtained in part (i)
2. Suppose we have N=1000 samples from a sample sequence of a random process.
   i) Determine the frequency resolution of the Bartlett, Welch (50 % overlap) and Blackman-Tukey methods for a quality factor Q=10.
   ii) Determine the record lengths (M) for the Bartlett, Welch (50 % overlap) and Blackman-Tukey methods.
3. A random signal is generated by passing zero-mean white Gaussian noise with unit variance through a filter with system function

$$H(z) = \frac{1}{\left(1+az^{-1}+0.99z^{-2}\right)\left(1-az^{-1}+0.98z^{-2}\right)}$$

   i) Sketch a typical plot of the theoretical power spectrum $\Gamma_{xx}(f)$ for a small value of the parameter a $(i.e., 0 < a < 0.1)$. Pay careful attention to the value of the two spectral peaks and the value of $P_{xx}(\omega)$ for $\omega = \pi/2$.
   ii) Let $a = 0.1$. Determine the section length M required to resolve the spectral peaks of $\Gamma_{xx}(f)$ when using Bartlett's method.
   iii) Consider the Blackman –Tukey method of smoothing the periodogram. How many lags of the correlation estimate must be used to obtain resolution comparable to that of the Bartlett estimate considered in part (b)?

Course Outcome 4 (CO4):

1. Determine the mean, and the autocorrelation of the sequence $x[n]$, which is the output of a ARMA (1,1) process described by the difference equation $x[n] = 0.5x[n-1] + w[n] - w[n-1]$ where $w[n]$ is a white noise process with variance σ_w^2.
2. Determine the mean, and the autocorrelation of the sequence $x[n]$, which is the output of a MA (2) process described by the difference equation $x[n] = w[n] - 2w[n-1] + w[n-1]$ where $w[n]$ a white noise process with variance is σ_w^2.

3. An MA(2) process has the autocorrelation sequence $\gamma_{xx}(m)=\begin{cases} 6\sigma_w^2, & m=0 \\ -4\sigma_w^2, & m=\pm1 \\ -2\sigma_w^2, & m=\pm2 \\ 0, & otherwise \end{cases}$
   i. Determine the coefficients of the MA(2) process that have the foregoing autocorrelation
   ii. Is the solution unique? If not, give all possible solutions.

Course Outcome 5 (CO5):

1. Consider an optimum FIR filter specified by the input correlation matrix $R = Toeplitz\left\{1,\frac{1}{4}\right\}$ and cross-correlation vector $\mathbf{d}=\begin{bmatrix}1 & \frac{1}{2}\end{bmatrix}^T$
   i) Determine the optimum impulse response c_0 and the MMSE P_0.
   ii) Express c_0 and P_0 in terms of the eigen values and eigen vectors of $\mathbf{R}$.
2. The first five samples of the autocorrelation sequence of a signal $x(n)$ are $r(0)=1, r(1)=0.8, r(2)=0.6, r(3)=0.4$ and $r(4)=0.3$. Compute the FLP, the BLP, the optimum symmetric smoother and the corresponding MMSE (a) by using normal equations method and (b) by using the inverse of the normal equations matrix.
3. Consider the signal $x(n)=y(n)+v(n)$, where $y(n)$ is a useful random signal corrupted by noise $v(n)$. The processes $y(n)$ and $v(n)$ are uncorrelated with PSDs $R_y\left(e^{j\omega}\right)=\begin{cases}1, & 0\le|\omega|\le\frac{\pi}{2} \\ 0, & \frac{\pi}{2}<|\omega|\le\pi\end{cases}$ and $R_v\left(e^{j\omega}\right)=\begin{cases}1, & \frac{\pi}{4}\le|\omega|\le\frac{\pi}{2} \\ 0, & 0\le|\omega|<\frac{\pi}{4}\, and\, \frac{\pi}{2}<|\omega|\le\pi\end{cases}$ respectively.
   i) Determine the optimum IIR filter and the MMSE
   ii) Determine a third order optimum FIR filter and the corresponding MMSE

Course Outcome 6 (CO6):

1. Show that the pseudo spectrum for the MUSIC algorithm is equivalent to the minimum-variance spectrum in the case of an infinite signal-to-noise ratio.
2. Find a relationship between the minimum-norm pseudo spectrum and the all-pole model spectrum in the case of an infinite signal-to-noise ratio.
3. For the MUSIC algorithm, we showed a means of using the MUSIC pseudo spectrum to derive a polynomial that could be rooted to obtain frequency estimates, which is known as root-MUSIC. Find a similar rooting method for the minimum-norm frequency estimation procedure.

Course Outcomes 7 (CO7):

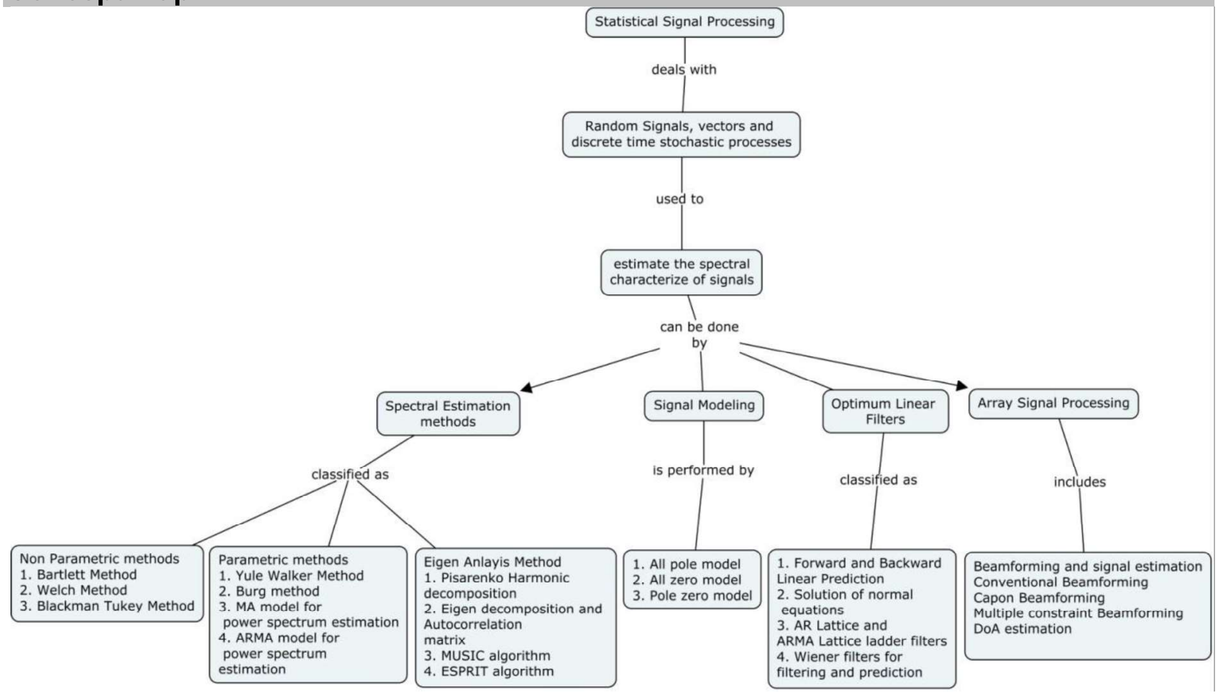
1. Consider a narrowband spatially propagating signal with a speed of propagation c. The signal impinges on an M=2 element ULA from an angle $\phi=0^0$ with a spacing d between the elements. For illustration purposes, let the temporal content of the signal be a pulse.
   i) Let the time of arrival of the pulse at the first sensor be t=0. At what time does the signal arrive at the second sensor?
   ii) Do any other angles ϕ produce the same delay between the two sensors? Why?
2. The optimum beamformer weights with MVDR normalization are found by solving the following optimization

$$\min \quad P_{i+n}$$
$$\textit{subject to } \mathbf{c}^H \mathbf{v}(\varphi_s) = 1 .$$

Using Lagrange multipliers, show that MVDR optimum beamformer weight vector is
$$c_0 = \frac{\mathbf{R}_{i+n}^{-1}\mathbf{v}(\varphi_s)}{\mathbf{v}^H(\varphi_s)\mathbf{R}_{i+n}^{-1}\mathbf{v}(\varphi_s)}$$

3. The frost sample by sample adaptive beamformer was derived for the MVDR beamformer. Extend the frost sample by sample adaptive beamformer for the case of multiple constraints in an LCMV adaptive beamformer

Concept Map



Syllabus

Random variables and random processes: Random variables, random vectors, discrete time stochastic processes, linear systems with stationary random inputs, principles of estimation theory **Linear Signal Models:** All pole model, All zero model, pole-zero models, models with poles on unit circles. **Optimum Linear Filters**- Forward and backward linear prediction, solution of normal equations, AR lattice and ARMA lattice ladder filters, wiener filters for filtering and prediction, Channel Equalization in Data Transmission Systems **Non-Parametric methods:** Spectral analysis of deterministic signals, estimation of autocorrelation of stationary random signals, estimation of power spectrum of stationary random signals: Bartlett method, Welch method and Blackman Tukey method. **Parametric methods:** Yule Walker method, Burg method for AR model parameters, MA model for power spectrum estimation, ARMA model for power spectrum estimation, minimum variance spectral estimation. **Eigen Analysis methods:** Pisarenko Harmonic decomposition method, Eigen decomposition of the autocorrelation matrix for sinusoids in white noise, MUSIC algorithm, ESPRIT algorithm. **Array Signal Processing –** Narrowband model, multiple DoAs and multiple sources, sensor spacing design, spatial resolution and array aperture, beamforming and signal estimation, conventional beamforming, capon beamforming, multiple constraint beamforming, DoA estimation

Learning Resources

- Umberto Spagnolini, Politecnico diMilano, "Statistical Signal Processing in Engineering", John Wiley & Sons Ltd, 2018.
- Dimitris G. Manolakis, Vinay K. Ingle and Stephen M. Kogon, "Statistical and Adaptive Signal Processing", Artech House, 2005.
- John G.Proakis and Dimitris G.Manolakis, "Digital Signal Processing Principles, Algorithms and Applications", Prentice-Hall of India, Fourth Edition, 2006.
- Alexander D. Poularikas, "Discrete Random Signal Processing and Filtering Primer with MATLAB", CRC Press, 2009
- Sophocles J. Orfanidis, "Optimum Signal Processing", McGraw-Hill Publishing Company, 2007.
- Prof. Prabin Kumar Bora, IIT Guwahati, "Statistical Signal Processing", NPTEL Video Lectures: https://nptel.ac.in/courses/108/103/108103158/

Course Contents and Lecture Schedule

No.	Topic	No. of Hours	COs
1	**Random variables and Random processes**		
1.1	Random variables, random vectors.	1	CO1
1.2	discrete time stochastic processes	1	CO1
1.3	linear systems with stationary random inputs	1	CO1
1.4	principles of estimation theory	1	CO1
2	**Linear Signal Models**		
2.1	All pole model	1	CO2
2.2	All zero mode	1	CO2
2.3	pole-zero models	1	CO2
2.4	models with poles on unit circles	1	CO2
2.5	Tutorial	1	CO2
3	**Optimum Linear Filters**		
3.1	Forward and backward linear prediction	1	CO3
3.2	solution of normal equations	1	CO3
3.3	AR lattice and ARMA lattice ladder filters	1	CO3
3.4	wiener filters for filtering and prediction	1	CO3
3.5	Tutorial	1	CO3
4	**Non Parametric methods**		
4.1	Spectral analysis of deterministic signals	1	CO4
4.2	Estimation of autocorrelation of stationary random signals	1	CO4
4.3	estimation of power spectrum of stationary random signals: Bartlett method	1	CO4
4.4	Welch method	1	CO4
4.5	Blackman Tukey method	1	CO4
4.6	Tutorial	1	CO4
5	**Parametric methods**		
5.1	Yule Walker method	1	CO5
5.2	Burg method for AR model parameters	1	CO5
5.3	MA model for power spectrum estimation	1	CO5
5.4	ARMA model for power spectrum estimation	1	CO5
5.5	Minimum variance spectral estimation.	1	CO5
5.6	Tutorial	1	CO5
6.	**Eigen Analysis methods**		
6.1	Pisarenko Harmonic decomposition method	1	CO6

6.2	Eigen decomposition of the autocorrelation matrix for sinusoids in white noise	1	CO6
6.3	MUSIC algorithm	1	CO6
6.4	ESPRIT algorithm	1	CO6
6.5	Tutorial	1	CO6
7	**Array Signal Processing**		
7.1	Narrowband model, multiple DoAs and multiple sources	1	CO7
7.2	sensor spacing design, spatial resolution and array aperture	1	CO7
7.3	beamforming and signal estimation	1	CO7
7.4	conventional beamforming, capon beamforming	1	CO7
7.5	multiple constraint beamforming, DoA estimation	1	CO7
	Total	36	

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18ECPR0	LDPC AND POLAR CODES	Category	L	T	P	Credit
		PEES	2	1	0	3

Preamble

The objective of the course on “LDPC and POLAR Codes” is to present the encoding and decoding techniques along with the corresponding mathematical theory for Low Density Parity Check (LDPC) and polar codes. These codes are used in 5G wireless communication systems. This course focuses on the key topics of encoder design of LDPC codes, decoding algorithms of LDPC codes, code construction for polar codes, decoding of polar codes, channel polarization, channel combining, channel splitting and performance of LDPC and polar codes, whose selection is based on the grounds of theoretical value and practical importance.

Prerequisite

18EC530 Analog and Digital Communication Systems

Course Outcomes

On the successful completion of the course students will be able to

CO#	Course Outcome Statement	Weightage in %
CO1	Encode and decode messages using Reed Muller code and Reed Solomon Code.	10
CO2	Encode and decode messages using LDPC code.	10
CO3	Encode messages using the principles of construction of Polar encoder structures	15
CO4	Decode the polar coded messages with the principles of Successive Cancellation Decoding (SCD) for polar codes	15
CO5	Determine the capacity and mathematical framework of Polar coder and decoder.	15
CO6	Compare the performance of Polar Codes and LDPC code	20

CO Mapping with CDIO Curriculum Framework

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS3	Apply	Value	Mechanism	1.3, 2.1.1, 2.1.2, 3.1.1, 3.1.2, 3.2.5
CO2	TPS3	Apply	Value	Mechanism	1.3, 2.1.1, 2.1.2, 3.1.1, 3.1.2, 3.2.5
CO3	TPS3	Apply	Value	Mechanism	1.3, 2.1.1, 2.1.2, 3.1.1, 3.1.2, 3.2.5
CO4	TPS3	Apply	Value	Mechanism	1.3, 2.1.1, 2.1.2, 3.1.1, 3.1.2, 3.2.5
CO5	TPS3	Apply	Value	Mechanism	1.3, 2.1.1, 2.1.2, 3.1.1, 3.1.2, 3.2.5
CO6	TPS4	Analyze	Value	Complex Overt Responses	1.3, 2.1.1, 2.1.2, 2.1.3, 2.1.4, 3.1.1, 3.1.2, 3.2.5

Mapping with Programme Outcomes and Programme Specific Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	S	M	L	-	-	-	-	-	-	-	-	-	M	-	-
CO2	S	M	L	-	M	-	-	-	M	-	-	-	M	-	L
CO3	S	M	L	-	M	-	-	-	M	-	-	-	M	-	L
CO4	S	M	L	-	M	-	-	-	M	-	-	-	M	-	L
CO5	S	M	L	-	M	-	-	-	M	-	-	-	M	-	L
CO6	S	S	M	L	M	-	-	-	M	-	-	-	S	L	L

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

Cognitive Levels	Continuous Assessment Tests			Assignment			End Semester Examination
	1	2	3	1	2	3	
Remember	20	0	0	0	0	0	0
Understand	20	20	20	40	0	0	20
Apply	60	80	60	60	50	25	60
Analyse	0	0	20	0	0	25	20
Evaluate	0	0	0	0	0	0	0
Create	0	0	0	0	0	0	0

Assessment Pattern: Psychomotor

Psychomotor Skill	Assignment-1	Assignment-2	Assignment-3
Perception	-	-	-
Set	-	-	-
Guided Response	-	-	-
Mechanism	-	50	50
Complex Overt Responses	-	-	-
Adaptation	-	-	-
Origination	-	-	-

Sample Questions for Course Outcome Assessment

Course Outcome 1 (CO1):

1. Determine the Reed-Muller canonical expansion for the Boolean function in 4 variables (X_1, X_2, X_3, X_4) that corresponds to the vector having a 1 location (1111) and zero elsewhere.
2. Show that the Reed Muller code $RM(0,m)$ is the Repetition code and determine the generator matrix and parity check matrix for the Reed-Muller code $RM(2,4)$
3. Determine the symbol-error correcting capability of $(7,3)$ R-S code? How many bits are there per symbol? Use the generator polynomial for the $(7,3)$ R-S code to encode the message 010110111 (rightmost bit is earliest bit) in systematic form. Use polynomial division to find the parity polynomial, and show the resulting codeword in polynomial form and in binary form.

Course Outcome 2 (CO2):

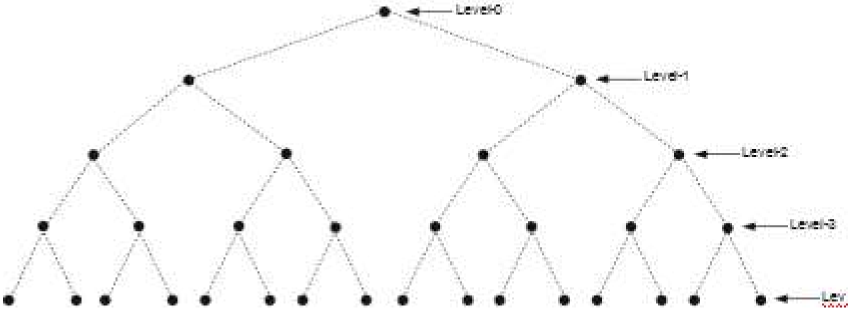
1. Construct the $(3,4)$ LDPC matrix assuming that the codeword length is 20. Using the tanh rule develop an iterative algorithm for decoding.
2. Consider a binary symmetric channel (BSC) with input and output alphabet $\{\pm 1\}$, as opposed to the usual alphabet $\{0,1\}$. Show that a posteriori LLR, λ_n with both intrinsic information and extrinsic information is except that of the channel reliability is $\log((1-p)/p)$ instead of $2/\sigma^2$, where p is the cross over probability.
3. Consider an NR-LDPC code with base matrix of dimension 42×52 and expansion - factor $z = 384$. The first two message blocks are punctured. Assume that your message consists of only 8×384 bits, and the transmitted bit dimension is 40×384 bits. Obtain the number of parity bits that need to be punctured

Course Outcome 3 (CO3):

1. Construct the polar encoder structure for N = 4 in a recursive manner, i.e. construct, W in a recursive manner using two W_2 and one R_4.
2. Find the systematic form of the generator matrix of polar codes for N = 2, N= 4, N = 8, N = 16, and N = 32
3. Construct the syndrome table of the polar codes for N = 2, N = 4, N = 8, N= 16,and N = 32

Course Outcome 4(CO4):

1. Let *N*=16, and assume that the first 10 bits are decoded and the decoded bits are $u_1^{10} = [0 \quad 0 \quad 1 \quad 1 \quad 1 \quad 0 \quad 0 \quad 1 \quad 1 \quad 0 \quad 1]$ we want to decode the 11th bit, i.e., u_{11}. Distribute the first decoded 10 bits to the tree nodes. Use generator matrices G_4 and G_2 for the bit distribution process (Fig.1)



(Fig. 1)

2. For a binary erasure channel, if the erasure probability is $\alpha = 0.3$, calculate the channel capacities for $N = 8$.
3. Consider a polar encoder for *N* = 8, and assume that binary erasure channels with erasure probabilities $\alpha = 0.5$ are employed for the transmission of code bits and the code rate is *R* = 0.5. The channel outputs are given as $y_1^8 = [1 \quad 0 \quad -1 \quad 1 \quad 0 \quad -1 \quad 1 \quad 0]$. Decode the code bits using the received signal vector y^8, and determine the data bits used in encoding operation.

Course Outcome 5(CO5):

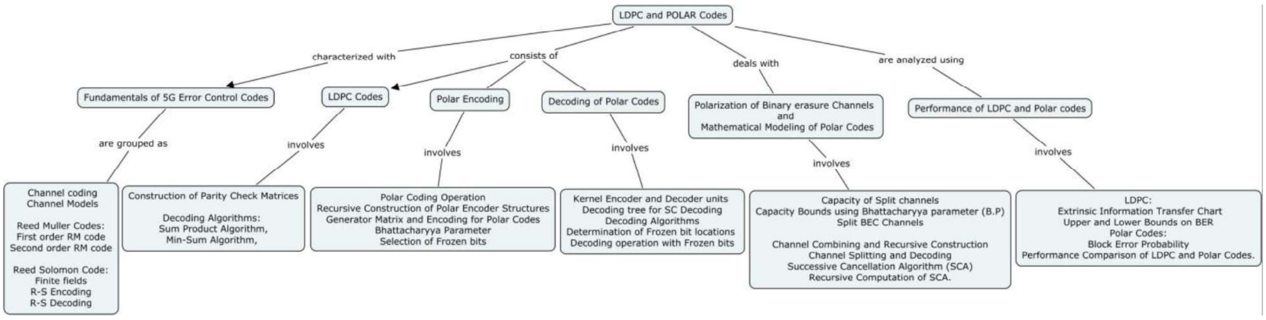
1. Consider the successive cancellation decoder for a polar codeword length 2^n. Determine the size of the belief vector received by the fifth node at depth, r.
2. Consider a $(16,13)$ polar code constructed using the reliability sequence as provided in the 5G standard. Find the generator matrix for this code in systematic form: $G_{sys} = [I_{13} \quad P]$, where I_{13} is the 13×13 identity matrix and P is a 13×13 matrix. Obtain the systematic form by computing $G_{16} = G_2^{\otimes 4}$, where $G_2 = \begin{bmatrix} 1 & 0 \\ 1 & 1 \end{bmatrix}$ and $\otimes$ denotes the Kronecker product. From G_{16} remove the rows which corresponds to frozen bit positions to obtain the generator matrix, G. Then convert G to systematic form by performing Gaussian elimination without column swapping. The number of non-zero entries in the P part of the systematic generator matrix $G_{sys} = [I_{13} \quad P]$. Determine the minimum distance of the code.
3. Consider a coded - BPSK transmission over an AWGN channel using the $(16,8)$ polar code constructed using the reliability sequence as given in the 5G standard. The received vector is $[0.8 \quad 2.0 \quad 0.6 \quad -2.2 \quad -1.25 \quad 1.3]$ by an interior node. Consider decoding the received vector using the successive cancellation decoder. The nodes at each layer are numbered from left to right starting from 0. A node can be uniquely indexed by specifying the depth and the node number. Determine the frozen bit positions in this code.

Course Outcome 6(CO6):

1. The random process $\widetilde{X}(t)$ is defined as $\widetilde{X}(t) = \widetilde{A}\cos(\omega t + \widetilde{\theta})$ where $\widetilde{A}$ and $\widetilde{\theta}$ are independent random variables. Find the mean value $m(t)$ of this random process.
2. Show the path between the input and outputs of the split channels W_4^1, W_4^3 and represent the paths by binary sequences, and calculate the probability of each path.

3. Consider the $(3,1)$ repetition code. (a) Show that the Tanner graph has no cycle (b) Show that the message - passing algorithm converges to the true a posteriori LLR's after two iterations.

Concept Map



Syllabus

Fundamentals of 5G Error Control Codes: Channel Coding, Channel Models - B-DMC,BSC,BEC,AWGN, Reed Muller Codes - First order, Higher order, Reed - Solomon Codes - Finite Fields, Reed Solomon (R-S) Codes - Finite Fields, R-S Encoding, R-S Decoding, **Encoder design and Decoding Algorithms for LDPC Codes:** Construction of Parity Check Matrices, Decoding Algorithms - Sum-Product Algorithm, Min-Sum Algorithm. **Information Theory Perspective of Polar Codes and Polar Encoding:** The Philosophy of Polar Codes, Fundamental ideas of Polar Codes, Butterfly Structure, Polar Coding Operation, Recursive Construction of Polar Encoder Structures, Generator Matrix and Encoding for Polar Codes, Bhattacharyya Parameter, Frozen bits, Selection of Frozen bits. **Decoding of Polar Codes:** Kernel Encoder and Decoder Units of the Polar Codes, Decoding Tree for the Successive Cancellation Decoding of Polar Codes, Level Indices and Determination of Levels for Bit Distribution, Decoding Algorithm for Polar Codes, Determination of Frozen bit locations for Binary Erasure Channel (BEC), Decoding Operation with Frozen Bits. **Polarization of Binary Erasure Channels and Mathematical Modelling of Polar Codes:** Polarization of BEC **-** Split Channels and Capacity of Split Channels in the presence of Binary Erasure Channels - Capacity of Split Channels for $N = 4$ - Capacity bounds using Bhattacharyya parameter (B.P), Split Binary Erasure Channels, Mathematical Modelling of Polar Codes - Channel combining and recursive construction of Polar Encoder structures - Channel Splitting and Decoding of Polar Codes - Mathematical Description of Successive Cancellation Algorithm, Recursive Computation of the Successive Cancellation Algorithm. **Performance of LDPC and Polar Codes:** LDPC - Extrinsic Information Transfer Chart, Mutual Information based Upper and Lower Bounds on the BER, Performance Analysis of Polar Codes - Block Error Probability, Performance Comparison of LDPC codes and Polar Codes in 5G.

Learning Resources

- Bernard Sklar, "Digital Communications - Fundamental and Applications", Prentice Hall PTR, second edition, 2001.
- Michele Franceschini, Gianluigi Ferrari, Riccardo Raheli, "LDPC Coded Modulations", Springer, 2009.
- Orhan Gazi ,"Polar Codes: A Non-Trivial Approach to Channel Coding", Springer , 2019.
- Andre Neubaur, Jurgen Freudenberger, Volker Kuhn, "Coding Theory Algorithms, Architectures and Applications", John Wiley & Sons, 2007.
- Sassan Ahmadi, "5G NR Architecture, Technology, Implementation, and operation of 3GPP New Radio Standards", Academic Press, 2019.

- E. Arıkan, “Channel polarization: a method for constructing capacity-achieving codes for symmetric binary-input memory less channels”, IEEE Trans. Inf. Theory, Vol. 55, No.7, pp.3051–3073, July 2009.
- A. Andi, O. Gazi, “Fast decoding of polar codes using tree structure", IET Communications, Vol.13, No.14, Aug 2019.
- E. Arıkan, “Performance comparison of polar codes and Reed-Muller codes”, IEEE Communication Letters., Vol. 12,No. 6,June 2008,pp.447-449.
- LDPC and Polar Codes in 5G Standard, Course in NPTEL: https://nptel.ac.in/courses/108/106/108106137/, - 2019, By Prof. Andrew Thangaraj, IIT Madras.

Course Contents and Lecture Schedule

S.No.	Topic	No. of Lectures	CO
1	**Fundamentals of 5G Error Control Codes**		
1.1	Channel Coding	1	CO1
1.2	Channel Models	1	CO1
1.3	Reed Muller Codes:		
1.3.1	First order R-M Code	1	CO1
1.3.2	Higher Order R-M Code	1	CO1
1.4	Reed Solomon Code:		
1.4.1	Finite Fields	1	CO1
1.4.2	R-S Encoding	1	CO1
1.4.3	R-S Decoding	1	CO1
2	**Encoder design and Decoding algorithms for LDPC Codes**		
2.1	Construction of Parity Check Matrices	2	CO2
2.2	Decoding Algorithms :		
2.2.1	Sum - Product Algorithm	1	CO2
2.2.2	Min - Sum Algorithm	1	CO2
3	**Information Theory Perspective of Polar Codes and Polar Encoding**		
3.1	The Philosophy of Polar Codes	1	CO3
3.2	Fundamental ideas of Polar Codes	1	CO3
3.3	Butterfly Structure	1	
3.4	Polar Coding Operation	1	CO3
3.5	Recursive Construction of Polar Encoder Structures	1	CO3
3.6	Generator Matrix and Encoding for Polar Codes	1	CO3
3.7	Bhattacharyya Parameter	1	CO3
3.8	Selection of Frozen bits	1	CO3
4	**Decoding of Polar Codes**		
4.1	Kernel Encoder and Decoder Units of the Polar Codes	1	CO4
4.2	Decoding Tree for the Successive Cancellation Decoding of Polar Codes	1	CO4
4.3	Level Indices and Determination of Levels for Bit Distribution	1	CO4
4.4	Decoding Algorithm for Polar Codes	1	CO4
4.5	Determination of Frozen bit locations for BEC Channels	1	CO4
4.6	Decoding Operation with Frozen Bits	1	CO4
5	**Polarization of Binary Erasure Channels and Mathematical modeling of Polar Codes**		

5.1	Polarization of BEC :		CO5
5.1.1	Split Channels and Capacity of Split Channels in the presence of Binary Erasure Channels	1	CO5
5.1.2	Capacity of Split Channels for $N = 4$	1	CO5
5.1.3	Capacity bounds using Bhattacharyya parameter (B.P),	1	CO5
5.1.4	Split Binary Erasure Channels	1	CO5
5.2	Mathematical Modelling of Polar Codes:		CO5
5.2.1	Channel combining and recursive construction of Polar Encoder structures	1	CO5
5.2.2	Channel Splitting and Decoding of Polar Codes	1	CO5
5.2.3	Mathematical Description of Successive Cancellation Algorithm	1	CO5
5.2.4	Recursive Computation of the Successive Cancellation Algorithm	1	CO5
6	**Performance of LDPC and Polar Codes**		
6.1	Performance Analysis of LDPC Code :		CO6
6.1.1	Extrinsic Information Transfer Chart	1	CO6
6.1.2	Mutual Information based Upper and Lower Bounds on the BER	1	CO6
6.2	Performance analysis Polar Code :		CO6
6.3	Block Error Probability	1	CO6
6.4	Performance Comparison of LDPC and Polar Codes.	1	CO6
	Total	36	

Course Designers:

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18ECPS0	PHYSICAL CHANNEL PROCESSING IN 5G NR	Category	L	T	P	Credit
		PEES	2	1	0	3

Preamble

The objective of the course on "Physical Channel Processing in 5G New Radio (NR)" is to present the communication techniques and procedures used in the physical layer of 5G new radio standards. The course covers 5G NR features, spectral requirements, frame structure, radio interface architecture, channel sounding, multi antenna, retransmission, power control, synchronization characteristics. This course would be more helpful in carrying out projects in recent telecommunication domain.

Prerequisite

18EC530 Analog and Digital Communication Systems

Course Outcomes

On the successful completion of the course students will be able to

CO#	Course Outcome Statement	Weightage in %
CO1	Compare the enhanced features of 5G NR over 4G LTE and Describe the Frame structure of 5G NR	15
CO2	Determine suitable channel estimation algorithm for calculating parameters from channel sounding features of 5G NR	15
CO3	Determine the receiver structure for transport channel processing of uplink and downlink in 5G NR	20
CO4	Determine the receiver structure for control channel processing of uplink and downlink in 5G NR	20
CO5	Describe the multi-antenna, retransmission, power control features of 5G NR	15
CO6	Determine suitable frequency and timing estimation algorithms for initial access and synchronization features of 5G NR	15

*** Weightage depends on Bloom's Level, number of contact hours

CO Mapping with CDIO Curriculum Framework

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS2	Understand	Respond	Guided Response	1.3, 2.1.1,2.1.2, 2.4.6, 3.2.3
CO2	TPS3	Apply	Value	Mechanism	1.3, 2.1.1, 2.1.2, 2.4.2, 2.4.6, 2.5.1, 3.1.1, 3.2.3, 4.5.5, 4.6.2
CO3	TPS3	Apply	Value	Mechanism	1.3, 2.1.1, 2.1.2, 2.4.2, 2.4.6, 2.5.1, 3.1.1, 3.2.3, 4.5.5, 4.6.2
CO4	TPS3	Apply	Value	Mechanism	1.3, 2.1.1, 2.1.2, 2.4.2, 2.4.6, 2.5.1, 3.1.1, 3.2.3, 4.5.5, 4.6.2
CO5	TPS2	Understand	Respond	Guided Response	1.3, 2.1.1,2.1.2, 2.4.6, 3.2.3
CO6	TPS3	Apply	Value	Mechanism	1.3, 2.1.1, 2.1.2, 2.4.2, 2.4.6, 2.5.1, 3.1.1, 3.2.3, 4.5.5, 4.6.2

Mapping with Programme Outcomes and Programme Specific Outcomes

COs	PO1	PO 2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	M	L	-	-	-	-	-	-	-	-	-	-	M	-	-
CO2	S	M	L	-	-	-	-	-	-	-	-	-	M	-	-
CO3	S	M	L	-	-	-	-	-	-	-	-	-	M	-	-
CO4	S	M	L	-	S	-	-	-	S	S	-	-	M	-	M
CO5	M	L	-	-	-	-	-	-	-	-	-	-	M	-	-
CO6	S	M	L	-	-	-	-	-	-	-	-	-	M	-	-

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

Cognitive Levels	Continuous Assessment Tests			Assignment			End Semester Examination
	1	2	3	1	2	3	
Remember	0	0	0	0	0	0	0
Understand	20	20	20	0	0	0	20
Apply	80	80	80	100	50	50	80
Analyze	0	0	0	0	0	0	0
Evaluate	0	0	0	0	0	0	0
Create	0	0	0	0	0	0	0

Assessment Pattern: Psychomotor

Psychomotor Skill	Assignment-1	Assignment-2	Assignment-3
Perception	-	-	-
Set	-	-	-
Guided Response	-	-	-
Mechanism	-	50	50
Complex Overt Responses	-	-	-
Adaptation	-	-	-
Origination	-	-	-

Sample Questions for Course Outcome Assessment

Course Outcome 1 (CO1):

1. List the requirements of 5G New Radio.
2. List out the various Uplink and Downlink 5G NR Operating bands. Also mention the duplex modes.
3. Compare Normal RS Structure and Wideband RS Structure in 5G NR Physical layer control signalling.

Course Outcome 2 (CO2):

1. Draw the single port CSI-RS Structure consisting of a single resource element within RB.
2. Represent different spatial filters applied to different CSI-RS.
3. Draw the time and frequency structures of Sounding Reference Signalling.

Course Outcome 3 (CO3):

1. Determine the receiver structures for PDSCH in 5GNR with single transmit and single receive antenna.
2. Determine the receiver structures for PUSCH in 5GNR with single transmit and single receive antenna.
3. Determine the receiver structures for PDSCH in 5GNR with single transmit and multiple receive antenna.

Course Outcome 4 (CO4):

1. Explain the mapping of PUSCH and PUCCH information to physical resources.
2. Consider a PDCCH downlink control channel in 5GNR. It transmits information about the number of OFDM symbols used by control channels in a sub-frame. The 32 bit transmitting sequences for each values of CFI are listed below

CFI <b0, b1, …, b31>

1<0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1>
2 <1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0>
3<1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1>
4 <0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0>

Assuming that PDCCH uses single antenna port for the transmitter and receiver, derive expression for probability of error in detection of the CFI value.

3. In case of fixed group assignment the sequence group to use for PUCCH transmission is given by the physical-layer cell identity modulo 30, where the cell identity ranges from 0 to 63. Determine the group assignment for the given cell identities.

Course Outcome 5 (CO5):

1. Describe the multi antenna transmission modes in downlink 5G New Radio.
2. Determine the Bit Error Rate for the Physical Downlink Hybrid ARQ Indicator channel (PDCCH) with SIMO processing.
3. Precoding is done for multi antenna transmission in 5G New Radio uplink. Determine the rank of the precoding matrix given below.

$$\begin{bmatrix} +1 \\ +1 \\ +1 \\ -1 \end{bmatrix} \quad \begin{bmatrix} +1 & 0 \\ +1 & 0 \\ 0 & -1 \\ 0 & -1 \end{bmatrix} \quad \begin{bmatrix} +1 & 0 & 0 \\ +1 & 0 & 0 \\ 0 & +1 & 0 \\ 0 & 0 & +1 \end{bmatrix} \quad \begin{bmatrix} +1 & 0 & 0 \\ -1 & 0 & 0 \\ 0 & +1 & 0 \\ 0 & 0 & +1 \end{bmatrix} \quad \begin{bmatrix} +1 & 0 & 0 \\ 0 & +1 & 0 \\ +1 & 0 & 0 \\ 0 & 0 & +1 \end{bmatrix}$$

For the DFT spread OFDM in uplink, the allowed DFT sizes are 60, 72, and 96. However a DFT size of 84 is not allowed. Justify.

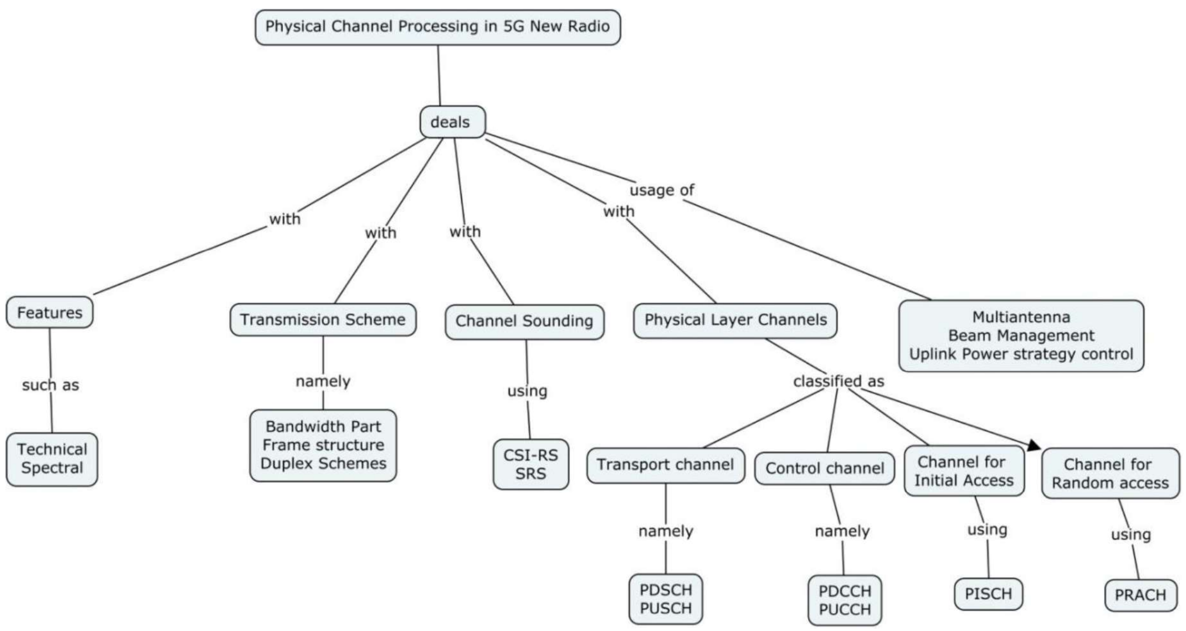
Course Outcome 6 (CO6):

1. Consider 4 length time domain transmitted sequence defined by $x(n) = [1+1j, 1-1j, 1+1j, 1-1j]$.

Consider a normalised frequency offset of 0.3. Determine the received sequence with ideal channel conditions. Apply schmidle Cox algorithm to determine the original frequency offset if $\Delta f = 15KHz$.

2. Apply the Schmidle Cox algorithm for symbol timing estimation in 5G New Radio.
3. What do you mean by beta offset in 5GNR?

Concept Map



Syllabus

5G Overview: 3GPP and the standardization of Mobile Communication, the next generation 5G New Radio, 5G Standardization, ITU-R Activities from 3G to 5G, 5G and IMT-2020, 3GPP Standardization, Spectrum for 5G, Frequency bands for NR, RF Exposure above 6GHz **NR Overview:** Higher Frequency Operation and Spectrum Flexibility, Ultra lean design, Forward compatibility, Transmission scheme, bandwidth parts and frame structure, Duplex schemes, Low latency support, Scheduling and data transmission, control channels, Beam centric design and Multi antenna transmission, Initial access, Interworking and LTE Coexistence **Transmission scheme**: Frequency domain location of NR Carrier, Carrier aggregation, Supplementary uplink, Duplex schemes, Antenna ports, Quasi co-location **Channel sounding:** Downlink channel sounding-CSI-RS, Downlink Measurements and reporting, Uplink channel sounding- SRS **Transport channel processing:** channel coding, Rate matching and physical layer hybrid ARQ Functionality, Scrambling, Modulation, Layer mapping, Uplink DFT Precoding, Multi antenna precoding, Resource mapping, Downlink reserved resources, Reference signals, Physical layer control signalling: Downlink, Uplink, **Multi-antenna Transmission:** Downlink Multi-antenna precoding, NR Uplink Multi-antenna precoding, **Beam Management:** Beam adjustment and Beam Recovery **Retransmission Protocols, Uplink Power and Timing control, Initial access:** Cell search, Random access.

Learning Resources

- Sassan Ahmadi, “5G NR Architecture, Technology, Implementation, and operation of 3GPP New Radio Standards”, Academic Press, 2019.
- Erik Dahlman, Stefan Parkvall, Johan Skold, “5G NR, The Next Generation Wireless Access Technology”, Academic Press,2018.
- 3GPP TS 23.502, Procedures for the 5G system (Release 15), April 2019.
- 3GPP TS 38.101-1, NR, User Equipment (UE) Radio Transmission and Reception; Part 1: Range 1 Standalone (Release 15), December 2018.
- 3GPP TS 38.101-2: NR, User Equipment (UE) Radio Transmission and Reception; Part 2: Range 2 Standalone (Release 15), December 2018.
- 3GPP TS 38.104, NR, Base Station (BS) Radio Transmission and Reception (Release 15), December 2018.
- 3GPP TS 38.202, NR, Services Provided by the Physical Layer (Release 15), December 2018.
- 3GPP TS 38.211, NR, Physical Channels and Modulation (Release 15), December 2018.
- 3GPP TS 38.212, NR, Multiplexing and Channel Coding (Release 15), December 2018.
- 5G New Radio, ShareTechNote. http://www.sharetechnote.com

Course Contents and Lecture Schedule

No.	Topic	No. of Hours	COs
1	**5G Overview**		
1.1	3GPP and the standardization of Mobile Communication, the next generation 5G New Radio	1	CO1
1.2	5G Standardization	1	CO1
1.3	ITU-R Activities from 3G to 5G	1	CO1
1.4	5G and IMT-2020	1	CO1
1.5	3GPP Standardization	1	CO1
1.6	Spectrum for 5G, Frequency bands for NR, RF Exposure above 6GHz	1	CO1
2	**NR Overview**		
2.1	Higher Frequency Operation and Spectrum Flexibility, Ultra lean design	1	CO1
2.2	Forward compatibility, Transmission scheme, bandwidth parts and	1	CO1

	frame structure		
2.3	Duplex schemes, Low latency support, Scheduling and data transmission, control channels	1	CO1
2.4	Beam centric design and Multi antenna transmission	1	CO1
2.5	Initial access, Interworking and LTE Coexistence	1	CO1
3	**Transmission scheme**		
3.1	Frequency domain location of NR Carrier	2	CO2
3.2	Carrier aggregation	2	CO2
3.3	Supplementary uplink, Duplex schemes	2	CO2
3.4	Antenna ports, Quasi co-location	1	CO2
4	**Channel sounding**		
4.1	Downlink channel sounding-CSI-RS	2	CO3
4.2	Downlink Measurements and reporting	2	CO3
4.3	Uplink channel sounding- SRS	2	CO3
5	**Transport channel processing**		
5.1	channel coding, Rate matching and physical layer hybrid ARQ Functionality	2	CO4
5.2	Scrambling, Modulation, Layer mapping	1	CO4
5.3	Uplink DFT Precoding, Multi antenna precoding	1	CO4
5.4	Resource mapping, Downlink reserved resources	1	CO4
5.5	Reference signals	1	CO4
5.6	Physical layer control signalling: Downlink, Uplink	1	CO4
6	**Multi antenna Transmission**		
6.1	Downlink Multi antenna precoding	1	CO5
6.2	NR Uplink Multi antenna precoding	1	CO5
7	**Beam Management**		
7.1	Beam adjustment and Beam Recovery	2	CO5
8	**Retransmission Protocols, Uplink Power and Timing control, Initial access**		
8.1	Cell search, Random access	1	CO6
Total		36	

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18ECPT0	DEEP LEARNING FOR SPEECH PROCESSING

Category	L	T	P	Credit
PE	2	1	0	3

Preamble

The objective of this course is to develop techniques which can enable machines to understand complex real-world signals like text and speech. This course covers methods which model, analyse, classify and detect the underlying information modalities present in real world signals. This course consists of descriptions of signal processing tools for learning patterns in speech signals as the description of a class of machine learning tools which have been successfully used for these signals.

Prerequisite

18EC440 Signal Processing

Course Outcomes

On the successful completion of the course students will be able to

CO#	Course Outcome Statement	Weightage in %
CO1	Process speech signals using machine learning algorithms to convert them to text and speech.	10
CO2	Classify the text and speech signals using representations of these signals such as lexical, syntactic, semantic and discourse.	15
CO3	Identify the spoken word using digit dataset applied as input to supervised or unsupervised neural network architectures	15
CO4	Map the speech data in various forms using convolutional neural networks.	10
CO5	Extract past and future dependencies at a given point of the speech to enable more number of command recognitions using RNN, Attention Mechanism and Memory Augmented Networks.	20
CO6	Select the appropriate acoustic features to train and validate Automatic Speech Recognition systems.	15
CO7	Design an end to end speech recognition system based on connectionists temporal classification techniques.	15

*** Weightage depends on Bloom's Level, number of contact hours

CO Mapping with CDIO Curriculum Framework

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS2	Understand	Respond	Guided Response	1.3, 2.1.1, 2.1.2
CO2	TPS3	Apply	Value	Mechanism	1.3, 2.1.1, 2.1.2, 2.1.3, 2.5.1
CO3	TPS3	Apply	Value	Mechanism	1.3, 2.1.1, 2.1.2, 2.4.2, 2.4.6, 2.5.1, 3.1.1, 3.2.3,
CO4	TPS3	Apply	Value	Mechanism	1.3, 2.1.1, 2.1.2, 2.4.2, 2.4.6, 2.5.1, 3.1.1, 3.2.3,
CO5	TPS3	Apply	Value	Mechanism	1.3, 2.1.1, 2.1.2, 2.4.2, 2.4.6, 2.5.1, 3.1.1, 3.2.3,
CO6	TPS4	Analyse	Organise	Complex Overt Responses	1.3, 2.1.1, 2.1.2, 2.1.3, 2.1.4, 2.4.2, 2.4.6, 2.5.1, 3.1.1, 3.2.3, 4.5.5
CO7	TPS3	Apply	Value	Mechanism	1.3, 2.1.1, 2.1.2, 2.4.2, 2.4.6, 2.5.1, 3.1.1, 3.2.3, 4.5.5

Mapping with Programme Outcomes and Programme Specific Outcomes

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	M	L	-	-	S	-	-	-	L	-	-	-	L	-	-
CO2	S	M	L	-	-	-	-	-	-	-	-	-	M	-	-
CO3	S	M	L	-	S	-	-	-	L	-	-	-	M	-	-
CO4	S	M	L	-	S	-	-	-	L	-	-	-	M	-	-
CO5	S	M	L	-	-	-	-	-	-	-	-	-	M	-	-
CO6	S	S	M	L	-	-	-	-	-	-	-	-	S	-	-
CO7	S	M	L	-	-	L	-	L	-	-	-	-	M	-	-

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

Cognitive Levels	Continuous Assessment Tests			Assignment			End Semester Examination
	1	2	3	1	2	3	
Remember	0	0	0	0	0	0	0
Understand	20	20	20	0	0	0	20
Apply	80	60	60	50	50	50	60
Analyse	0	20	20	0	0	0	20
Evaluate	0	0	0	0	0	0	0
Create	0	0	0	0	0	0	0

Assessment Pattern: Psychomotor

Psychomotor Skill	Assignment-1	Assignment-2	Assignment-3
Perception	-	-	-
Set	-	-	-
Guided Response	-	-	-
Mechanism	50	50	50
Complex Overt Responses	-	-	-
Adaptation	-	-	-
Origination	-	-	-

Sample Questions for Course Outcome Assessment

Course Outcome 1 (CO1):

1. What are Machine Learning Pipelines?
2. What is the class called which transforms a set of columns in a speech data frame to a single Dense Vector representation in ML?
3. How the class is called which transforms a string class label to a class index in ML?

Course Outcome 2 (CO2):

1. Take a word, for example, “machine.” Write it ten times. Also ask a friend to write it ten times. Analyzing these twenty images, try to find features, types of strokes, curvatures, loops, how you make the dots, and so on, that discriminate your handwriting from your friend’s.
2. Assume we are given the task to build a system that can distinguish junk email. What is in a junk e-mail that lets us know that it is junk? How can the computer detect junk through a syntactic analysis? What would you like the computer to do if it detects a junk e-mail—delete it automatically, move it to a different file, or just highlight it on the screen?
3. List the various speech representations given to ML.

Course Outcome 3 (CO3):

1. What are some linear methods for dimensionality reduction?
2. Why Support Vector Machines are also called "maximum margin classifier"?
3. How are Random Forest different in re-sampling from Gradient Boosted Trees?

Course Outcome 4 (CO4):

1. How to train Convolutional neural network to enhance the speech data?
2. How to deal with over fitting problem in speech signal analysis?
3. Can CNN and LSTM (Long Short Term Memory) use in speech emotion recognition? Justify.

Course Outcome 5 (CO5):

1. Draw the simple RNN based speech classifier for sentiment classification.
2. Is Recurrent Neural Network used in Google Speech recognition system? If So, Explain.
3. What do you mean by Residual Long Short Term Memory?

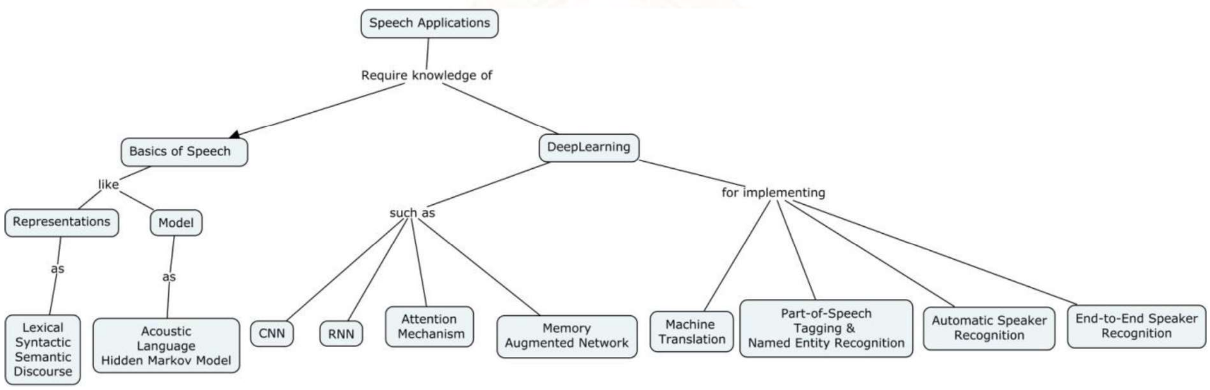
Course Outcome 6 (CO6):

1. Given the observable Markov model with three states s_1, s_2, s_3 , initial probabilities $\Pi = [0.5 \quad 0.2 \quad 0.3]^T$ and transition probabilities $A = \begin{bmatrix} 0.4 & 0.3 & 0.3 \\ 0.2 & 0.6 & 0.2 \\ 0.1 & 0.1 & 0.8 \end{bmatrix}$ Generate 3 sequences of 5 states.
2. Standard telephone audio has a sampling rate of 8 kHz and 16-bit precision. CD quality is 44.1 kHz, 16-bit precision, while contemporary speech processing focuses on 16 kHz or higher. What is the bit rate? How do you model raw high dimensional speech signal?
3. List the types of filters or filter banks applicable for Mel Frequency Cepstral Coefficients (MFCC) in Automatic Speech Recognition system?

Course Outcome 7 (CO7):

1. Explain the Neural attention model for Speech Command Recognition system.
2. Draw the statistical speech recognition system.
3. How do you fix the state alignment with feature observations in end to end speech recognition system?

Concept Map



Syllabus

Machine Learning Overview: Supervised learning, Unsupervised learning, Semi-supervised learning, Active learning, Transfer learning, Multitask learning, Reinforcement learning, **Text and Speech basics:** Morphological analysis, Lexical Representations, Syntactic Representations, Semantic Representations, Discourse Representations, Language Models, Text classification, Text clustering, Machine translation, Automated speech recognition, Natural language processing, Speech processing **Deep Learning algorithms:** Multilayer Perceptron, Model Training, Unsupervised Deep Learning, Framework Considerations **Convolutional Neural Networks:** Basic building blocks of CNN, Forward and Backward Propagation in CNN, Text inputs and CNN, Classic CNN Architectures, Applications of CNN in NLP, Fast algorithms for Convolutions **Recurrent Neural Networks:** Basic building blocks of RNN, Applications of RNN in NLP **Automatic Speech Recognition (ASR):** Acoustic Features, Acoustic Model, Language Model, HMM

Decoding, DNN/HMM Hybrid Model, Voice Technologies that use ASR **Deep Learning techniques for text and speech:** Attention Mechanism, Memory Augmented Networks **Transfer Learning:** Multitask learning, Zero shot, One shot and Few shot learning **End to End Speech Recognition:** Connectionist temporal classification, End to End decoding, Speech embeddings and unsupervised speech recognition

Learning Resources

- Uday Kamath, John Liu, James Whitaker, "Deep Learning for NLP and Speech Recognition", Springer, 2019.
- Max A Little, Machine Learning for Signal Processing: Data science, Algorithms and Computational Statistics,Oxford University Press, 2019.
- C.M.Bishop, "Pattern Recognition and Machine Learning", C.M. Bishop, 2nd Edition, Springer, 2011.
- I.Goodfellow, Y.Bengio, A.Courville, "Deep Learning", MIT Press, 2016.
- D.Yu,L. Deng, "Automatic Speech Recognition," Springer 2014.
- Ethem Alpaydın, "Introduction to Machine learning", The MIT Press Cambridge, Massachusetts,2010
- Michael Bowles, "Machine learning in Python: Essential techniques for predictive analysis," John Wiley and sons, 2015.

Course Contents and Lecture Schedule

No.	Topic	No. of Hours	COs
1	**Machine Learning Overview**		
1.1	Supervised learning, Unsupervised learning	1	CO1
1.2	Semi- supervised learning, Active learning	1	CO1
1.3	Transfer learning, Multitask learning	1	CO1
1.4	Reinforcement learning	1	CO1
2	**Text and Speech basics**		
2.1	Morphological analysis, Lexical Representations	1	CO2
2.2	Syntactic Representations, Semantic Representations	1	CO2
2.3	Discourse Representations, Language Models	1	CO2
2.4	Text classification, Text clustering	1	CO2
2.5	Machine translation, Automated speech recognition	1	CO2
2.6	Natural language processing, Speech processing	1	CO2
3	**Deep Learning algorithms**		
3.1	Multilayer Perceptron	2	CO3
3.2	Model Training	2	CO3
3.3	Unsupervised Deep Learning, Framework Considerations	2	CO3
4	**Convolutional Neural Networks**		
4.1	Basic building blocks of CNN, Forward and Backward Propagation in CNN	2	CO4
4.2	Text inputs and CNN, Classic CNN Architectures	2	CO4
4.3	Applications of CNN in NLP,	2	CO4
4.4	Fast algorithms for Convolutions	1	CO4
5	**Recurrent Neural Networks**		
5.1	Basic building blocks of RNN	1	CO5
5.2	Applications of RNN in NLP	1	CO5
6	**Automatic Speech Recognition (ASR)**		
6.1	Acoustic Features, Acoustic Model,	1	CO6
6.2	Language Model, HMM Decoding	1	CO6
6.3	DNN/HMM Hybrid Model	1	CO6
6.4	Voice Technologies that use ASR	1	CO6
7	**Deep Learning techniques for text and speech**		
7.1	Attention Mechanism, Memory Augmented Networks	1	CO6

8	**Transfer Learning**		
8.1	Multitask learning, Zero shot	1	CO6
8.2	One shot and Few shot learning	1	CO6
9	**End to End Speech Recognition**		
9.1	Connectionist temporal classification	1	CO7
9.2	End to End decoding	2	CO7
9.3	Speech embeddings and unsupervised speech recognition	1	CO7
Total		36	

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18ECPU0	VLSI DEVICE MODELING	Category	L	T	P	Credit
		PE	3	0	0	3

Preamble

The present and future generation VLSI systems are all expected using MOSFETs. Over the years, the VLSI industry has systematically adapted to the use of only MOSFETs for all purposes. This course introduces the principles of device modeling, in which device physics and experimentally observed device performances characteristics are combined to lead predictable equations and expressions for device performance under scenarios of excitation.

Prerequisite

18EC430 CMOS VLSI Systems

Course Outcomes

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

CO#	Course Outcome Statement	Weightage in %
CO1	Describe about the different modeling of MOS transistor.	15
CO2	Examine C-V and I-V characteristics of MOSFET.	20
CO3	Solve CMOS scaling issues and Short channel MOSFETs.	15
CO4	Apply technological remedies for short channel effects.	15
CO5	Build the different types of Non-Classical Transistors	20
CO6	Interpret TCAD design flow and classical models	15

CO Mapping with CDIO Curriculum Framework

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS2	Understand	Respond	-	1.3, 2.1.1, 2.1.2, 2.4.1, 2.4.2, 2.4.5, 3.2.3, 3.2.5
CO2	TPS4	Analyse	Organise	Complex Overt Responses	1.3, 2.1.1, 2.1.2, 2.1.3, 2.5.1, 3.1.1, 3.2.3
CO3	TPS3	Apply	Value	Mechanism	1.3, 2.1.1, 2.1.2, 2.5.1, 3.1.1, 3.2.3
CO4	TPS3	Apply	Value	Mechanism	1.3, 2.1.1, 2.1.2, 2.5.1, 3.1.1, 3.2.3
CO5	TPS3	Apply	Value	Mechanism	1.3, 2.1.1, 2.1.2, 2.5.1, 3.1.1, 3.2.3
CO6	TPS2	Understand	Respond	Guided response	1.3, 2.1.1, 2.1.2, 2.4.1, 2.4.2, 2.4.5, 3.2.3, 3.2.5.

Mapping with Programme Outcomes and Programme Specific Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	M	L	-	-	-	-	-	L	L	L	-	-	L	-	L
CO2	S	S	M	L	-	-	-	L	L	L	-	-	S	-	L
CO3	S	M	L	-	-	-	-	L	L	L	-	-	M	-	L
CO4	S	M	L	-	-	-	-	L	L	L	-	-	M	-	L
CO5	S	M	L	-	-	-	-	L	L	L	-	-	M	-	L
CO6	M	L	-	-	L	-	-	-	L	L	-	-	L	-	L

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

Cognitive Levels	Continuous Assessment Tests			Assignment			End Semester Examination
	1	2	3	1	2	3	
Remember	0	0	0	0	0	0	0
Understand	20	20	20	0	0	0	20
Apply	30	80	80	100	100	60	60
Analyse	50	0	0	0	0	0	20
Evaluate	0	0	0	0	0	0	0
Create	0	0	0	0	0	0	0

Assessment Pattern: Psychomotor

Psychomotor Skill	Assignment-1	Assignment-2	Assignment-3
Perception	-	-	-
Set	-	-	-
Guided Response	-	-	-
Mechanism	-	-	40
Complex Overt Responses	-	-	-
Adaptation	-	-	-
Origination	-	-	-

Sample Questions for Course Outcome Assessment

Course Outcome 1 (CO1):

1. List out the requirements for MOSFET modeling for RF applications.
2. Explain in detail about the different modeling of MOS transistor.
3. Describe about simple charge control model with necessary equations.

Course Outcome 2 (CO2):

1. Investigate about Frequency dependent capacitance.
2. Analyse the effect of non-idealities on capacitance –voltage of MOSFET.
3. Deduce parameter extraction from MOSFET C-V characteristics.

Course Outcome 3 (CO3):

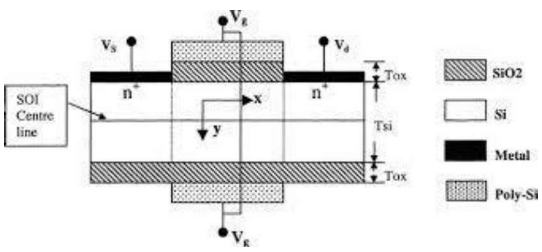
1. Illustrate the short channel effects of MOSFET.
2. Relate constant field scaling and constant voltage scaling.
3. Interpret about Channel length of MOSFET.

Course Outcome 4 (CO4):

1. Construct techniques to reduce short channel effects of MOS Devices.
2. Examine Strain engineering and Halo implants.
3. Interpret Quantum effects in MOSFETs.

Course Outcome 5 (CO5):

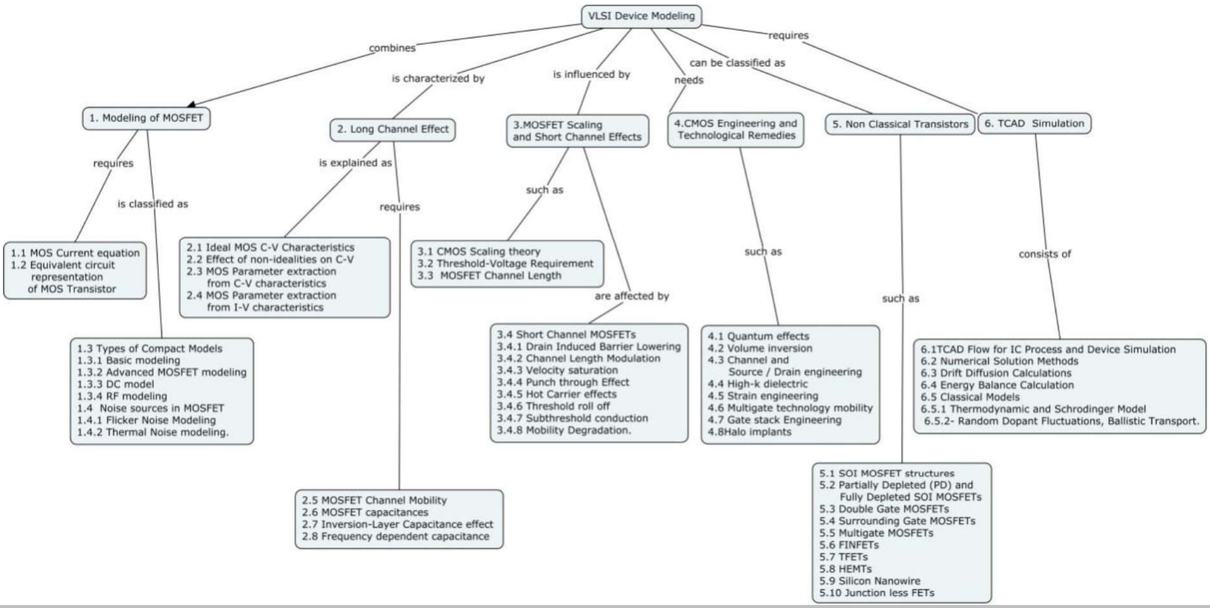
1. Illustrate the operation of Multigate MOSFETs.
2. Calculate the electro static potential of given structure with the suitable boundary conditions.



3. Explain the electrostatics DG- MOS system with the suitable equations.
   a. Gate Voltage effect.
   b. Semiconductor thickness effect.
   c. Asymmetry effect.
   d. Oxide thickness effect.
   e. Electron tunnel current.

Course Outcome 6 (CO6):
1. Differentiate the various numerical solution methods in TCAD.
2. Describe in detail about Classical TCAD Models.
3. List the steps involved in the TCAD flow for IC design and Device simulation.

Concept Map



Syllabus

Modeling of MOSFET: MOS Current Equation, Equivalent circuit representation of MOS Transistor, Types of Compact Models: Basic modeling, Advanced MOSFET modeling, DC model, RF modeling - Noise sources in MOSFET: Flicker and Thermal Noise modeling. **Long Channel Effects:** Ideal MOS C-V Characteristics, Effect of non-idealities on C-V, MOS Parameter extraction from C-V characteristics and I-V characteristics - MOSFET Channel Mobility – MOSFET capacitances, Inversion-Layer Capacitance effect and Frequency-dependent capacitance. **MOSFET Scaling and Short Channel Effects:** CMOS Scaling theory - Threshold-Voltage Requirement – MOSFET Channel Length - Short Channel MOSFETs: Drain Induced Barrier Lowering, Channel Length Modulation, Velocity saturation, Punch through Effect, Hot Carrier effects, threshold roll-off, Sub-threshold conduction, Mobility Degradation. **CMOS Engineering and Technological Remedies:** Quantum effects, Volume inversion, Channel and Source / Drain engineering, High-k dielectric, Strain engineering, Multigate technology mobility, Gate stack Engineering, Halo implants.**Non – Classical Transistors:** SOI MOSFET structures, Partially Depleted (PD) and Fully Depleted SOI MOSFETs – Double Gate, Surrounding Gate, Multigate MOSFETs – FINFETs - TFETs – HEMTs – Silicon Nanowires – Junctionless FETs. **TCAD Simulation**: TCAD Flow for IC Process and Device Simulation, Numerical Solution Methods, Drift Diffusion Calculations, Energy Balance Calculation, Classical Models - Thermodynamic and Schrodinger Model - Random Dopant Fluctuations, Ballistic Transport.

Learning Resources

- Y.Tsividis & Colin McAndrew, "The MOS Transistor", 3rd Edition, Oxford University Press, 2013.
- Y. Taur and T. H. Ning, "Fundamentals of Modern VLSI Devices", Cambridge University Press, Cambridge, United Kingdom, 2014.
- A.B.Bhattacharyya , " Compact MOSFET Models for VLSI Design", John Wiley & Sons Ltd, 2015
- Trond Ytterdal, Yuhua Cheng and Tor A. Fjeldly Wayne Wolf, "Device Modeling for Analog and RF CMOS Circuit Design", John Wiley & Sons Ltd, 2015
- Snowden C. M.," Introduction to Semiconductor Device Modeling", World Scientific Press, Singapore, 1986

- J.P.Colinge "FinFETs and other Multigate Transistors", Springer, Germany, 2010.
- Prof.S.Karmalkar, IIT Madras, Semiconductor Device Modeling, NPTEL video Lectures:https://nptel.ac.in/courses/117/106/117106033/
- Prof.K.N.Bhat, Dr.S.A.Shivashankar, Dr.Navakanta Bhat, IISC, Bangalore, Nano Electronics: Devices & Materials, NPTEL video Lectures:https://nptel.ac.in/courses/117/108/117108047/

Course Contents and Lecture Schedule

No.	Topic	No. of Hours	COs
1	**Modeling Of MOSFET**		
1.1	MOS Current Equation, Equivalent circuit representation of MOS Transistor	1	CO1
1.2	Types of Compact Models		
1.2.1	Basic modeling	1	CO1
1.2.2	Advanced MOSFET modeling	1	CO1
1.2.3	DC model	1	CO1
1.2.4	RF modeling	1	CO1
1.3	Noise sources in MOSFET		
1.3.1	Flicker Noise modelling, Thermal Noise modeling	1	CO1
2	**Long Channel Effects**		
2.1	Ideal MOS C-V Characteristics	1	CO2
2.2	Effect of non-idealities on C-V	1	CO2
2.3	MOS Parameter extraction from C-V characteristics	1	CO2
2.4	MOS Parameter extraction from I-V characteristics	1	CO2
2.5	MOSFET Channel Mobility	1	CO2
2.6	MOSFET capacitances, Inversion-Layer Capacitance effect, Frequency dependent capacitance	1	CO2
3	**MOSFET Scaling and Short Channel Effects:**		
3.1	CMOS Scaling theory	1	CO3
3.2	Threshold-Voltage Requirement	1	CO3
3.3	MOSFET Channel Length	1	CO3
3.4	Short Channel MOSFETs		
3.4.1	Drain Induced Barrier Lowering, Channel Length Modulation	1	CO3
3.4.2	Velocity saturation , Punch through Effect, Hot Carrier effects	1	CO3
3.4.3	Threshold roll off, Subthreshold conduction, Mobility Degradation.	1	CO3
4	**CMOS Engineering and Technological Remedies:**		
4.1	Quantum effects	1	CO4
4.2	Volume inversion	1	CO4
4.3	Channel and Source / Drain engineering	1	CO4
4.4	High-k dielectric	1	CO4
4.5	Strain engineering, Multigate technology mobility	1	CO4
4.6	Gate stack Engineering, Halo implants	1	CO4
5.	**Non-Classical Transistors:**		
5.1	SOI MOSFET structure, Partially Depleted (PD) and Fully Depleted SOI MOSFETs	1	CO5
5.2	Double Gate MOSFETs, Surrounding Gate MOSFETs	1	CO5
5,3	Multigate MOSFETs, FINFETs	1	CO5
5.4	TFETs	1	CO5
5.5	HEMTs	1	CO5
5.6	Silicon Nanowires, Junction less FETs.	1	CO5
6	**TCAD Simulation**:		
6.1	TCAD Flow for IC Process and Device Simulation	1	CO6
6.2	Numerical Solution Methods,	1	CO6

6.3	Drift Diffusion Calculations	1	CO6
6.4	Energy Balance Calculation	1	CO6
6.5	Classical Models		
6.5.1	Thermodynamic and Schrodinger Model	1	CO6
6.5.2	Random Dopant Fluctuations and Ballistic Transport	1	CO6

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18ECPV0	LOW POWER CMOS VLSI SYSTEM

Category	L	T	P	Credit
PEES	3	0	0	3

Preamble

Increased levels of integration (increased functionality) and higher throughput under tight power budgets has led to the need for low power circuits and systems. Portable communication and computation have driven the need for low-power electronics. Recent progress has been made in creating tools for estimating power dissipation in CMOS circuits. The research approach is to use accurate and efficient power estimation techniques to drive the design of new low-power systems. Software tools for testing integrated circuits, rapid fault simulation, and failure analysis are also being developed. This course discusses design techniques, estimation and optimisation of power at various levels of design abstraction for designing energy-efficient digital systems.

Prerequisite

18EC430 CMOS VLSI Systems

Course Outcomes

On the successful completion of the course students will be able to

CO#	Course Outcome Statement	Weightage in %
CO1	Calculate the dynamic and static power dissipation for CMOS Digital logic Circuits.	15
CO2	Estimate the switching power in CMOS digital circuits using probabilistic and statistical techniques.	15
CO3	Estimate the leakage current for the low voltage CMOS digital circuits.	15
CO4	Modify, at the algorithm level for minimum power consumption.	15
CO5	Optimize the given Digital logic and arithmetic circuits for reduced power consumption.	15
CO6	Suggest circuit design techniques for the different elements of Memory to reduce power consumption.	15
CO7	Describe the techniques to consider while designing software for a low power system	10

CO Mapping with CDIO Curriculum Framework

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS3	Apply	Value	Mechanism	1.3, 2.1.1, 2.1.3, 2.4.2, 2.5.1, 3.1.1, 3.2.3
CO2	TPS3	Apply	Value	Mechanism	1.3, 2.1.1, 2.1.3, 2.4.6, 2.5.1, 3.1.1, 3.2.3
CO3	TPS3	Apply	Value	Mechanism	1.3, 2.1.1, 2.1.3, 2.4.6, 2.5.1, 3.1.1, 3.2.3
CO4	TPS4	Analyse	Organise	Complex Overt Response	1.3, 2.1.1, 2.1.3, 2.1.5, 2.4.6, 2.5.1, 2.5.4, 3.2.3
CO5	TPS4	Analyse	Organise	Complex Overt Response	1.3, 2.1.1, 2.1.3, 2.1.5, 2.4.6, 2.5.1, 2.5.4, 3.2.3
CO6	TPS4	Analyse	Organise	Complex Overt Response	1.3, 2.1.1, 2.1.3, 2.5.1
CO7	TPS2	Understand	Respond	Guided Response	1.3, 2.5.4, 3.2.6

Mapping with Programme Outcomes and Programme Specific Outcomes

Cos	PO1	PO2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2	PSO 3
CO1	S	M	L	-	-	-	-	L	L	L	-	L	M	-	L
CO2	S	M	L	L	-	-	-	L	L	L	-	L	M	-	L
CO3	S	M	L	L	-	-	-	L	L	L	-	L	M	-	L
CO4	S	S	M	L	-	-	-	L	L	L	-	L	S	-	L
CO5	S	S	M	L	-	-	-	L	L	L	-	L	S	-	L
CO6	S	S	M	L	-	-	-	L	L	L	-	L	S	-	L
CO7	M	L	-	-	-	-	-	-	-	-	-	-	L	-	-

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

Cognitive Levels	Continuous Assessment Tests			Assignment			End Semester Examination
	1	2	3	1	2	3	
Remember	20	0	0	0	0	0	0
Understand	20	20	20	0	0	0	20
Apply	60	40	40	100	100	0	50
Analyse	0	40	40	0	0	100	30
Evaluate	0	0	0	0	0	0	0
Create	0	0	0	0	0	0	0

Assessment Pattern: Psychomotor

Psychomotor Skill	Assignment 2	Assignment 3
Perception	-	-
Set	-	-
Guided Response	-	-
Mechanism	-	-
Complex Overt Responses	-	-
Adaptation	-	-
Origination	-	-

Sample Questions for Course Outcome Assessment

Course Outcome 1(CO1):

1. A 32 bit off-chip bus operating at 5V and 66 MHz clock rate is driving a capacitance of 25 pF/bit. Each bit is estimated to have a toggling probability of 0.25 at each clock cycle. What is the power dissipation in operating the bus?
2. The chip size of the CPU is 15mm*25mm with the clock frequency of 300MHZ operating at 3.3.The length of the clock signal estimated to be twice the circumference of the chip. Assume that the clock signal is routed on a metal layer with the width of 1.2um and parasitic capacitance of the metal layer is 1Ff/um^2.What is the power dissipation of the clock signal?
3. Silicon is doped with boron to a concentration of $N_A=4*10^{17}$ atoms/cm^3 and the semiconductor is used to form a junction with an aluminium metal with work function 4.1eV. Calculate the work function difference between the metal and semiconductor. Assume the intrinsic concentration carrier concentration of silicon is $1.5*10^{10}$ cm^{-3} at room temperature of T=300K.

Course Outcome 2(CO2):

1. Find the dynamic Power Dissipation of a circuit operating at 500 MHZ with a supply voltage of 0.9 V and a capacitance value per unit area 150 pf/mm^2.The chip size is 80mm^2.Assume the activity factor to be 0.1.
2. Find the area and power for the given function F1=ab+db+ce all inputs have equal probability = 0.5 The signal activities are D(a)=0.2; D(b)=0.3; D(c)=0.1; D(d)=2.5; D(e)=0.1;

3. Calculate the power for the given function F2= ac+cd+be, whose primary inputs have equal probability of 0.5. The signal activities are D(a)=0.2; D(b)=0.3; D(c)=0.1; D(d)=2.5; D(e)=0.1.

Course Outcome 3(CO3):

1. Draw a semiconductor MOSFET transistor showing the possible sources of leakage currents in it and also derive the expression for the CMOS leakage current.
2. Illustrate the process of overcoming the leakage current by explaining the operation of domino logic NAND gate.

Course Outcome 4 (CO4):

1. Use the pass-transistor logic circuits to construct the logic function *F*= $AB+\overline{B}C+\overline{A}\cdot\overline{B}$
2. Construct a logic function $F = AB + AC + \overline{A}D\overline{E} + BE$ using CPL and DPTL and LEAP. Use binary decision diagram (BDD) to design the above logic function.
3. Using and domino dynamic logic circuits, design a logic function $F = A \oplus B \oplus C$ in one stage and two cascading stages. Analyse and discuss the transient performance of the circuit for load capacitances of 0.01pF, 0. 1pF, and 0.5pF, and at supply voltages of 5V, 3.3V, 2.5V, and 1.5V.

Course Outcome 5 (CO5):

1. Use static CMOS logic circuits and complementary pass-transistor logic (CPL) to design the parallel adder. Which approach has the best speed performance (smallest propagation delay)? For the design with the best speed performance, is its throughput also the highest?
2. Compare the performance of the multipliers using Wallace tree reduction with 3-to-2 and 4-to-2 compressor, modified Booth encoder/decoder, and combining modified Booth encoder/decoder with Wallace tree reduction.

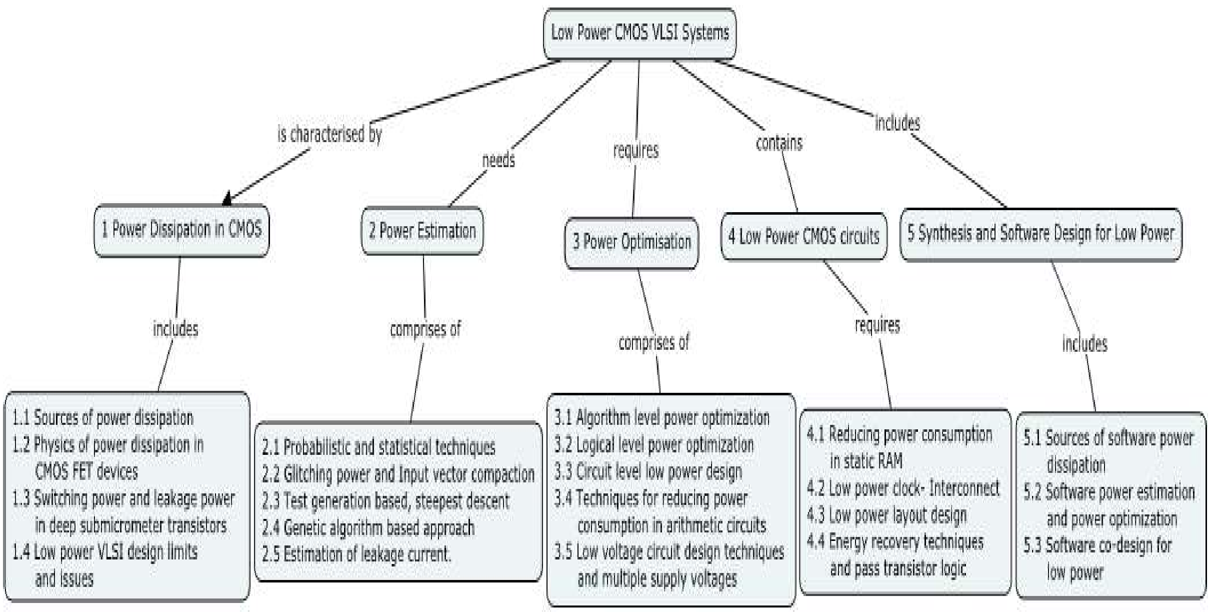
Course Outcome 6(CO6):

1. List the factors that affect the initial voltage difference in the DRAM bit lines during the read cycle of the memory circuit.
2. When the supply voltage is lowered, examine the influence of initial voltage difference in the bit lines during the read cycle?

Course Outcome 7(CO7):

1. Explain the average power dissipation associated with each instruction sequence of instruction set for ILPA.
2. Describe the instruction ordering and operand ordering techniques used for reducing the power dissipation associated with software synthesis.

Concept Map



Syllabus

Power Dissipation in CMOS: Sources of power dissipation, Physics of power dissipation in CMOS FET devices: switching power and leakage power in deep submicrometer transistors, low power VLSI design limits and issues.
Power Estimation: Average power estimation techniques at logic level: probabilistic, statistical, Glitching power, Input vector compaction, Circuit level power estimation, Estimation of maximum power: Test generation based, steepest descent and genetic algorithm based approach, Estimation of leakage current.
Power Optimization : Algorithm level, Logical level and Circuit level power Optimization techniques, Techniques for reducing power consumption in arithmetic circuits, Low voltage circuit design techniques and multiple supply voltages.
Low Power CMOS Circuits: Reducing power consumption in static RAM: Memory cell, Bit lines, write driver circuit and sense amplifier circuits, Low power clock- Interconnect and layout design, Special techniques: Energy recovery techniques and pass transistor logic.
Synthesis and Software Design for Low Power: Sources of software power dissipation. Software power estimation, software power optimization, Co-design for low power.

Learning Resources

- Kaushik Roy and Sharat Prasad, "Low Power CMOS VLSI Circuit Design", Wiley India, Reprint 2009.
- Gary Yeap, "Practical Low Power Digital VLSI Design", Kluwer, 1998.
- A.P. Chandrakasan and R.W. Broadersen, "Low Power Digital CMOS Design", Kluwer,1995.
- Abdellatif Bellaouar, Mohamed. I. Elmasry, "Low Power Digital VLSI designs" Kluwer, 1995.
- Dimitrios Soudris, Chirstian Pignet, Costas Goutis, "Designing CMOS Circuits for Low Power", Kluwer, 2002.
- J.B. Kuo and J.H Lou, "Low voltage CMOS VLSI Circuits", Wiley, 1999.
- Wang, B. H. Calhoun and A. P. Chandrakasan, "Sub-threshold Design for Ultra Low-Power Systems", Springer, 2006.

Course Contents and Lecture Schedule

Module No.	Topic	No. of Lectures	CO
1	**Power Dissipation in CMOS**		
1.1	Sources of power dissipation	1	CO1
1.2	Physics of power dissipation in CMOS FET devices	2	CO1
1.3	switching power and leakage power in deep submicrometer transistors	2	CO1
1.4	low power VLSI design limits and issues	1	CO1
2	**Power Estimation**		
2.1	Probabilistic and statistical techniques	2	CO2
2.2	Glitching power and Input vector compaction	2	CO2
2.3	Circuit level power estimation: Test generation based, steepest descent	2	CO2
2.4	genetic algorithm based approach	1	CO3
2.5	Estimation of leakage current.	1	CO3
3.	**Power Optimization**		
3.1	Algorithm level power optimization	1	CO4
3.2	Logical level power optimization	1	CO4
3.3	Circuit level low power design	1	CO4
3.4	Techniques for reducing power consumption in arithmetic circuits	2	CO5
3.5	Low voltage circuit design techniques and multiple supply	2	CO5

	voltages		
4	**Low Power CMOS Circuits**		
4.1	Reducing power consumption in static RAM	3	CO6
4.2	Low power clock- Interconnect	2	CO6
4.3	Low power layout design	2	CO6
4.4	Energy recovery techniques and pass transistor logic	2	CO6
5	**Synthesis and Software Design for Low Power**		
5.1	Sources of software power dissipation	2	CO7
5.2	Software power estimation and software power optimization	2	CO7
5.3	Software co-design for low power	2	CO7
	Total Number of Hours	**36**	

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18ECPW0	CAD FOR VLSI

Category	L	T	P	Credit
PEES	3	0	0	3

Preamble

The semiconductor industry has advanced tremendously over the last ten years with features sizes being downscaled from micrometer to nanometer regime today. Hence, Computer Aided Design (CAD) tools play an important role in delivering high system performance. This course introduces the techniques of modelling digital systems at various abstraction levels and exploring the various algorithms in VLSI physical design, which serve as a basis for the research and development of new Computer Aided Design (CAD) tools.

Prerequisite

18EC430 CMOS VLSI Systems

Course Outcomes

On the successful completion of the course students will be able to

CO#	Course Outcome Statement	Weightage in %
CO1	Use the knowledge of computational and optimization algorithms and tools applicable to solving CAD related problems	10
CO2	Represent mechanism for Boolean functions that has application in logic synthesis and Verification	15
CO3	Partition or divide the system into smaller portions based on the performance such as area, wirelength and cost matrices.	15
CO4	Determine the approximate location of each module in a chip area.	20
CO5	Use Optimization algorithms in placement to determine the best position for each module on the chip.	20
CO6	Analyse the Optimizations algorithms in VLSI Global and Detailed Routing process based on their wirelength and area constraints.	20

CO Mapping with CDIO Curriculum Framework

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS3	Apply	Value	Mechanism	1.3, 2.1.1, 2.1.2,2.4.2,2.4.3, 2.4.6, 2.5.1,2.5.4,3.1.1
CO2	TPS3	Apply	Value	Mechanism	1.3, 2.1.1, 2.1.2, 2.4.2,2.4.3, 2.4.6, 2.5.1
CO3	TPS3	Apply	Value	Mechanism	1.3, 2.1.1, 2.1.2, 2.4.2,2.4.3, 2.4.6, 2.5.1,2.5.4 ,3.1.1,3.1.5
CO4	TPS3	Apply	Value	Mechanism	1.3, 2.1.1, 2.1.2, 2.4.2,2.4.3, 2.4.6, 2.5.1,2.5.4,3.1.1,3.1.5
CO5	TPS3	Apply	Value	Mechanism	1.3, 2.1.1, 2.1.2, 2.4.2,2.4.3, 2.4.6, 2.5.1,2.5.4,3.1.1, 3.1.5
CO6	TPS4	Analyse	Organise	Complex Overt Responses	1.3, 2.1.1, 2.1.2, 2.4.2,2.4.3, 2.4.6, 2.5.1,2.5.4, ,3.1.1,3.1.5

Mapping with Programme Outcomes and Programme Specific Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	S	M	L	-	M	-	-	L	L	L	-	L	M	-	L
CO2	S	M	L	-	M	-	-	L	L	L	-	L	M	-	L
CO3	S	M	L	-	M	-	-	L	L	L	-	L	M	-	L
CO4	S	M	L	-	M	-	-	L	L	L	-	L	M	-	L
CO5	S	M	L	-	M	-	-	L	L	L	-	L	M	-	L
CO6	S	S	M	L	M	-	-	L	L	L	-	L	S	-	L

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

Cognitive Levels	Continuous Assessment Tests			Assignment			End Semester Examination
	1	2	3	1	2	3	
Remember	0	0	0	0	0	0	0
Understand	20	20	20	0	0	0	20
Apply	80	80	60	70	30	30	60
Analyse	0	0	20	0	40	40	20
Evaluate	0	0	0	0	0	0	0
Create	0	0	0	0	0	0	0

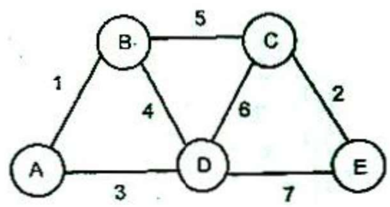
Assessment Pattern: Psychomotor

Psychomotor Skill	Assignment-1	Assignment-2	Assignment-3
Perception	-	-	-
Set	-	-	-
Guided Response	-	-	-
Mechanism	30	30	20
Complex Overt Responses	-	-	10
Adaptation	-	-	-
Origination	-	-	-

Sample Questions for Course Outcome Assessment

Course Outcome 1 (CO1):

1. Differentiate DFS and BFS search methods.
2. Find the shortest path between "A" and "E" in the graph shown in Figure using Dijkstra's algorithm and also find the minimum spanning tree for the same graph using Prim's algorithm



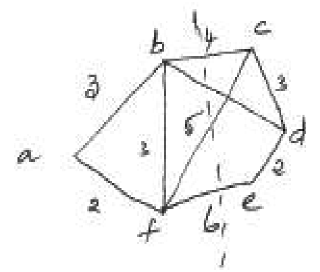
3. Discuss on the VLSI Design methodologies used for IC layout design.
4. Explain the Gajski's Y-chart.

Course Outcome 2 (CO2):

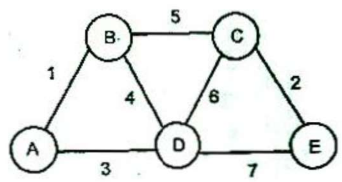
1. For the Boolean function f (x_1,x_2, x_3) = (0,1,2,5,6,7).Find its locally and globally minimal irredundant prime cover.
2. With suitable example, explain how ROBDD can be used in different applications.
3. Draw the ROBDD for the given function f = ab(c + d)

Course Outcome 3 (CO3):

1. Explain how Kernighan-Lin algorithm is used for partitioning and using the algorithm, find the minimum cut for the graph shown in Figure.



2. Find the shortest path between “A” and “E” in the graph shown in Figure using Dijkstra’s algorithm and also find the minimum spanning tree for the same graph using Prim’s algorithm



3. Design a cost function for the general building block placement problem which considers the wire length, estimated area, module overlap, and aspect ratio of the entire layout.

Course Outcome 4 (CO4):

1. Prove that there is a one to one correspondence between a sliceable floorplan and a normalized Polish expression.
2. Given a Polish expression corresponding to a given a slicing floorplan, show that the expression 12-3-.....-n- can be reached and vice versa.
3. Find an optimal implementation of modules M_1,.........M_8 for sizing of the following sliceable floorplans.

   Floor 1: 1 2 V 3 4 V H 5 6 V 7 8 V H V

   Floor 2: 1 2 V 3 4 V 5 H 6 V 7 H 8 V H

Course Outcome 5 (CO5):

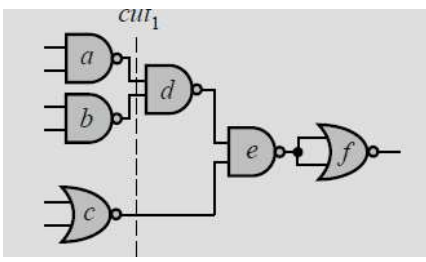
1. Given: (1) placement P of blocks a-f and their pins (right) and (2) nets N1-N3 and their net weights.Estimate the total weighted wirelength of P using theRMST model.

   N1 = (a1,b1,d2) w(N1) = 2

   N2 = (c1,d1,f1) w(N2) = 4

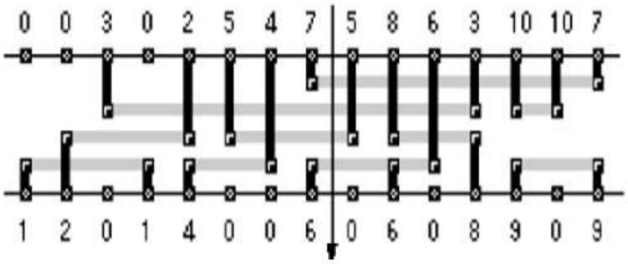
   N3 = (e1,f2) w(N3) = 1

2. Given: (1) circuit with gates a-f (left), (2) 2 × 4 layout (right), and (3) initial vertical cut cut1. Find a placement with minimum wirelength using alternating cutline directions and theKL algorithm.

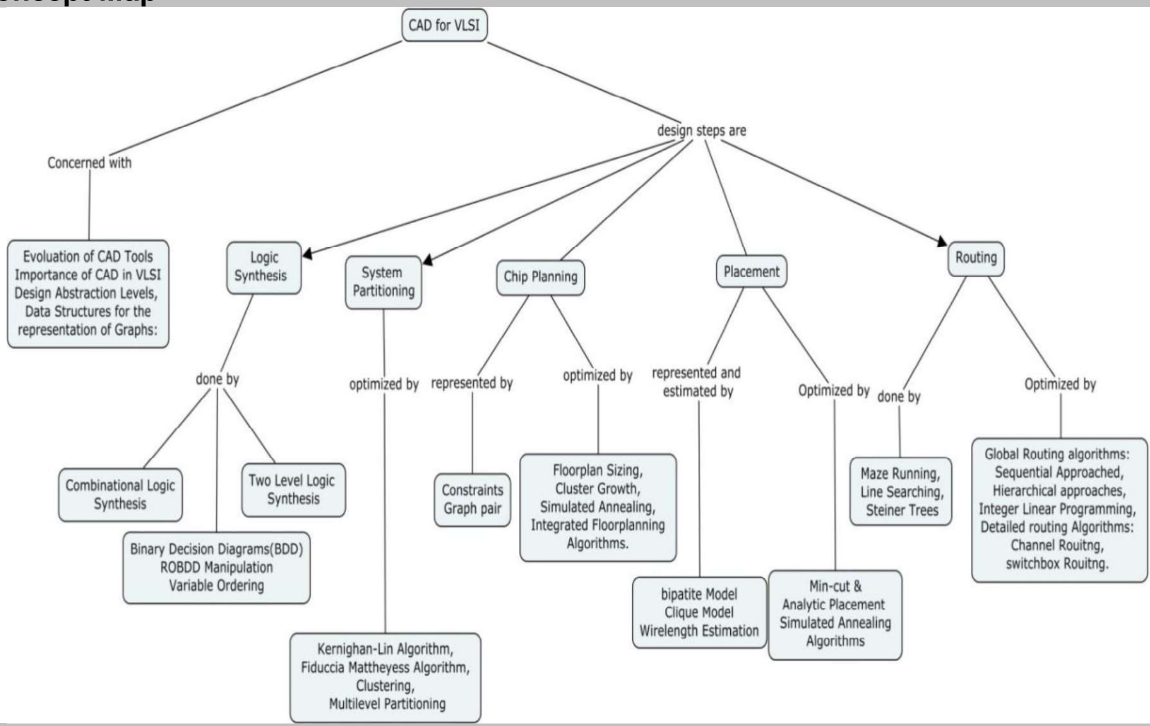


Course Outcome 6 (CO6):

1. Show that left edge algorithm produces a solution, with a number of rows exactly equal to the density of the problem.
2. Draw the horizontal and vertical constraint graphs for the channel shown in below figure. Explain how to handle the net that exist the channel and its pseudo terminal.



Concept Map



Syllabus

VLSI Design Automation Tools: Evolution of CAD Tools, Importance of Design Automation, Design Abstraction Levels, Data Structures for the representation of Graphs: Representation of graphs using matrices; Paths, connectedness; circuits, cut sets, trees; Voltage and current spaces of a directed graph and their complementary orthogonally; Elementary graph algorithms involving BFS and DFS trees, such as finding connected and 2-connected components of a graph, the minimum spanning tree, shortest path between a pair of vertices in a graph. **Logic Synthesis:** Combinational Logic Synthesis, Binary Decision Diagrams, Reduced Ordered BDD principles, ROBDD Manipulation, Variable Ordering, Two Level Logic Synthesis. **System Partitioning:** Terminology, Optimization Goals, Partitioning Algorithms: Kernighan-Lin Algorithm, Extension of Kernighan–Lin Algorithm, Fiduccia Mattheyess Algorithm, Clustering, Multilevel Partitioning, System Partitioning onto Multiple FPGAs. **Chip Planning**: Terminology, Optimization Goals in Floorplanning, Floorplan Representations: Floorplan to a Constraint-Graph Pair, Floorplanning Algorithms: Floorplan Sizing, Cluster Growth, Simulated Annealing, Integrated Floorplanning Algorithms. **Placement:** Circuit Representation: bipartite Model, Clique Model, Wire length Estimation; Global Placement Algorithms: Min-cut Placement, Analytic Placement, and Simulated Annealing Algorithms. **Routing:** Maze Running, Line Searching, Steiner Trees; Global Routing: Sequential Approached, Hierarchical approaches, Integer Linear Programming, Detailed routing: Channel routing, switchbox routing. Routing in Field Programmable Gate Arrays: Array Based FPGAs and Row Based FPGAs.

Learning Resources

- S.H. Gerez, Algorithms for VLSI Design Automation, Wiley-India, Reprint 2008

- N.A. Sherwani, Algorithms for VLSI Physical Design Automation, Kluwer Academic Publisher,1998
- Andrew B.Khang,Lienig, Markov and Hu, ” VLSI Physical Design: From Graph Partitioning to Timing Closure “, Springer, 2011
- Giovanni De Micheli, Synthesis and Optimization of Digital Circuits, Tata McGrawHill, 1994
- D.D Gajski et al., High Level Synthesis: Introduction to Chip and System Design, Kluwer Academic Publishers, 1992
- M. Sarrafzadeh and C.K. Wong, An Introduction to VLSI Physical Design, McGraw Hill, 1996.
- Weblink: https://www.coursera.org/learn/vlsi-cad-logic
- Weblink: https://nptel.ac.in/courses/106/106/106106088/

Course Contents and Lecture Schedule

No.	Topic	No. of Hours	COs
1	**VLSI Design Automation Tools**		
1.1	Evolution of CAD Tools, Importance of Design Automation	1	CO1
1.2	Design Abstraction Levels	1	CO1
1.3	Representation of graphs using matrices; Paths, connectedness; circuits, cut sets, trees	1	CO1
1.4	Voltage and current spaces of a directed graph and their complementary orthogonally	1	CO1
1.5	Elementary graph algorithms involving BFS and DFS trees, such as finding connected and 2-connected components of a graph	1	CO1
1.6	The minimum spanning tree, shortest path between a pair of vertices in a graph	1	CO1
2	**Logic Synthesis**		
2.1	Combinational Logic Synthesis	1	CO2
2.2	Binary Decision Diagrams	1	CO2
2.3	Reduced Ordered BDD principles	1	CO2
2.4	ROBDD Manipulation, Variable Ordering	1	CO2
2.5	Two Level Logic Synthesis	1	CO2
	Assignment I: Implement the graph algorithms in VLSI Design Problems using C/C++/python with Data structure concept.		CO1, CO2
3	**System Partitioning**		
3.1	Terminology, Optimization Goals	1	CO3
3.2	Partitioning Algorithms: Kernighan-Lin Algorithm	1	CO3
3.3	Extension of Kernighan–Lin Algorithm	1	CO3
3.4	Fiduccia Mattheyess Algorithm	1	CO3
3.5	Clustering, Multilevel Partitioning	1	CO3
3.6	System Partitioning onto Multiple FPGAs.		
4	**Chip Planning**		
4.1	Terminology, Optimization Goals in Floorplanning	1	CO4
4.2	Floorplan Representations: Floorplan to a Constraint-Graph Pair,	1	CO4
4.3	Floorplanning Algorithms: Floorplan Sizing	1	CO4
4.4	Cluster Growth	1	CO4
4.5	Simulated Annealing	1	CO4
4.6	Integrated Floorplanning Algorithms	1	CO4
	Assignment II: Implement the Partitioning/Floorplanning Optimization Algorithm using C/C++/python with Data structure concept.		CO3, CO4
5.	**Placement Algorithms**		
5.1	Circuit Representation: bipartite Model, Clique Model	1	CO5

5.2	Wire length Estimation	1	CO5
5.3	Global Placement: Min-cut Placement	1	CO5
5.4	Analytic Placement	1	CO5
5.5	Simulated Annealing Algorithms	1	CO5
6	**Routing Algorithms**		
6.1	Maze Running, Line Searching	1	CO6
6.2	Steiner Trees	1	CO6
6.3	Global Routing: Sequential Approached	1	CO6
6.4	Hierarchical approaches, Integer Linear Programming	1	CO6
6.5	Detailed routing: Channel Routing, switchbox Rouitng	2	CO6
6.6	Routing in Field Programmable Gate Arrays: Array Based FPGAs and Row Based FPGAs.	2	CO6
	Assignment III: Compare the performance of various placement and routing algorithms in VLSI Circuits using EDA Tools		CO5, CO6

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18ECPY0	ASIC DESIGN

Category	L	T	P	Credit
PE	3	0	0	3

Preamble

The course aims at ASIC physical design flow, including partitioning, floor-planning, placement, routing and testing. Also the objective is to give the student an understanding of basics of System on Chip.

Prerequisite

Nil

Course Outcomes

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

CO#	Course Outcome Statement	Weightage in %
CO1	Describe the ASIC Design flow, ASIC types and Library design	15
CO2	Use algorithms to partition the ASIC to meet the given objectives	15
CO3	Use floorplanning and placement algorithms to place the logic cells inside the flexible blocks of an ASIC	20
CO4	Use global and detailed routing algorithms to route the channels in ASIC and apply techniques for circuit extraction	20
CO5	Use techniques to test ASIC	15
CO6	Explain System on Chip, On chip communication architectures and utilizing Platform based design.	15

CO Mapping with CDIO Curriculum Framework

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS2	Understand	Respond	-	1.3, 2.1.2, 2.4.1, 2.4.2
CO2	TPS3	Apply	Value	-	1.3, 2.1.1, 2.1.2, 2.4.1, 2.4.2, 3.2.5
CO3	TPS3	Apply	Value	-	1.3, 2.1.1, 2.1.2, 2.4.1, 2.4.2, 3.2.5
CO4	TPS3	Apply	Value	-	1.3, 2.1.1, 2.1.2, 2.4.1, 2.4.2, 3.2.5
CO5	TPS3	Apply	Value	-	1.3, 2.1.1, 2.1.2, 2.4.1, 2.4.2, 3.2.5
CO6	TPS2	Understand	Respond	-	1.3, 2.1.1, 2.1.2, 2.4.1, 2.4.2

Mapping with Programme Outcomes and Programme Specific Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	M	L	-	-	-	-	-	L	L	L	-	L	L	-	L
CO2	S	M	L	-	-	-	-	L	L	L	-	L	M	-	L
CO3	S	M	L	-	-	-	-	L	L	L	-	L	M	-	L
CO4	S	M	L	-	-	-	-	L	L	L	-	L	M	-	L
CO5	S	M	L	-	-	-	-	L	L	L	-	L	M	-	L
CO6	M	L	-	-	-	-	-	L	L	L	-	L	L	-	L

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

Cognitive Levels	Continuous Assessment Tests			Assignment			End Semester Examination
	1	2	3	1	2	3	
Remember	10	0	0	0	0	0	0
Understand	40	20	40	50	0	50	30
Apply	50	80	60	50	100	50	70
Analyse	0	0	0	0	0	0	0
Evaluate	0	0	0	0	0	0	0
Create	0	0	0	0	0	0	0

Assessment Pattern: Psychomotor

Psychomotor Skill	Assignment-1	Assignment-2	Assignment-3
Perception	-	-	-
Set	-	-	-
Guided Response	-	-	-
Mechanism	-	-	-
Complex Overt Responses	-	-	-
Adaptation	-	-	-
Origination	-	-	-

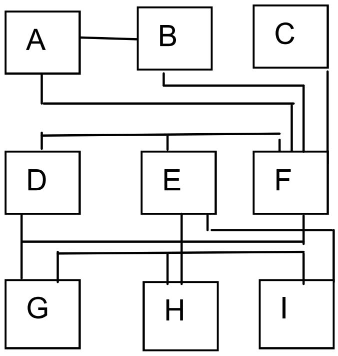
Sample Questions for Course Outcome Assessment

Course Outcome 1 (CO1):

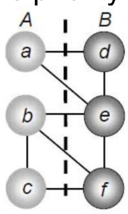
1. Draw the flowchart for ASIC design flow.
2. Explain the different types of ASICs
3. Discuss about the significance of ASIC libraries.

Course Outcome 2 (CO2):

1. Explain about the steps in the iterative partitioning improvement algorithm.
2. Apply constructive partitioning algorithm to partition the given network to meet the following objectives.
   - Use no more than three ASICs
   - Each ASIC is to contain no more than three logic cells.
   - Use minimum number of external connections for each ASIC

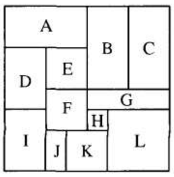


3. Use Kernighan-Lin algorithm to optimally partition the graph shown in figure below. The dotted line represents the initial partitioning. Assume all nodes have the same weight and all edges have the same priority.



Course Outcome 3 (CO3)

1. Discuss about the goals and objectives of floorplanning.
2. Explain the steps involved in Mincut placement algorithm.
3. Represent the floorplan shown in the figure below as its
   a) Floorplan tree.
   b) Polar horizontal graph
   c) Polar vertical graph



Course Outcome 4 (CO4)

1. With neat diagrams, explain about ‘a cycle’ in vertical constraint graph for channel routing.
2. Three block a, b and c are given below along with their size options. Determine the shape function for each block a, b, c and construct the minimum area top level floorplan.

$$a: w_a = 5, h_a = 4\ ,\ b: w_b = 3, h_b = 1\ or\ w_b = 1, h_b = 3,$$
$$c: w_c = 2, h_c = 1\ or\ w_c = 1, h_c = 2$$

3. Use Dogleg Left-Edge Algorithm to route a channel with the following pin connections (ordered left to right).

$$TOP = [A\ B\ 0\ B\ A\ D\ C\ E]\ ,\ BOT = [B\ 0\ C\ A\ C\ E\ D\ D]$$

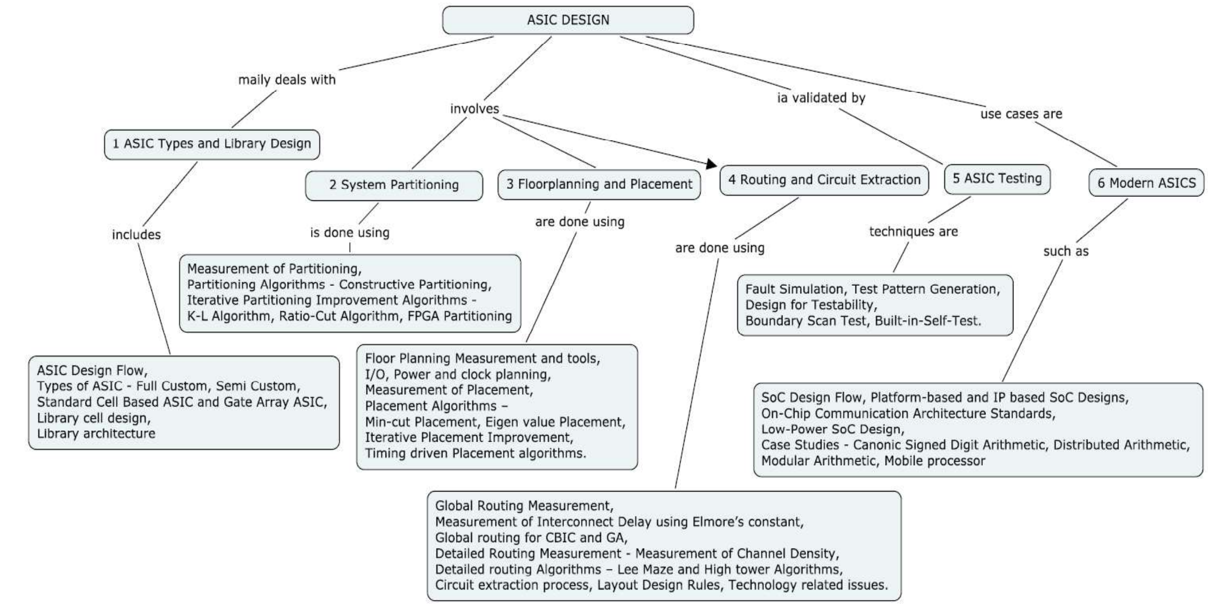
Course Outcome 5 (CO5)

1. Discuss about Design for Testability.
2. With neat diagram, explain about Boundary Scan Test.
3. Use Automatic Test Pattern Generation (ATPG) technique to test a typical circuit.

Course Outcome 5 (CO5)

1. Draw the flowchart of a typical SoC design flow.
2. Discuss about the parameters that has to be considered for Low-Power SoC design.
3. Explain about the features of a typical Mobile processor.

Concept Map



Syllabus

ASIC Types and Library Design: ASIC Design Flow, Types of ASIC - Full Custom, Semi Custom – Standard Cell Based ASIC and Gate Array ASIC - Library cell design - Library architecture. **System Partitioning**: Measurement of Partitioning, Partitioning Algorithms - Constructive Partitioning, Iterative Partitioning Improvement Algorithms - Kernighan-Lin Algorithm, Ratio-Cut Algorithm, FPGA Partitioning. **Floorplanning and Placement:** Floor Planning Measurement and tools, I/O, Power and clock planning, Measurement of Placement, Placement Algorithms – Min-cut Placement, Eigen value Placement, Iterative Placement Improvement, Timing Driven Placement algorithms. **Routing and Circuit Extraction:** Global Routing Measurement – Measurement of Interconnect Delay using Elmore's constant, Global routing for CBIC and GA, Detailed Routing Measurement - Measurement of Channel Density, Detailed routing Algorithms – Lee Maze and High tower Algorithms, Circuit extraction process, Layout Design Rules, Technology related issues. **ASIC TESTING:** Fault Simulation, Test Pattern Generation, Design for Testability, Boundary Scan Test, Built-in-Self-Test. **Modern ASICs**: SoC Design Flow, Platform-based and IP based SoC Designs, On-Chip Communication Architecture Standards, Low-Power SoC Design, Case Studies - Canonic Signed Digit Arithmetic, Distributed Arithmetic, Modular Arithmetic, Mobile processor.

Learning Resources

- Michael John Sebastian Smith, "Applications Specific Integrated Circuits", Pearson Education, 2013.
- H.Gerez, "Algorithms for VLSI Design Automation", John Wiley, 1999.
- Andrew B.Khang, Lienig, Markov and Hu, " VLSI Physical Design: From Graph Partitioning to Timing Closure ", Springer, 2011.
- J..M.Rabaey, A. Chandrakasan, and B.Nikolic, "Digital Integrated Circuit Design Perspective (2/e)", PHI 2003.
- Hoi-Jun Yoo, Kangmin Leeand Jun Kyong Kim, "Low-Power NoC for High-Performance SoC Design", CRC Press, 2008.
- S.Pasricha and N.Dutt," On-Chip Communication Architectures System on Chip Interconnect, Elsveir", 2008.
- Wayne Wolf, "Modern VLSI design" - Addison Wesley, 1998.
- Prof. Santosh Biswas, IIT Guwahati, NPTEL Video Lecture on "Optimization Techniques for Digital VLSI Design", weblink:
- https://nptel.ac.in/courses/108/103/108103108/www.asic-design.com.
- Prof. Santosh Biswas, IIT Guwahati, NPTEL Video Lecture on "Design Verification and Test of Digital VLSI Circuits", weblink: https://nptel.ac.in/courses/106/103/106103116/
- Website: www.asic-world.com

Course Contents and Lecture Schedule

No.	Topic	No. of Hours	COs
1	**ASIC Types and Library Design**		
1.1	ASIC Design Flow	1	CO1
1.2	Types of ASIC - Full Custom, Semi Custom	1	CO1
1.3	Standard Cell Based ASIC and Gate Array ASIC	2	CO1
1.4	Library cell design	1	CO1
1.5	Library architecture	1	CO1
2	**System Partitioning**		
2.1	Measurement of Partitioning	1	CO2
2.2	Partitioning Algorithms - Constructive Partitioning	1	CO2
2.3	Iterative Partitioning Improvement Algorithms- Kernighan-Lin algorithm	2	CO2
2.4	Ratio-Cut Algorithm	1	CO2

2.5	FPGA Partitioning	1	CO2
3	**Floorplanning and Placement**		
3.1	Floor Planning Measurement and tools	1	CO3
3.2	I/O, Power and clock planning	1	CO3
3.3	Measurement of Placement	1	CO3
3.4	Placement Algorithms – Min-cut Placement	1	CO3
3.5	Eigen value Placement, Iterative Placement Improvement	1	CO3
3.6	Timing Driven Placement algorithms	1	CO3
4	**Routing and Circuit Extraction**		
4.1	Global Routing Measurement	1	CO4
4.2	Measurement of Interconnect Delay using Elmore's constant	1	CO4
4.3	Global routing for CBIC and GA	1	CO4
4.4	Detailed Routing Measurement-Measurement of Channel Density,	1	CO4
4.5	Detailed routing Algorithms – Lee Maze and High tower Algorithms,	1	CO4
4.6	Circuit extraction process, Layout Design Rules, Technology related issues	1	CO4
5	**ASIC TESTING**		
5.1	Fault Simulation	1	CO5
5.2	Test Pattern Generation Test	1	CO5
5.3	Design for Testability, Boundary Scan Test	2	CO5
5.4	Built-in-Self-Test	2	CO5
6.	**Modern ASICs**		
6.1	SoC Design Flow	1	CO6
6.2	Platform-based and IP based SoC Designs	1	CO6
6.3	On-Chip Communication Architecture Standards	1	CO6
6.4	Low-Power SoC Design	1	CO6
6.5	Case Studies - Canonic Signed Digit Arithmetic, Distributed Arithmetic	1	CO6
6.6	Modular Arithmetic, Mobile processor	1	CO6
	Total	36	

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18ECPZ0	IOT SYSTEM AND APPLICATIONS

Category	L	T	P	Credit
PE	3	0	0	3

Preamble

The objectives of this course are to provide in-depth understanding of the underlying concepts of Internet of things, building blocks, domain-specific IoT, and Design methodology for IoT. Also the course provides knowledge on Python coding to embed the coding in various open source hardware such as Raspberry Pi and Arduino. Eventually the course extends the students' knowledge up to the level of building cost effective IoT system for real world scenario with the open source hardware and software tool chains.

Prerequisite

18EC350 Microprocessors and Microcontrollers

Course Outcomes

On the successful completion of the course, students will be able t

CO Number	Course Outcome Statement	Weightage in %
CO1	Explain the terms and definitions of embedded system and networking with various protocols	20
CO2	Describe the functionality of architecture of IoT	20
CO3	Use different hardware and software tools for the IoT implementation	20
CO4	Develop hardware building block for IoT system for the given scenario	20
CO5	Apply the software tools chains for the given real world scenario fulfilling the IoT requirements	10
CO6	Apply the features and operations of various open source hardware and software	10

CO Mapping with CDIO Curriculum Framework

CO#	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS2	Understand	Respond	-	1.3, 2.1.1, 2.1.2, 2.4.2, 2.4.6, 2.5.1, 3.1.1, 3.2.3
CO2	TPS2	Understand	Respond	-	1.3, 2.1.1, 2.1.2, 2.5.1, 3.1.1, 3.2.3
CO3	TPS3	Apply	Value	-	1.3,, 2.1.1, 2.1.2, 2.5.1, 3.1.1, 3.2.3
CO4	TPS3	Apply	Value	Mechanism	1.3, 2.1.1, 2.1.2, 2.1.3, 2.5.1
CO5	TPS3	Apply	Value	-	1.3, 2.1.1, 2.1.2, 2.1.3, 2.5.1
CO6	TPS3	Apply	Value	Mechanism	1.3, 2.1.1, 2.1.2, 2.5.1

Mapping with Programme Outcomes and Programme Specific Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3
CO1	M	L	-	-	-	-	-	-	-	-	-	-	L	-	-
CO2	M	L	-	-	-	-	-	-	-	-	-	-	L	-	-
CO3	S	M	L	-	L	-	-	L	L	L	-	L	M	-	L
CO4	S	M	L	-	L	-	-	L	L	L	-	L	M	-	L
CO5	S	M	L	-	L	-	-	L	L	L	-	L	M	-	L
CO6	S	M	L	-	L	-	-	L	L	L	-	L	M	-	L

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

Cognitive Levels	Continuous Assessment Tests			Assignment			End Semester Examination
	1	2	3	1	2	3	
Remember	0	0	0	0	0	0	0
Understand	60	20	20	100	0	0	40
Apply	40	80	80	0	70	70	60
Analyse	0	0	0	0	0	0	0
Evaluate	0	0	0	0	0	0	0
Create	0	0	0	0	0	0	0

Assessment Pattern: Psychomotor

Psychomotor Skill	Assignment-1	Assignment-2	Assignment-3
Perception	-	-	-
Set	-	-	-
Guided Response	-	-	-
Mechanism	-	30	30
Complex Overt Responses	-	-	-
Adaptation	-	-	-
Origination	-	-	-

Course Level Assessment Questions

Course Outcome 1(CO1)

1. Summarize the value proposition of IoT
2. Classify the key functions of IoT?
3. Illustrate the components for weather reporting with IoT.

Course Outcome 2 (CO2)

1. Interpret the advantages of a switch rather than a hub to interconnect several machines
2. Explain the use of cloud for IoT?
3. Explain the need of protocol for OSHW communication

Course Outcome 3 (CO3)

1. Develop building blocks in HW components of IoT
2. Construct a model for an IoT framework.
3. Develop a hardware circuit for IoT for different scenario?

Course Outcome 4 (CO4)

1. Plan for a flow for optimization in IoT.
2. Develop pseudo code for accessing sensors in python
3. Develop an Arduino code for accessing sensors and actuators

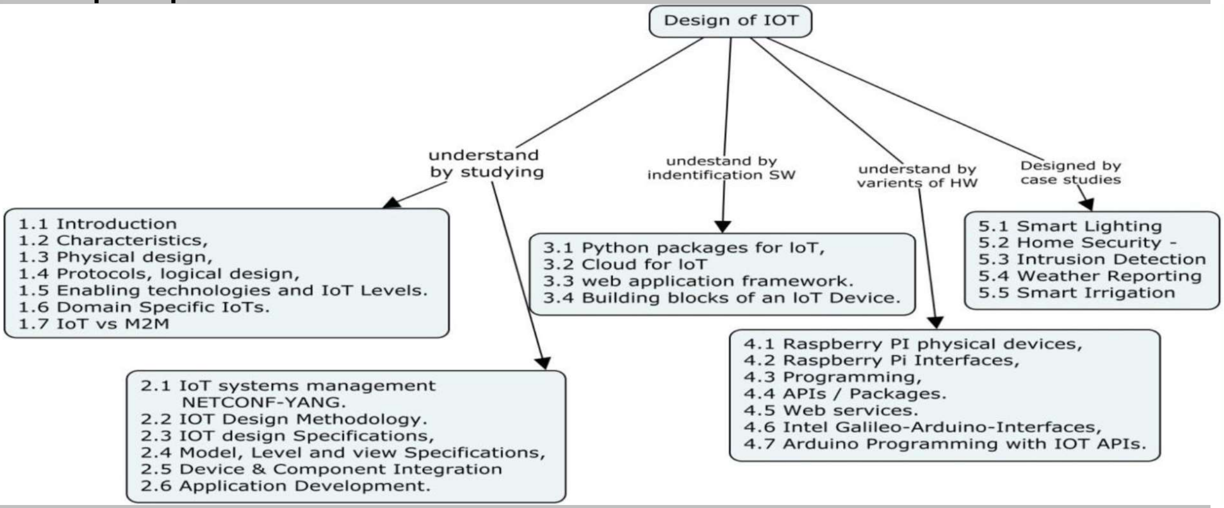
Course Outcome 5 (CO5)

1. Consider a point to point link 50 Km. in length. At what bandwidth would propagation delay equal transmit delay for 100 bytes packet? What about 512 byte packets?
2. Develop an IoT System with sensors for monitoring agriculture field
3. Develop an IoT System with sensors for street light monitoring and control

Course Outcome 6 (CO6)

1. Develop a python code for accessing sensors and actuators
2. Measure the propagation delay of an IoT system when an algorithm is running with a defined rate with networking
3. Describe the model for IoT domain specific applications.

Concept Map



Syllabus

Internet of Things System: Characteristics, Physical design, Protocols, logical design, Enabling technologies and IoT Levels. Domain Specific IoT: Medical IoT vs M2M. Design Methodology: IoT systems management with NETCONF-YANG. IoT Design Methodology, IoT design Specifications, Model, Level and view Specifications, Device & Component Integration and Application Development. Logical Design and Physical Devices: Python packages of interest for IoT. Cloud for IoT -AWS, Google cloud and IBM cloud. Python web application framework, Basic building blocks of a IoT Device. Open Source Hardware: Raspberry PI physical devices, Raspberry Pi Interfaces, Programming, APIs / Packages, Web services, Intel Galileo-Arduino-Interfaces, Arduino Programming with IoT APIs. Case Studies: Smart lighting, home security, weather reporting BOT, smart irrigation and other real time applications of IoT with LORA -Connecting IoT to cloud.

Learning Resources

- Arshdeep Bahga, Vijay Madisetti, “Internet of Things – A hands-on approach”, Universities Press, 2015
- Peter Waher “Learning Internet of Things”, Packt Publishing, UK, 2015.
- Miguel de Sousa”, Internet of Things with Intel Galileo” ”, Packt Publishing, UK, 2015.
- Marco Schwartz, “Internet of Things with the Arduino Yun”, Packt Publishing, 2014.

Course Contents and Lecture Schedule

Module No	Topic	No. of Lectures	COs
1	**Internet of Things System**		
1.1	Definition & Characteristics and Physical Design of IoT	1	CO1
1.2	Logical Design, Functional Blocks and Communication Models	1	CO1
1.3	Enabling Technologies, Levels & Deployment Templates	1	CO1
1.4	Domain Specific IoTs (Medicals, Smart Lighting, Smart Appliances Intrusion Detection)	1	CO2
1.5	IoT and M2M-differences	1	CO2
2	**Design Methodology**		
2.1	IoT systems management with NETCONF-YANG	1	CO3
2.2	IoT Design Specifications	1	CO3
2.3	Model, Level and view Specifications	1	CO3
2.4	Device & Component Integration	1	CO2
2.5	Application Development	1	CO2
2.6	Basic building blocks of an IoT Device	1	CO3

3	**Logical Design and Physical Devices**		
3.1	Introduction to Python	2	CO3
3.2	Control Flow Functions Modules Packages for IoT	2	CO3
3.3	Cloud for IoT	2	CO3
3.4	Python web application framework	2	CO4
3.5	Programming, APIs / Packages	2	CO4
4	**Open Source Hardware**		
4.1	Raspberry PI physical devices	3	CO4
4.2	Raspberry Pi Interfaces	3	CO4
4.3	Web services	3	CO5
4.4	Intel Galileo-Arduino-Interfaces	3	CO5
4.5	Arduino Programming with IoT APIs	3	CO5
5	**Case Studies**		
5.1	Smart Lighting	1	CO6
5.2	Home Security -Intrusion Detection	1	CO6
5.3	Weather Reporting BOT	1	CO6
5.4	Smart Irrigation	1	CO6

Course Designers:

- Dr. K.Hariharan khh@tce.edu

18ECRA0	REAL TIME EMBEDDED SYSTEMS

Category	L	T	P	Credit
PE	3	0	0	3

Preamble

The course begins by embedded hardware components, general operating system and real time operating system fundamentals and discussing how and why it differs from the traditional sequential level programming. It covers the theory and practice of handling RTOS functions through a set of detailed examples. It discusses the concept of multitasking and scheduler in RTOS. Inter Tasks communication and synchronization and some examples.

Prerequisite

18EC350 Microprocessors and Microcontrollers

Course Outcomes

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

CO Number	Course Outcome Statement	Weightage in %
CO1	Describe the embedded hardware system	20
CO2	Distinguish between conventional operating system and a real-time operating system	20
CO3	Measure the effectiveness of RTOS over conventional OS	20
CO4	Develop pseudo codes for multitasking scheduler	20
CO5	Develop a model for a real time embedded system	10
CO6	Apply methods and protocol for validation and testing	10

CO Mapping with CDIO Curriculum Framework

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS2	Understand	Respond	-	1.3, 2.1.1, 2.1.2, 2.4.2, 2.4.6, 2.5.1, 3.1.1, 3.2.3
CO2	TPS2	Understand	Respond	-	1.3, 2.1.1, 2.1.2, 2.5.1, 3.1.1, 3.2.3
CO3	TPS3	Apply	Value	-	1.3,, 2.1.1, 2.1.2, 2.5.1, 3.1.1, 3.2.3
CO4	TPS3	Apply	Value	-	1.3, 2.1.1, 2.1.2, 2.1.3, 2.5.1
CO5	TPS3	Apply	Value	Mechanism	1.3, 2.1.1, 2.1.2, 2.1.3, 2.5.1
CO6	TPS3	Apply	Value	-	1.3, 2.1.1, 2.1.2, 2.5.1

Mapping with Programme Outcomes and Programme Specific Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	M	L	-	-	-	-	-	-	-	-	-	-	L	-	-
CO2	M	L	-	-	-	-	-	-	-	-	-	-	L	-	-
CO3	S	M	L	-	L	-	-	L	L	L	-	L	M	-	L
CO4	S	M	L	-	L	-	-	L	L	L	-	L	M	-	L
CO5	S	M	L	-	L	-	-	L	L	L	-	L	M	-	L
CO6	S	M	L	-	L	-	-	L	L	L	-	L	M	-	L

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

Cognitive Levels	Continuous Assessment Tests			Assignment			End Semester Examination
	1	2	3	1	2	3	
Understand	60	20	20	100	0	0	40
Apply	40	80	80	0	100	70	60
Analyse	0	0	0	0	0	0	0
Evaluate	0	0	0	0	0	0	0
Create	0	0	0	0	0	0	0

Assessment Pattern: Psychomotor

Psychomotor Skill	Assignment-1	Assignment-2	Assignment-3
Perception	-	-	-
Set	-	-	-
Guided Response	-	-	-
Mechanism	-	-	30
Complex Overt Responses	-	-	-
Adaptation	-	-	-
Origination	-	-	-

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Illustrate a real-time embedded system.
2. Describe the characteristics of an conventional and real time system
3. Classify the real time embedded system?

Course Outcome 2 (CO2)

1. Demonstrate various scheduler functions
2. Explain co-routine functions in a real time embedded system
3. Demonstrate a system call and it is implementation.

Course Outcome 3(CO3):

1. Identify the system functionality with real time application
2. Build an embedded system with the requirement of real time applications
3. Describe the various system call in a given scenario of real time situation

Course Outcome 4 (CO4):

1. Compare the functions of base class to a derived class.
2. Experiment the interrupts with different priority cases
3. Develop a flow model of a context switching in OS function?

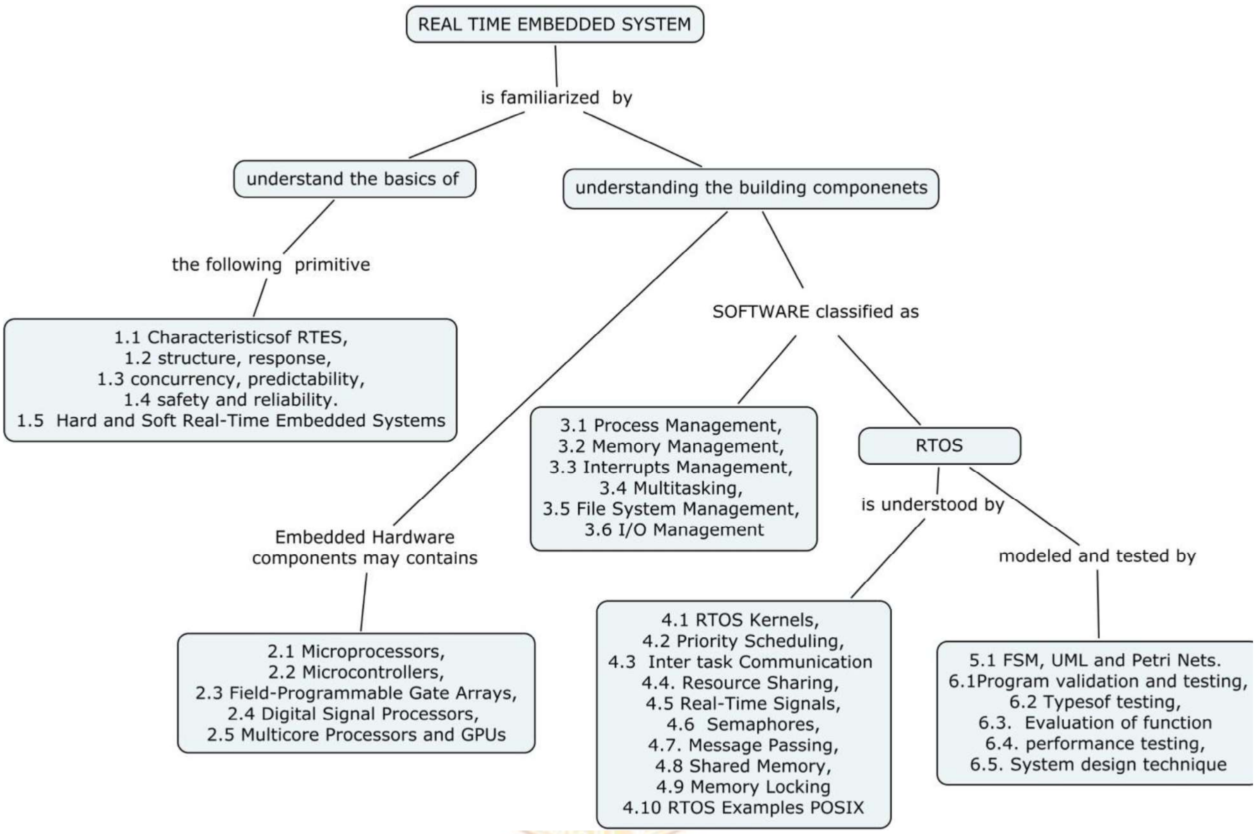
Course Outcome 5 (CO5):

1. Develop c code to implement a semaphore
2. Develop a c code to implement a ring buffer
3. Develop the pseudo code for the function of inter process communication.

Course Outcome 6 (CO6):

1. Develop pseudo code to implement a test cases
2. Develop an UML model to implement a ring buffer
3. Develop a Petri net for the function of inter process communication.

Concept Map



Syllabus

Real-Time Embedded Systems: Embedded Systems and Real-Time Embedded System characteristics, Structure, Response, Concurrency, Predictability, Safety and Reliability, Hard and Soft Real-Time Embedded Systems. **Embedded Hardware Components:** Microprocessors, Microcontrollers, Field Programmable Gate Arrays, Digital Signal Processors, Multicore Processors and GPUs. **Functions of Operating Systems:** Process Management, Memory Management, Interrupts Management, Multitasking, File System Management, I/O Management. **Real-Time Operating Systems:** Characteristics of RTOS Kernels, Priority Scheduling, Intertask Communication and Resource Sharing, Real-Time Signals, Semaphores, Message Passing, Shared Memory, Memory Locking and RTOS Examples POSIX. **System modeling**: FSM, UML and Petri Nets. **Validation and testing:** Program Validation and Testing, Types of Testing, Evaluation of Function and Performance Testing, System Design Technique.

Learning Resources

- Jiacun Wang" Real-Time Embedded Systems, "Wiley publication 1st edition 2017.
- Philip A. Laplante,"Real time systems Analysis and Design – An Engineer's Handbook", IEEE computer society press PHI, 2nd Ed. 1997.
- Allan. V. Shaw, "Real Time systems and software", John Wiley & Sons, 2000.

Course Contents and Lecture Schedule

No.	Topic	No. of Lectures	Cos
1	**Real-Time Embedded Systems**:		
1.1	Embedded Systems and Real-Time Embedded System characteristics,.	2	CO1
1.2	structure, response, concurrency, predictability, safety and reliability	2	CO1
1.3	Hard and Soft Real-Time Embedded Systems	2	CO1

2	**Embedded Hardware components:**		
2.1	Microprocessors, Microcontrollers Digital Signal Processors,	2	CO2
2.2	Field-Programmable Gate Arrays,	3	CO2
2.3	Multicore Processors and GPUs	3	CO3
3	**Functions of Operating Systems:**		
3.1	Process Management, Memory Management	2	CO3
3.2	Interrupts Management,	2	CO3
3.3	Multitasking	2	CO4
3.4	File System Management, I/O Management	2	CO4
4	**Real-Time Operating Systems**		
4.1	Characteristics of RTOS Kernels,	2	CO2
4.2	Priority Scheduling,	1	CO2
4.3	Inter task Communication and Resource Sharing,	1	CO3
4.4	Real-Time Signals, Semaphores,	2	CO3
4.5	Message Passing,	1	CO3
4.6	Shared Memory, Memory Locking	1	CO4
4.7	RTOS Examples POSIX	2	CO4
5	**System Modelling**		
5.1	FSM. UML and petrinets	4	CO6
6	**Validation and testing**		
6.1	Program validation and testing	2	CO5
6.2	Types of testing	2	CO5
6.3	Evaluation of function and performance testing	1	CO6
6.4	System design technique	1	CO5

Course Designers:

- Dr. K.Hariharan khh@tce.edu
- Dr.M.S.K.Manikandan manimsk@tce.edu

1.

18ECRB0	ADHOC AND SENSOR NETWORKS	Category	L	T	P	Credit
		PEES	3	0	0	3

Preamble

The objective of this course is to introduce students with fundamental concepts, design issues and solutions to the issues – architectures and protocols - and the state-of-the-art research developments in ad hoc and sensor networks.

Prerequisite

14EC510 Data Communication Networks

Course Outcomes

On the successful completion of the course students will be able to

CO#	Course Outcome Statement	Weightage in %
CO1	Identify the necessity of Ad Hoc and Sensor networks	15
CO2	Use various MAC protocols for Adhoc Network	20
CO3	Use various routing protocols for Adhoc Network	20
CO4	Use appropriate network protocol to provide solutions for transport layer issues	20
CO5	Analyze the MAC, routing issues in Ad hoc and sensor networks	15
CO6	Explain the applications and future trends in Wireless Sensor Network	10

CO Mapping with CDIO Curriculum Framework

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS2	Understand	Respond	-	1.3, 2.1.1, 2.1.5
CO2	TPS3	Apply	Value	-	1.3, 2.2.22,1.5, 3.2,6
CO3	TPS3	Apply	Value	-	1.3, 2.1.1, 2.1.5, 3.2,6
CO4	TPS3	Apply	Value	-	1.3, 2.1.1, 2.3.1
CO5	TPS4	Analyze	Organise	-	1.3, 2.1.1, 2.1.5, 2.2.2, 2.3.1, 3.2,6
CO6	TPS2	Understand	Respond	-	1.3, 2.1.1, 2.1.5

Mapping with Programme Outcomes and Programme Specific Outcomes

Cos	PO 1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	M	L	-	-	-	-	-	-	-	-	-	-	L	-	-
CO2	S	M	L	-	-	-	-	-	-	-	-	L	M	-	-
CO3	S	M	L	-	-	-	-	-	-	-	-	L	M	-	-
CO4	S	M	L	-	-	-	-	-	-	L	-	L	M	-	-
CO5	S	S	M	L	L	-	-	-	-	L	-	L	S	-	-
CO6	M	L	-	-	-	-	-	-	-	-	-	-	L	-	-

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

Cognitive Levels	Continuous Assessment Tests			Assignment			End Semester Examination
	1	2	3	1	2	3	
Remember	20	0	0	0	0	0	0
Understand	40	40	40	0	0	0	40
Apply	40	60	40	100	100	70	40
Analyse	0	0	20	0	0	30	20
Evaluate	0	0	0	0	0	0	0
Create	0	0	0	0	0	0	0

Assessment Pattern: Psychomotor

Psychomotor Skill	Assignment-1	Assignment-2	Assignment-3
Perception	-	-	-
Set	-	-	-
Guided Response	-	-	-
Mechanism	-	-	-
Complex Overt Responses	-	-	-
Adaptation	-	-	-
Origination	-	-	-

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Define hidden terminal problem and how it is alleviated at the MAC layer?
2. Define loop-free property ensured in on-demand routing protocols?
3. Identify and elaborate some of the important issues in pricing for multi hop wireless communication.

Course Outcome 2 (CO2):

1. Identify the advantages and limitations of routing protocol that uses GPS information for an ad hoc wireless network for search and rescue operations.
2. Give application scenarios where contention-based, reservation-based and packet scheduling-based MAC protocols can be used.
3. Calculate the probability of data packet collision in the MACA protocol. Assume that Tc is the control packet transmission and propagation delay, Tw is the optimal maximum back-off time, β is the percentage of ready nodes, and R is the transmission range of each node.

Course Outcome 3 (CO3):

1. Find out the probability of a path break for an eight-hop path, given that the probability of a link break is .2.
2. Consider the third iteration of LEACH protocol. If the desired number of nodes per cluster is ten, what is the threshold calculated for a node during its random number generation?
3. In FPRP, can a situation occur where a requesting node is not able to detect collisions that have occurred in the reservation request phase? If so, suggest simple modifications to solve the problem.

Course Outcome 4 (CO4):

1. Channel quality estimation can be done both at the sender and receiver. Which is more advantageous? Why?
2. In the CGSR protocol, the resources of the node chosen as the cluster-head get drained very quickly, more rapidly than the other nodes in the cluster. How can this problem be overcome?
3. Point out the implications of an extension of split TCP. Where every intermediate node acts as proxy node

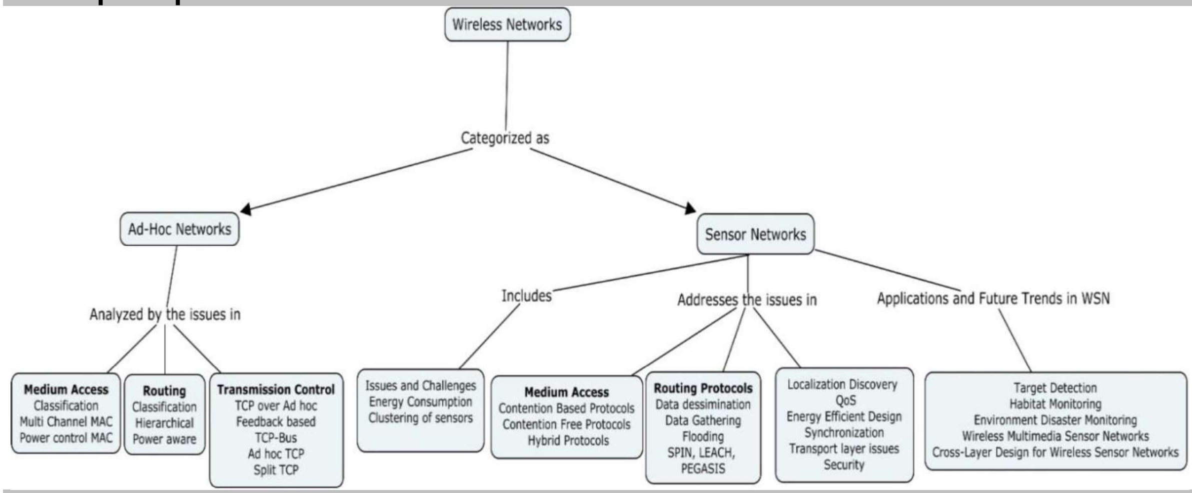
Course Outcome 5 (CO5):

1. During a research discussion, one of your colleagues suggested an extension of split-TCP where every intermediate node acts as proxy node. What would be the implications of such a protocol?
2. Determine the back-off calculation mechanism used in DWOP. Is it guaranteed to be accurate at all times? If not, explain why?
3. How does data gathering done in WSN?

Course Outcome 6 (CO6):

1. Design a habitat monitoring system using sensor networks
2. Design and develop a Cross layer Design based sensor networks.
3. Analyze the effect of the carrier sensing zone of a transmission on the performance of a MAC protocol.

Concept Map



Syllabus

Ad-hoc Mac: Design Issues in Ad-Hoc Networks - MAC Protocols – Issues, Classifications of MAC protocols: Contention Based Protocols, Contention Based Protocols with reservation mechanisms, Contention Based Protocols with Scheduling Mechanism – MAC protocol with Directional Antenna - Multi channel MAC & Power control MAC protocol. **Ad-Hoc Routing protocols and Ad-Hoc Transport layer:** Issues – Classifications of routing protocols: Table Driven Protocols, On-Demand Routing Protocols, Hybrid Routing Protocols – Hierarchical and Power aware Routing Protocols – Ad Hoc Transport Layer Issues, TCP Over Ad Hoc – Feedback based, TCP with explicit link, TCP-Bus, Ad Hoc TCP, and Split TCP. **WSN:** Introduction – Design Issues and challenges – Energy consumption – Clustering of sensors **MAC protocols:** Classifications of MAC protocols: Contention Based Protocols, Contention Free Protocols, Hybrid Protocols. **Routing Protocols for Wireless Sensor Networks:** Data Dissemination – Data Gathering – Routing Challenges and Design Issues in WSN - Routing Strategies in Wireless Sensor Networks: Flooding and Its Variants - Sensor Protocols for Information via Negotiation(SPIN) - Low-Energy Adaptive Clustering Hierarchy(LEACH) - Power-Efficient Gathering in Sensor Information Systems(PEGASIS) - Directed Diffusion - Geographical Routing - Location Discovery – QoS – Other issues: Energy Efficient Design, Synchronization, Transport layer issues, Security. **Applications and Case studies in Wireless Sensor Networks:** Target detection – Habitat Monitoring – Environment disaster Monitoring – Wireless Multimedia Sensor Networks - Cross-Layer Design for Wireless Sensor Networks

Learning Resources

- C.Siva Ram Murthy and B.S. Manoj, “Ad Hoc Wireless Networks – Architectures and Protocols”, Pearson Education, 2008.
- Jun Zheng and Abbas Jamalipour,“Wireless Sensor Network A Networking Perspective”, A John Wiley & Sons, Inc., Publication,2009.
- KazemSohraby, Daniel Minoli and TaiebZnati, “Wireless Sensor Networks: Technology, Protocols and Applications, A John Wiley & Sons, Inc., Publication, 2007.
- Carlos de Morais Cordeiro, Dharma Prakash Agrawal, “Ad Hoc and Sensor Networks, Theory and Applications”, World Scientific 2006.
- Feng Zhao and Leonidas Guibas, “Wireless Sensor Networks”, Morgan Kaufman Publishers, 2010.
- C.K.Toh, “Ad Hoc Mobile Wireless Networks”, Pearson Education, 2008.

Course Contents and Lecture Schedule

Module No.	Topic	No. of Hours	Course Outcome
1.	**Ad hoc Mac**		
1.1	Design Issues in Ad-Hoc Networks	1	CO1
1.2	MAC Protocols Issues	1	CO1

1.3	Classifications of MAC protocols: Contention Based Protocols	1	CO1
1.4	Contention Based Protocols with reservation mechanisms, Contention Based Protocols with Scheduling Mechanism	1	CO1
1.5	MAC protocol with Directional Antenna	2	CO1
1.6	Multichannel MAC	1	
1.7	Power control MAC protocol	1	
2.	**Ad-Hoc Routing protocols and Ad-Hoc Transport layer**		
2.1	Issues, Classifications of routing protocols: Table Driven Protocols	2	CO2
2.2	On-Demand Routing Protocols, Hybrid Routing Protocols	2	CO2
2.3	Hierarchical and Power aware Routing Protocols	1	CO3
2.4	Ad Hoc Transport Layer Issues, TCP Over Ad Hoc	2	CO3
2.5	Feedback based, TCP with explicit link, TCP-Bus	1	CO3
2.6	Ad Hoc TCP, and Split TCP	1	CO3
3.	**WSN: MAC protocols**		
3.1	Introductionof WSN	1	CO4
3.2	Design Issues and challenges and Energy consumption	1	CO4
3.3	Clustering of sensors	1	CO4
3.4	Classifications of MAC protocols: Contention Based Protocols	1	CO4
3.5	Contention Free Protocols, Hybrid Protocols	1	
4.	**Routing Protocols for Wireless Sensor Networks**		
4.1	Data Dissemination, Data Gathering	1	CO5
4.2	Routing Challenges and Design Issues in WSN	1	CO5
4.3	Routing Strategies in Wireless Sensor Networks: Flooding and Its Variants	1	CO5
4.4	SPIN , LEACH , PEGASIS	1	CO5
4.5	Directed Diffusion, Geographical Routing	1	
4.6	Location Discovery, QoS	1	
4.7	Other issues: Energy Efficient Design, Synchronization, Transport layer issues, Security	1	
5	**Applications and Case studies in Wireless Sensor Networks**		
5.1	Target detection	1	CO6
5.2	Habitat Monitoring	1	CO6
5.3	Environmental disaster Monitoring	1	CO6
5.4	Wireless Multimedia Sensor Networks	1	CO6
5.5	Cross-Layer Design for Wireless Sensor Networks	1	CO6
	Total Hours	**36**	

Course Designers:

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18ECRC0	MULTIMEDIA COMPRESSION TECHNIQUES	Category	L	T	P	Credit
		PEES	3	1	0	4

Preamble

This course aims at understanding characteristics of various multimedia data and apply a suitable coding/compression technique to efficiently represent the data.

Prerequisite

NIL

Course Outcomes

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

CO#	Course Outcome Statement	Weightage in %
CO1	Characterize Multimedia data and its Compression with performance measures	10
CO2	Determine the performance of lossless compression techniques such as variable-length coding, Arithmetic and Dictionary-based coding	25
CO3	Determine the performance of lossy compression techniques such as scalar and vector quantization and transform coding	20
CO4	Illustrate the performance of Image compression standards such as JPEG 2000 and JBIG	15
CO5	Illustrate the performance of video compression schemes such as H.261 and MPEG	15
CO6	Illustrate the performance of Audio compression techniques such as G.726, Vocoder, MPEG Audio, Surround sound and Silence Compression	15

CO Mapping with CDIO Curriculum Framework

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS2	Understand	Respond	-	1.3, 2.4.6
CO2	TPS3	Apply	Value	-	1.3, 3.2.4, 3.3.1, 4.1.2, 4.5.3
CO3	TPS3	Apply	Value	-	1.3, 3.2.4, 3.3.1, 4.1.2, 4.5.3
CO4	TPS3	Apply	Value	-	1.3, 3.2.4, 3.3.1, 4.1.2, 4.5.3
CO5	TPS3	Apply	Value	-	1.3, 3.2.4, 3.3.1, 4.1.2, 4.5.3
CO6	TPS3	Apply	Value	-	1.3, 3.2.4, 3.3.1, 4.1.2, 4.5.3

Mapping with Programme Outcomes

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	M	L	L	L	-	-	-	-	-	L	-	-	L	-	-
CO2	S	M	L	M	-	-	L	-	-	L	-	-	M	L	-
CO3	S	M	L	M	-	-	L	-	-	L	-	-	M	L	-
CO4	S	M	L	M	-	-	L	-	L	M	-	-	M	L	-
CO5	S	M	L	M	-	-	M	L	L	M	-	-	M	L	-
CO6	S	M	L	M	-	L	M	L	L	M	-	-	M	L	-

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

Cognitive Levels	Continuous Assessment Tests			Assignment			End Semester Examination
	1	2	3	1	2	3	
Remember	0	0	0	0	0	0	0
Understand	20	20	20	20	20	20	20
Apply	80	80	80	80	80	80	80
Analyse	-	-	-	-	-	-	-
Evaluate	-	-	-	-	-	-	-
Create	-	-	-	-	-	-	-

Assessment Pattern: Psychomotor

Psychomotor Skill			
Perception	-	-	-
Set	-	-	-
Guided Response	-	-	-
Mechanism	-	-	-
Complex Overt Responses	-	-	-
Adaptation	-	-	-
Origination	-	-	-

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Using your own words, describe what is “multimedia”?
2. Is multimedia simply a collection of different types of media?
3. Identify three novel multimedia applications. Discuss why you think these are novel and their potential impact.
4. State entropy
5. Discuss redundancies
6. What is the term “compression Ratio” in compression?

Course Outcome 2 (CO2):

1. How integer arithmetic could be used to generate binary code and examine the same for the typical scenario of u(n) = 54 and l(n) = 33 with m = 6.
2. For an alphabet A = {a1, a2, a3} with p(a1) = 0.7, p(a2) = 0.2, p(a3) = 0.1. Design a ‘3’ bit Tunstall code.
3. Encode the following sequence by LZ77 approach with window = 14 , LAB = 5 a b c a r a d a b r a r r a a d r r
4. A source emits letters from an alphabet A = {a1, a2, a3, a4, a5} with probabilities P (a1) = 0.15, P (a2) = 0.04, P (a3) = 0.26, P (a4) = 0.05 & P (a5) = 0.5
   a. Calculate the entropy, b.Find Huffman code, c. Average length of the code and its redundancy

Course Outcome 3 (CO3):

1. What is rate distortion theory?
2. Define vector quantization and give its merit.
3. Compute the covariance matrix of the following set of 4 vectors.
   $[1\ 0\ 0]^T$, $[0\ 0\ 0]^T$,$[1\ 1\ 0]^T$, $[1\ 1\ 1]^T$
4. The wavelet coefficients of the given image are shown in figure. Encode and decode the coefficients using SPIHT algorithm.

34	0	1	-1
0	0	-1	1
4	-4	10	-6
-4	4	6	-10

Course Outcome 4 (CO4):

1. Explain the bi-level lossless compression standard.
2. You are given a computer cartoon picture and a photograph. If you have a choice of using either JPEG compression or GIF, which compression would you apply for these two images? Justify your answer.
3. Is the JPEG2000 bitstream SNR scalable? Also, explain how it is achieved using the EBCOT algorithm.
4. Could we use wavelet-based compression in ordinary JPEG? How?

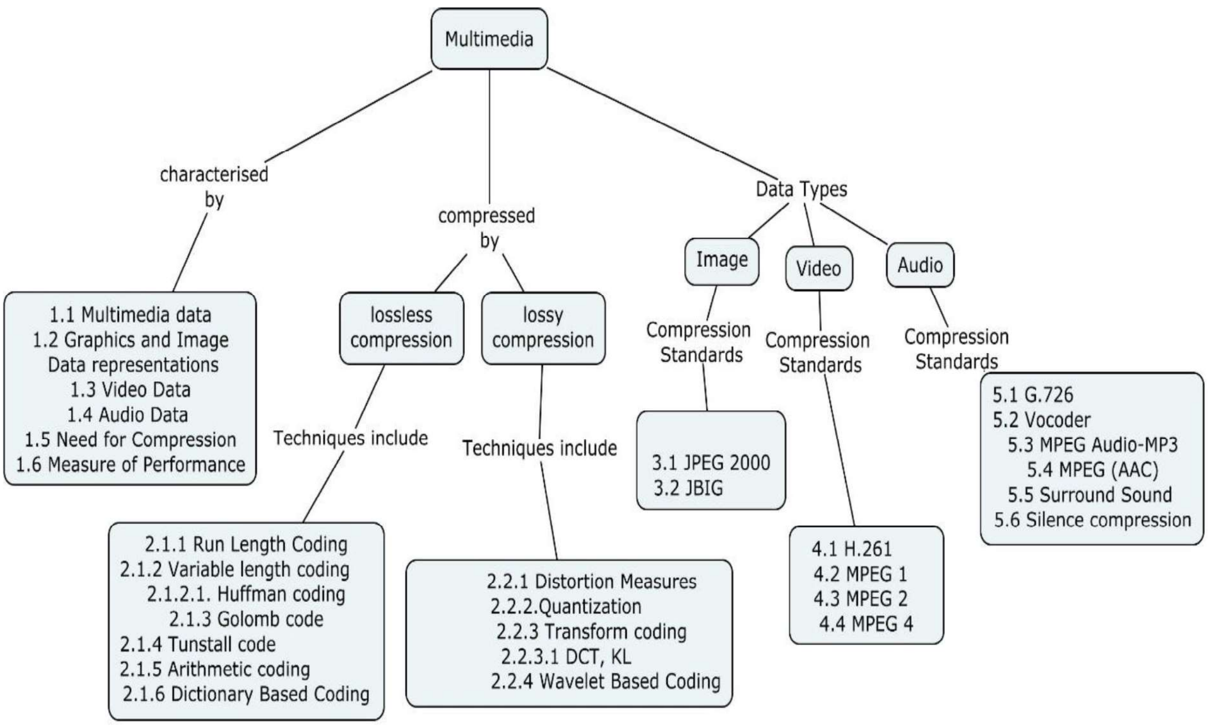
Course Outcome 5 (CO5):

1. In block-based video coding, what takes more effort: compression or decompression? Explain why.
2. As we know, MPEG video compression uses I-, P-, and B-frames. However, the earlier H.261 standard does not use B-frames. Describe a situation in which video compression would not be as effective without B-frames.
3. B-frames provide obvious coding advantages, such as increase in SNR at low bitrates and bandwidth savings. What are some of the disadvantages of B-frames?

Course Outcome 6 (CO6):

1. Linear prediction analysis can be used to estimate the shape of the envelope of the short-time spectrum. Given ten LP coefficients a1,...,a10, how do we get the formant position and bandwidth?
2. Give a simple time domain method for pitch estimation based on the autocorrelation function. What problem will this simple scheme have when based on one speech frame? If we have three speech frames, including a previous frame and a future frame, how can we improve the estimation result?
3. Describe the ITU G.726 standard for ADPCM system.
4. What is the compression ratio of MPEG audio if stereo audio sampled with 16 bits per sample at 48 kHz is reduced to a bitstream of 256 kbps?

Concept Map



Syllabus

Multimedia Data Representation: Text, Graphics and Image data representation, Video data, Audio data, Need for Compression and Coding of Multimedia data, Measures of Performance.

Multimedia Data Compression-Lossless Compression Techniques: Run length coding-Variable Length Coding: Huffman Coding- Non binary Huffman coding- Extended Huffman-Adaptive Huffman, Golomb code- Tunstall Code, Arithmetic Coding, Dictionary Based Coding **–** Static Dictionary-Digram coding -Adaptive Dictionary-LZ77, LZ78, LZW.

Lossy Compression Techniques: Distortion Measures-The Rate-Distortion Theory-Quantization- Scalar and Vector Quantization, Transform Coding-Discrete Cosine Transform, Karhunen–Loève Transform, Wavelet Based Coding- Sub band coding - Embedded Zero tree of Wavelet Coding (EZW) -Set Partitioning in Hierarchical Trees (SPIHT) coders;

Image Compression Standards: JPEG 2000, Bilevel Image Compression Standards: JBIG;

Video Compression Standards: Introduction to Video Compression-Video Compression Based on Motion Compensation-Search for Motion Vectors H.261, MPEG 1 -MPEG-2-MPEG-4-Object-Based Visual Coding in MPEG-4.

Audio Compression Standards: G.726, Vocoder-MPEG Audio- MPEG 1 Layer III(MP3)-MPEG 2 (AAC)- Surround sound - Dolby Digital- DTS X **-** Silence Compression.

Text Books

1. Li, Ze-Nian, Mark S. Drew, and Jiangchuan Liu, "Fundamentals of multimedia" Springer, 2021.
2. Khalid Sayood, "Introduction to Data Compression" Fifth Edition, Morgan Kauffmann Publishers, Inc, Newnes, 2020.

Reference Books

1. David Salomon, "Data Compression: The Complete Reference", Fourth Edition Springer Science & Business Media, 2007.
2. David Salomon, "A Guide to Data Compression Methods", Fourth Edition Springer Science & Business Media, 2013.
3. Darrel Hankerson, Greg A. Harris, and Peter D. Johnson Jr, "Introduction to information theory and data compression", CRC press, 2003.
4. Mark Nelson, Jean Louf Goilly, "The Data Compression Book", BPB Publications, 1995.

Course Contents and Lecture Schedule

Module No.	Topic	No. of lectures
1.	**Multimedia- Data Representation**	
1.1	What is Multimedia	1
1.2	Graphics and Image Data Representations	1
1.3	Video Data	1
1.4	Audio Data	1
1.5	Need for Compression and Coding of Multimedia data	0.5
1.6	Measures of Performance	0.5
2.	**Multimedia Data Compression**	
2.1	**Lossless Compression Techniques**	
2.1.1	Run length Coding	1
2.1.2	Variable Length Coding	1
2.1.2.1	Huffman Coding and its variations- Baseline, Non Binary, Extened and Adaptive Huffman	4
2.1.3	Golomb code	1
2.1.4	Tunstall Code	1
2.1.5	Arithmetic coding	2
2.1.6	Dictionary Based Coding –Digrams, LZ77,LZ78, LZW	3
2.2	**Lossy Compression Techniques**	
2.2.1	Distortion Measures, Rate Distortion Theory	1

2.2.2	Scalar and Vector Quantization	2
2.2.3	DCT, KL Transform coding	2
2.2.4	Wavelet Based Coding	
2.2.4.1	Sub band coding	2
2.2.4.2	Embedded Zero tree of Wavelet coding	2
2.2.4.3	Set Partitioning in Hierarchical Trees (SPIHT)	2
3	**Image Compression Standards**	
3.1	JPEG 2000	2
3.2	Bi-level Image Compression Standards	
3.2.1	JBIG	2
4	**Video Compression Standards**	
4.1	H.261	2
4.2	MPEG 1	2
4.3	MPEG 2	1
4.4	MPEG 4	2
5.	**Audio Compression Standards**	
5.1	G.726	2
5.2	Vocoder	1
5.3	MPEG Audio- MP3	1
5.4	MPEG (AAC)	1
5.5	Surround Sound- Dolby Digital and DTS X	2
5.6	Silence Compression	1

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18ECRD0	SIGNAL PROCESSING IN 5G NR

Category	L	T	P	Credit
PEES	3	1	0	4

Preamble

The objective of the course on "Signal Processing in 5G New Radio (NR)" is to present the communication techniques, Procedures and Signal Processing Algorithms used in the physical layer of 5G new radio standards. The course covers 5G NR features, spectral requirements, frame structure, radio interface architecture, channel sounding, scheduling, multi antenna, retransmission, power control, synchronization characteristics. This course would be more helpful in carrying out projects in recent telecommunication domain.

Prerequisite

18EC530 Analog and Digital Communication Systems

Course Outcomes

On the successful completion of the course students will be able to

CO#	Course Outcome Statement	Weightage in %
CO1	Compare the enhanced features of 5G NR over 4G LTE and describe the frame structure of 5GNR	15
CO2	Determine suitable channel estimation algorithm for calculating parameters from channel sounding features of 5G NR	15
CO3	Determine the receiver structure for transport channel processing of uplink and downlink in 5G NR	20
CO4	Determine the receiver structure for control channel processing of uplink and downlink in 5G NR	20
CO5	Describe the multi-antenna, retransmission, power control features of 5G NR	15
CO6	Determine suitable frequency and timing estimation algorithms for initial access and synchronization features of 5G NR	15

CO Mapping with CDIO Curriculum Framework

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS2	Understand	Respond	-	1.3,2.1.1,2.1.2,2.4.6,3.2.3
CO2	TPS3	Apply	Value	Mechanism	1.3,1.2.1, 2.1.1, 2.1.2, 2.4.2, 2.4.6, 2.5.1, 3.1.1, 3.2.3, 4.5.5, 4.6.2
CO3	TPS3	Apply	Value	Mechanism	1.3,1.2.1, 2.1.1, 2.1.2, 2.4.2, 2.4.6, 2.5.1, 3.1.1, 3.2.3, 4.5.5, 4.6.2
CO4	TPS3	Apply	Value	Mechanism	1.3,1.2.1, 2.1.1, 2.1.2, 2.4.2, 2.4.6, 2.5.1, 3.1.1, 3.2.3, 4.5.5, 4.6.2
CO5	TPS2	Understand	Respond	Guided Response	1.3,2.1.1,2.1.2,2.4.6,3.2.3
CO6	TPS3	Apply	Value	Mechanism	1.3,1.2.1, 2.1.1, 2.1.2, 2.4.2, 2.4.6, 2.5.1, 3.1.1, 3.2.3, 4.5.5, 4.6.2

Mapping with Programme Outcomes and Programme Specific Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	M	L	-	-	-	-	-	-	-	-	-	-	M	-	-
CO2	S	M	L	-	-	-	-	-	-	-	-	-	M	L	-
CO3	S	M	L	-	-	-	-	-	-	-	-	-	M	L	-
CO4	S	M	L	-	S	-	-	-	S	S	-	-	M	L	-
CO5	M	L	-	-	-	-	-	-	-	-	-	-	M	-	-
CO6	S	M	L	-	-	-	-	-	-	-	-	-	M	-	-

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

Cognitive Levels	Continuous Assessment Tests			Assignment			End Semester Examination
	1	2	3	1	2	3	
Remember	0	0	0	0	0	0	0
Understand	20	20	20	0	0	0	20
Apply	80	80	80	100	50	50	80
Analyze	0	0	0	0	0	0	0
Evaluate	0	0	0	0	0	0	0
Create	0	0	0	0	0	0	0

Assessment Pattern: Psychomotor

Psychomotor Skill	Assignment-1	Assignment-2	Assignment-3
Perception	-	-	-
Set	-	-	-
Guided Response	-	-	-
Mechanism	-	50	50
Complex Overt Responses	-	-	-
Adaptation	-	-	-
Origination	-	-	-

Sample Questions for Course Outcome Assessment

Course Outcome 1 (CO1):

1. List the requirements of 5G New Radio.
2. Represent the 5G Spectrum defined by IMT Systems by the ITU-R.
3. List out the various Uplink and Downlink 5G NR Operating bands. Also mention the duplex modes.

Course Outcome 2 (CO2):

1. Draw the single port CSI-RS Structure consisting of a single resource element within RB.
2. Represent different spatial filters applied to different CSI-RS.
3. Draw the time and frequency structures of Sounding Reference Signalling.

Course Outcome 3 (CO3):

1. Determine the Receiver structure for PDSCH in 5GNR with single transmit and single receive antenna.
2. Determine the Receiver structure for PUSCH in 5GNR with single transmit and single receive antenna.
3. Determine the Receiver structure for PDSCH in 5GNR with single transmit and multiple receive antenna.

Course Outcome 4 (CO4):

1. Explain the mapping of PUSCH and PUCCH information to physical resources.
2. Consider a PDCCH downlink control channel in 5GNR. It transmits information about the number of OFDM symbols used by control channels in a sub-frame. The 32 bit transmitting sequences for each values of CFI are listed below

   CFI <**b0, b1, …, b31**>

1<0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1>
2 <1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0>
3<1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1,0,1,1>
4 <0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0>

Assuming that PDCCH uses single antenna port for the transmitter and receiver, derive expression for probability of error in detection of the CFI value.

3. In case of fixed group assignment the sequence group to use for PUCCH transmission is given by the physical-layer cell identity modulo 30, where the cell identity ranges from 0 to 63. Determine the group assignment for the given cell identities.

Course Outcome 5 (CO5):

1. Describe the multi antenna transmission modes in downlink 5G New Radio.
2. Determine the Bit Error Rate for the Physical Downlink Hybrid ARQ Indicator channel (PDCCH) with SIMO processing.
3. Precoding is done for multi antenna transmission in 5G New Radio uplink. Determine the rank of the precoding matrix given below.

$$\begin{bmatrix} +1 \\ +1 \\ +1 \\ -1 \end{bmatrix} \quad \begin{bmatrix} +1 & 0 \\ +1 & 0 \\ 0 & -1 \\ 0 & -j \end{bmatrix} \quad \begin{bmatrix} +1 & 0 & 0 \\ +1 & 0 & 0 \\ 0 & +1 & 0 \\ 0 & 0 & +1 \end{bmatrix} \quad \begin{bmatrix} +1 & 0 & 0 \\ -1 & 0 & 0 \\ 0 & +1 & 0 \\ 0 & 0 & +1 \end{bmatrix} \quad \begin{bmatrix} +1 & 0 & 0 \\ 0 & +1 & 0 \\ +1 & 0 & 0 \\ 0 & 0 & +1 \end{bmatrix}$$

For the DFT spread OFDM in uplink, the allowed DFT sizes are 60,72,96. However a DFT size of 84 is not allowed. Justify.

Course Outcome 6 (CO6):

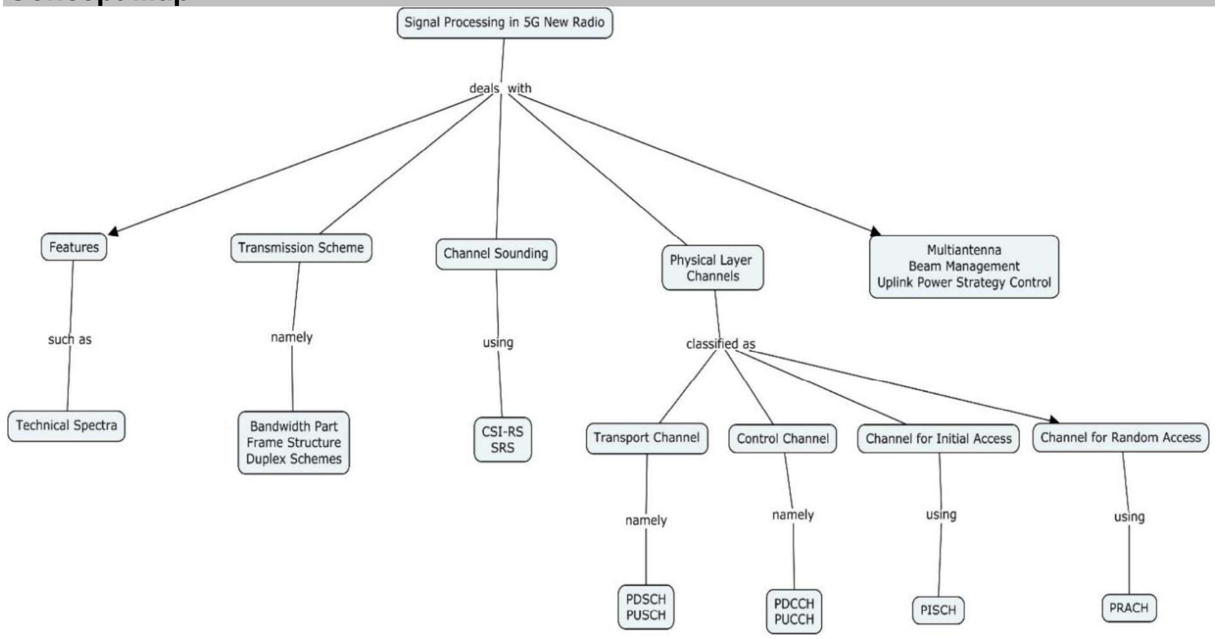
1. Consider 4 length time domain transmitted sequence defined by

$$x(n) = [1+1j, 1-1j, 1+1j, 1-1j].$$

Consider a normalised frequency offset of 0.3. Determine the received sequence with ideal channel conditions. Apply schmidle-Cox algorithm to determine the original frequency offset if $\Delta f = 15KHz$.

2. Apply the Schmidle Cox algorithm for symbol timing estimation in 5G New Radio.
3. What do you mean by beta offset in 5GNR?

Concept Map



Syllabus

5G Overview: 3GPP and the standardization of Mobile Communication, the next generation 5G New Radio, 5G Standardization, ITU-R Activities from 3G to 5G, 5G and IMT-2020, 3GPP Standardization, Spectrum for 5G, Frequency bands for NR, RF Exposure above 6GHz **NR Overview:** Higher Frequency Operation and Spectrum Flexibility, Ultra lean design, Forward compatibility, Transmission scheme, bandwidth parts and frame structure, Duplex schemes, Low latency support, Scheduling and data transmission, control channels, Beam centric design and Multi antenna transmission, Initial access, Interworking and LTE Coexistence **Transmission scheme**: Frequency domain location of NR Carrier, Carrier aggregation, Supplementary uplink, Duplex schemes, Antenna ports, Quasi co-location **Channel sounding:** Downlink channel sounding-CSI-RS, Downlink Measurements and reporting, Uplink channel sounding- SRS **Transport channel processing:** channel coding, Rate matching and physical layer hybrid ARQ Functionality, Scrambling, Modulation, Layer mapping, Uplink DFT Precoding, Multi antenna precoding, Resource mapping, Downlink reserved resources, Reference signals, Physical layer control signalling: Downlink, Uplink, **Multi-antenna Transmission:** Downlink Multi-antenna precoding, NR Uplink Multi-antenna precoding, **Beam Management:** Beam adjustment and Beam Recovery **Retransmission Protocols:** Hybrid ARQ with Soft combining**,** Radio Link Control (RLC)**,** Packet Data Convergence Protocol (PDCP), **Uplink Power and Timing control:** Uplink Power Control, Uplink Timing Control**, Initial access:** Cell search, Random access

Learning Resources

- Sassan Ahmadi, “5G NR Architecture, Technology, Implementation, and operation of 3GPP New Radio Standards”, Academic Press, 2019.
- Erik Dahlman, Stefan Parkvall, Johan Skold, “5G NR, The Next Generation Wireless Access Technology”, Academic Press,2018.
- 3GPP TS 23.502, Procedures for the 5G system (Release 15), April 2019.
- 3GPP TS 38.101-1, NR, User Equipment (UE) Radio Transmission and Reception; Part 1: Range 1 Standalone (Release 15), December 2018.
- 3GPP TS 38.101-2: NR, User Equipment (UE) Radio Transmission and Reception; Part 2: Range 2 Standalone (Release 15), December 2018.
- 3GPP TS 38.104, NR, Base Station (BS) Radio Transmission and Reception (Release 15), December 2018.
- 3GPP TS 38.202, NR, Services Provided by the Physical Layer (Release 15), December 2018.
- 3GPP TS 38.211, NR, Physical Channels and Modulation (Release 15), December 2018.
- 3GPP TS 38.212, NR, Multiplexing and Channel Coding (Release 15), December 2018.
- 5G New Radio, ShareTechNote. http://www.sharetechnote.com

Course Contents and Lecture Schedule:

No.	Topic	No. of Hours	COs
1	**5G Overview**		
1.1	3GPP and the standardization of Mobile Communication, the next generation 5G New Radio	1	CO1
1.2	5G Standardization	1	CO1
1.3	ITU-R Activities from 3G to 5G	1	CO1
1.4	5G and IMT-2020	1	CO1
1.5	3GPP Standardization	1	CO1
1.6	Spectrum for 5G, Frequency bands for NR, RF Exposure above 6GHz	1	CO1
2	**NR Overview**		
2.1	Higher Frequency Operation and Spectrum Flexibility, Ultra lean design	1	CO1
2.2	Forward compatibility, Transmission scheme, bandwidth parts and frame structure	1	CO1

2.3	Duplex schemes, Low latency support, Scheduling and data transmission, control channels	1	CO1
2.4	Beam centric design and Multi antenna transmission	1	CO1
2.5	Initial access, Interworking and LTE Coexistence	1	CO1
3	**Transmission scheme**		
3.1	Frequency domain location of NR Carrier	2	CO2
3.2	Carrier aggregation	2	CO2
3.3	Supplementary uplink, Duplex schemes	2	CO2
3.4	Antenna ports, Quasi colocation	1	CO2
4	**Channel sounding**		
4.1	Downlink channel sounding-CSI-RS	2	CO3
4.2	Downlink Measurements and reporting	2	CO3
4.3	Uplink channel sounding- SRS	2	CO3
5	**Transport channel processing**		
5.1	Channel coding, Rate matching and physical layer hybrid ARQ Functionality	2	CO4
5.2	Scrambling, Modulation, Layer mapping	2	CO4
5.3	Uplink DFT Precoding, Multi antenna precoding	1	CO4
5.4	Resource mapping, Downlink reserved resources	1	CO4
5.5	Reference signals	1	CO4
5.6	Physical layer control signaling: Downlink, Uplink	1	CO4
6	**Multi antenna Transmission**		
6.1	Downlink Multi antenna precoding	1	CO5
6.2	NR Uplink Multi antenna precoding	1	CO5
7	**Beam Management**		
7.1	Beam adjustment and Beam Recovery	2	CO5
8	**Retransmission Protocols**		
8.1	Hybrid ARQ with Soft combining	2	CO6
8.2	Radio Link Control (RLC)	2	CO6
8.3	Packet Data Convergence Protocol (PDCP)	2	CO6
9	**Uplink Power and Timing control**		
9.1	Uplink Power Control	2	CO6
9.2	Uplink Timing Control	2	CO6
10	**Initial access**		
10.1	Cell search, Random access	2	CO6
Total		48	

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18ECRE0	ALGORITHMS FOR VLSI DESIGN AUTOMATION

Category	L	T	P	Credit
PEES	3	1	0	4

Preamble

The semiconductor industry has advanced tremendously over the last ten years with features sizes being downscaled from micrometer to nanometer regime today. Due to the increasing high complexity of modern VLSI chip design, Computer Aided Design (CAD) tools play an important role in delivering high system performance. This course introduces the techniques of modelling digital systems at various abstraction levels and exploring the various algorithms in VLSI physical design, which serve as a basis for the research and development of new Computer Aided Design (CAD) tools.

Prerequisite

18EC260 – Digital System Design, 18EC430 – CMOS VLSI Systems

Course Outcomes

On the successful completion of the course students will be able to

CO#	Course Outcome Statement	Weightage in %
CO1	Demonstrate the knowledge of computational and optimization algorithms and tools applicable to solving CAD related problems	10
CO2	Represent mechanism for Boolean functions that has application in logic synthesis and Verification	15
CO3	Partition or divide the system into smaller portions based on the performance such as area, wire length and cost matrices.	15
CO4	Determine the approximate location of each module in a chip area.	20
CO5	Use Optimization algorithms in placement to determine the best position for each module on the chip.	20
CO6	Analyse the Optimizations algorithms in VLSI Global and Detailed Routing process based on their wire length and area constraints.	20

CO Mapping with CDIO Curriculum Framework

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS3	Apply	Value	Mechanism	1.3, 2.1.1, 2.1.2, 2.4.2, 2.4.3, 2.4.6, 2.5.1, 2.5.4, 3.1.1
CO2	TPS3	Apply	Value	Mechanism	1.3, 2.1.1, 2.1.2, 2.4.2, 2.4.3, 2.4.6, 2.5.1
CO3	TPS3	Apply	Value	Mechanism	1.3, 2.1.1, 2.1.2, 2.4.2, 2.4.3, 2.4.6, 2.5.1, 2.5.4, 3.1.1, 3.1.5
CO4	TPS3	Apply	Value	Mechanism	1.3, 2.1.1, 2.1.2, 2.4.2, 2.4.3, 2.4.6, 2.5.1, 2.5.4, 3.1.1, 3.1.5
CO5	TPS3	Apply	Value	Mechanism	1.3, 2.1.1, 2.1.2, 2.4.2, 2.4.3, 2.4.6, 2.5.1,2.5.4,3.1.1, 3.1.5
CO6	TPS4	Analyse	Organise	Complex Overt Responses	1.3, 2.1.1, 2.1.2, 2.4.2, 2.4.3, 2.4.6, 2.5.1,2.5.4, ,3.1.1,3.1.5

Mapping with Programme Outcomes and Programme Specific Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	S	M	L	-	L	-	-	L	L	L	-	L	M	-	L
CO2	S	M	L	-	L	-	-	L	L	L	-	L	M	-	L
CO3	S	M	L	-	L	-	-	L	L	L	-	L	M	-	L
CO4	S	M	L	-	L	-	-	L	L	L	-	L	M	-	L
CO5	S	M	L	-	L	-	-	L	L	L	-	L	M	-	L
CO6	S	S	M	L	L	-	-	L	L	L	-	L	S	-	L

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

Cognitive Levels	Continuous Assessment Tests			Assignment			End Semester Examination
	1	2	3	1	2	3	
Remember	0	0	0	0	0	0	0
Understand	20	20	20	0	0	0	20
Apply	80	80	60	100	30	30	60
Analyse	0	0	20	0	40	40	20
Evaluate	0	0	0	0	0	0	0
Create	0	0	0	0	0	0	0

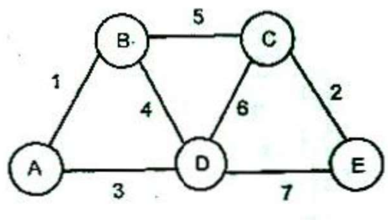
Assessment Pattern: Psychomotor

Psychomotor Skill	Assignment-1	Assignment-2	Assignment-3
Perception	-	-	-
Set	-	-	-
Guided Response	-	-	-
Mechanism	-	30	20
Complex Overt Responses	-	-	10
Adaptation	-	-	-
Origination	-	-	-

Sample Questions for Course Outcome Assessment

Course Outcome 1 (CO1):

1. Differentiate DFS and BFS search methods.
2. Find the shortest path between "A" and "E" in the graph shown in Figure using Dijkstra's algorithm and also find the minimum spanning tree for the same graph using Prim's algorithm



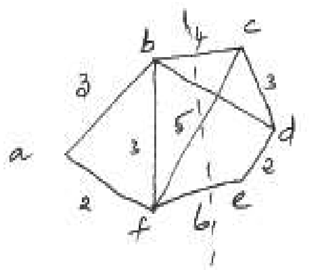
3. Discuss on the VLSI Design methodologies used for IC layout design.
4. Explain the Gajski Y-chart.

Course Outcome 2 (CO2):

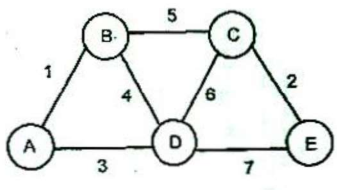
1. For the Boolean function f (x_1,x_2, x_3) = (0,1,2,5,6,7).Find its locally and globally minimal irredundant prime cover.
2. With suitable example, explain hoe ROBDD can be used in different applications.
3. Draw the ROBDD for the given function f = ab(c + d)

Course Outcome 3 (CO3):

1. Explain how Kernighan-Lin algorithm is used for partitioning and using the algorithm, find the minimum cut for the graph shown in Figure.



2. Find the shortest path between “A” and “E” in the graph shown in Figure using Dijkstra’s algorithm and also find the minimum spanning tree for the same graph using Prim’s algorithm



3. Design a cost function for the general building block placement problem which considers the wire length, estimated area, module overlap, and aspect ratio of the entire layout.

Course Outcome 4 (CO4):

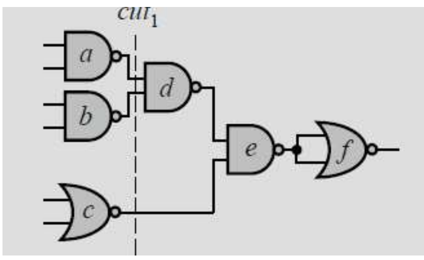
1. Prove that there is a one-to-one correspondence between a sliceable floorplan and a normalized Polish expression.
2. Given a Polish expression corresponding to a given a slicing floorplan, show that the expression 12-3-.....-n- can be reached and vice versa.
3. Find an optimal implementation of modules $M_{1,}$.........M_8 for sizing of the following sliceable floorplans.
   Floor 1: 1 2 V 3 4 V H 5 6 V 7 8 V H V
   Floor 2: 1 2 V 3 4 V 5 H 6 V 7 H 8 V H

Course Outcome 5 (CO5):

1. Given: (1) placement P of blocks a-f and their pins (right) and (2) nets N1-N3 and their net weights. Estimate the total weighted wirelength of P using the RMST model.

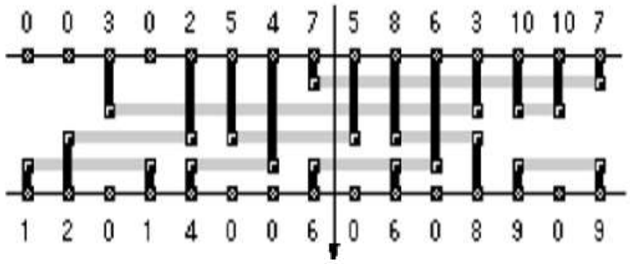
   N1 = (a1,b1,d2) w(N1) = 2
   N2 = (c1,d1,f1) w(N2) = 4
   N3 = (e1,f2) w(N3) = 1

2. Given: (1) circuit with gates a-f (left), (2) 2 × 4 layout (right), and (3) initial vertical cut cut1. Find a placement with minimum wirelength using alternating cutline directions and the KL algorithm.

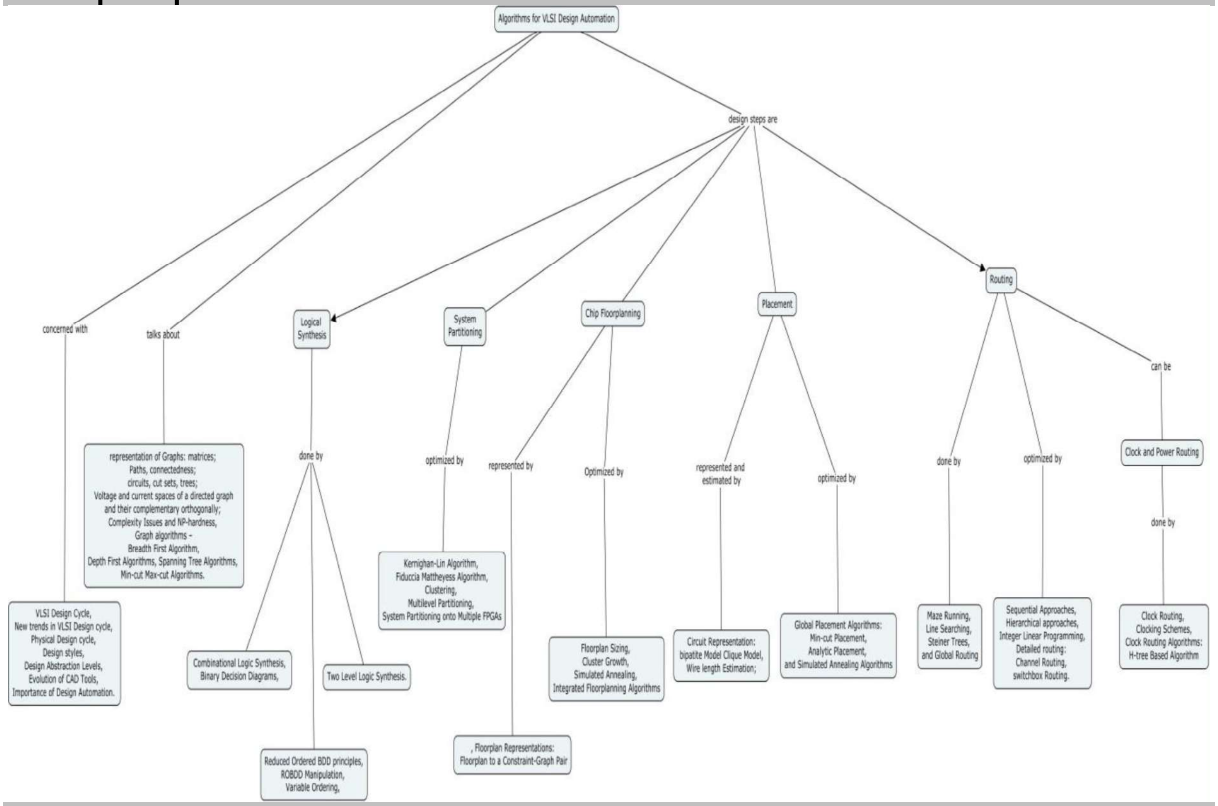


Course Outcome 6 (CO6):

1. Show that left edge algorithm produces a solution, with a number of rows exactly equal to the density of the problem.
2. Draw the horizontal and vertical constraint graphs for the channel shown in below figure. Explain how to handle the net that exist the channel and its pseudo terminal.



Concept Map



Syllabus

VLSI Design Automation: VLSI Design Cycle, New trends in VLSI Design cycle, Physical Design cycle, Design styles, Design Abstraction Levels, Evolution of CAD Tools, Importance of Design Automation. **Data Structures and Basic Algorithms:** Terminology, Data Structures for the representation of Graphs: matrices; Paths, connectedness; circuits, cut sets, trees; Voltage and current spaces of a directed graph and their complementary orthogonally; Complexity Issues and NP-hardness, Graph algorithms – Breadth First Algorithm, Depth First Algorithms, Spanning Tree Algorithms. **Logic Synthesis:** Combinational Logic Synthesis, Binary Decision Diagrams, Reduced Ordered BDD principles, ROBDD Manipulation, Variable Ordering, Two Level Logic Synthesis. **System Partitioning:** Terminology, Optimization Goals, Partitioning Algorithms: Kernighan-Lin Algorithm, Extension of Kernighan–Lin Algorithm, Fiduccia Mattheyess Algorithm, Clustering. **Chip Planning**: Terminology, Optimization Goals in Floorplanning, Floorplan Representations: Floorplan to a Constraint-Graph Pair, Floorplanning Algorithms: Floorplan Sizing, Cluster Growth, Simulated Annealing. **Placement:** Circuit Representation: Bipartite Model Clique Model, Wire length Estimation; Global Placement Algorithms: Min-cut Placement, Analytic Placement, and Simulated Annealing Algorithms. **Routing:** Maze Running, Line Searching, Steiner Trees, and Global Routing: Sequential Approaches, Hierarchical approaches, Detailed routing: Channel Routing, switchbox Routing. **Clock and Power Routing:** Clock Routing, Clocking Schemes, Design Considerations for the Clocking System, Problem Formulation, Clock Routing Algorithms: H-tree Based Algorithm, Power and Ground Routing.

Learning Resources

- Naveed Sherwani, Algorithms for VLSI physical design Automation, Kluwer Academic Publishers, 2010.
- S.H. Gerez, Algorithms for VLSI Design Automation, Wiley-India, Reprint 2008
- Sung Kyu Lim, “Practice Problems in VLSI physical design Automation”, Springer, 2008
- Charles J . Alpert, Dinesh P. Mehta, Sachin S. Sapatnekar, “Hand book of algorithms of Physical design Automation “, CRC press, 2009.
- Sadiq M .Sait, Habib Youssef, “VLSI Physical design automation theory and Practice”, World Scientific Publishing, 1999
- M. Sarrafzadeh and C.K. Wong, *An Introduction to VLSI Physical Design*, McGraw Hill, 1996
- D.D Gajski et al., *High Level Synthesis: Introduction to Chip and System Design*, Kluwer Academic Publishers, 1992
- https://www.coursera.org/learn/vlsi-cad-logic
- https://nptel.ac.in/courses/106/106/106106088/

Course Contents and Lecture Schedule

No.	Topic	No. of Hours	COs
1	**VLSI Design Automation Tools**		
1.1	VLSI Design Cycle, New trends in VLSI Design cycle, Physical Design cycle	2	CO1
1.2	Design styles,	1	CO1
1.3	Design Abstraction Levels, Evolution of CAD Tools, Importance of Design Automation.	1	CO1
1.4	**Data Structures and Basic Algorithms:** Terminology, Data Structures for the representation of Graphs: matrices; Paths, connectedness; circuits, cut sets, trees;	2	CO1
1.5	Voltage and current spaces of a directed graph and their complementary orthogonal	1	CO1
1.6	Complexity Issues and NP-hardness	2	CO1
1.7	Graph algorithms – Breadth First Algorithm, Depth First Algorithms	2	CO1
1.8	Spanning Tree Algorithms	2	CO1
2	**Logic Synthesis**		
2.1	Combinational Logic Synthesis	1	CO2
2.2	Binary Decision Diagrams	1	CO2
2.3	Reduced Ordered BDD principles	2	CO2
2.4	ROBDD Manipulation, Variable Ordering	1	CO2
2.5	Two Level Logic Synthesis	2	CO2
	Assignment I: Implement the graph algorithms in VLSI Design Problems using C/C++/python with Data structure concept.		CO1 & CO2
3	**System Partitioning**		
3.1	Terminology, Optimization Goals	1	CO3
3.2	Partitioning Algorithms: Kernighan-Lin Algorithm	2	CO3
3.3	Extension of Kernighan–Lin Algorithm	1	CO3
3.4	Fiduccia Mattheyess Algorithm	2	CO3
3.5	Clustering	1	CO3
4	**Chip Planning**		
4.1	Terminology, Optimization Goals in Floorplanning	1	CO4
4.2	Floorplan Representations: Floorplan to a Constraint-Graph Pair	1	CO4
4.3	Floorplanning Algorithms: Floorplan Sizing	2	CO4
4.4	Cluster Growth	2	CO4

4.5	Simulated Annealing	1	CO4
	Assignment II: Implement the Partitioning/Floorplanning Optimization Algorithm using C/C++/python with Data structure concept.		CO3 & CO4
5.	**Placement Algorithms**		
5.1	Circuit Representation: bipartite Model, Clique Model	2	CO5
5.2	Wire length Estimation	1	CO5
5.3	Global Placement: Min-cut Placement	1	CO5
5.4	Analytic Placement	1	CO5
5.5	Simulated Annealing Algorithms	2	CO5
6	**Routing Algorithms**		
6.1	Maze Running, Line Searching	2	CO6
6.2	Steiner Trees	1	CO6
6.3	Global Routing: Sequential Approached	1	CO6
6.4	Hierarchical approaches	1	CO6
6.5	Detailed routing: Channel Routing, switchbox Routing	2	CO6
	Assignment III: Compare the performance of various placement and routing algorithms in VLSI Circuits using EDA Tools		CO5 & CO6

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18ECRF0	LOW POWER VLSI DESIGN

Category	L	T	P	Credit
PEES	3	1	0	4

Preamble

Increased levels of integration (increased functionality) and higher throughput under tight power budgets has led to the need for changes in the traditional way of designing circuits and systems. Portable communication and computation have driven the need for low-power electronics. Recent progress has been made in creating tools for estimating power dissipation in CMOS circuits. The research approach is to use accurate and efficient power estimation techniques to drive the design of new low-power systems. Software tools for testing integrated circuits, rapid fault simulation, and failure analysis are also being developed. This course discusses design techniques, estimation and optimisation of power at various levels of design abstraction for designing energy-efficient digital systems used in battery operated devices

Prerequisite

18EC330 Electronic Circuits

Course Outcomes

On the successful completion of the course students will be able to

CO#	Course Outcome Statement	Weightage in %
CO1	Calculate the dynamic and static power dissipation for CMOS Digital logic Circuits.	15
CO2	Estimate the switching power in CMOS digital circuits using probabilistic and statistical techniques.	15
CO3	Estimate the leakage current for the low voltage CMOS digital circuits.	15
CO4	Optimize the given Digital logic and arithmetic circuits for reduced power consumption.	15
CO5	Suggest circuit design techniques for the different elements of Memory to reduce power consumption.	15
CO6	Modify the existing digital logic circuits and SRAM using the energy recovery techniques	15
CO7	Describe the techniques to consider while designing software for a low power system	10

CO Mapping with CDIO Curriculum Framework

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS3	Apply	Value	-	1.3, 2.1.1, 2.1.3, 2.4.2, 2.5.1, 3.1.1, 3.2.3
CO2	TPS3	Apply	Value	-	1.3, 2.1.1, 2.1.3, 2.4.6, 2.5.1, 3.1.1, 3.2.3, 4.4.3, 4.5.5
CO3	TPS3	Apply	Value	-	1.3, 2.1.1, 2.1.3, 2.4.6, 2.5.1, 3.1.1, 3.2.3, 4.4.3, 4.5.5
CO4	TPS4	Analyse	Organise	-	1.3, 2.1.1, 2.1.3, 2.1.5, 2.4.6, 2.5.1, 2.5.4, 3.2.3, 4.1.5, 4.3.3. 4.5.5
CO5	TPS4	Analyse	Organise	-	1.3, 2.1.1, 2.1.3, 2.1.5, 2.4.6, 2.5.1, 2.5.4, 3.2.3, 4.1.5, 4.3.3. 4.5.5
CO6	TPS4	Analyse	Organise	-	1.3, 2.1.1, 2.1.3, 2.5.1
CO7	TPS2	Understand	Respond	-	1.3, 2.5.4, 3.2.6

Mapping with Programme Outcomes and Programme Specific Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	S	M	L	-	L	-	-	L	L	L	-	-	M	L	-
CO2	S	M	L	L	L	-	-	L	L	L	-	L	M	L	-
CO3	S	M	L	L	L	-	-	L	L	L	-	L	M	L	-
CO4	S	S	M	M	L	-	-	L	L	L	-	L	S	L	L
CO5	S	S	M	M	L	-	-	L	L	L	-	L	S	L	L
CO6	S	S	M	M	L	-	-	L	L	L	-	L	S	L	L
CO7	M	L	-	-	-	-	-	-	-	-	-	-	L	-	-

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

Cognitive Levels	Continuous Assessment Tests			Assignment			End Semester Examination
	1	2	3	1	2	3	
Remember	20	0	0	-	-	-	0
Understand	20	20	20	-	-	-	20
Apply	60	40	30	100	100		50
Analyse	0	40	30	0	-	100	20
Evaluate	0	0	10	0	0	0	10
Create	0	0	0	0	0	0	0

Assessment Pattern: Psychomotor

Psychomotor Skill	Assignment 2	Assignment 3
Perception	-	-
Set	-	-
Guided Response	-	-
Mechanism	-	-
Complex Overt Responses	-	-
Adaptation	-	-
Origination	-	-

Sample Questions for Course Outcome Assessment

Course Outcome 1(CO1):

1. A 32 bit off-chip bus operating at 5V and 66 MHz clock rate is driving a capacitance of 25 pF/bit. Each bit is estimated to have a toggling probability of 0.25 at each clock cycle. What is the power dissipation in operating the bus?
2. The chip size of the CPU is 15mm*25mm with the clock frequency of 300MHZ operating at 3.3.The length of the clock signal estimated to be twice the circumference of the chip. Assume that the clock signal is routed on a metal layer with the width of 1.2um and parasitic capacitance of the metal layer is 1Ff/um^2.What is the power dissipation of the clock signal?
3. Silicon is doped with boron to a concentration of $N_A=4*10^{17}$ atoms/cm^3 and the semiconductor is used to form a junction with an aluminium metal with work function 4.1eV. Calculate the work function difference between the metal and semiconductor. Assume the intrinsic concentration carrier concentration of silicon is $1.5*10^{10}$ cm^{-3} at room temperature of T=300K.

Course Outcome 2(CO2):

1. Find the dynamic Power Dissipation of a circuit operating at 500 MHZ with a supply voltage of 0.9 V and a capacitance value per unit area 150 pf/mm^2.The chip size is 80mm^2.Assume the activity factor to be 0.1.
2. Find the area and power for the given function F1=ab+db+ce all inputs have equal probability = 0.5. The signal activities are D(a)=0.2; D(b)=0.3; D(c)=0.1; D(d)=2.5; D(e)=0.1;

3. Calculate the power for the given function F2= ac+cd+be. Whose primary inputs have equal probability of 0.5. The signal activities are D(a)=0.2; D(b)=0.3; D(c)=0.1; D(d)=2.5; D(e)=0.1.

Course Outcome 3(CO3):

1. Draw a semiconductor MOSFET transistor showing the possible sources of leakage currents in it and also derive the expression for the CMOS leakage current.
2. Illustrate the process of overcoming the leakage current by explaining the operation of domino logic NAND gate.

Course Outcome 4 (CO4):

1. Use the pass-transistor logic circuits to construct the logic function *F*= $AB+\overline{B}C+\overline{A}\cdot\overline{B}$
2. Construct a logic function $F = AB + AC + \overline{A}D\overline{E} + BE$ using CPL and DPTL and LEAP. Use binary decision diagram (BDD) to design the above logic function.
3. Using and domino dynamic logic circuits, design a logic function $F = A \oplus B \oplus C$ in one stage and two cascading stages. Analyse and discuss the transient performance of the circuit for load capacitances of 0.01pF, 0. 1pF, and 0.5pF, and at supply voltages of 5V, 3.3V, 2.5V, and 1.5V.

Course Outcome 5 (CO5):

1. Use static CMOS logic circuits and complementary pass-transistor logic (CPL) to design the parallel adder. Which approach has the best speed performance (smallest propagation delay)? For the design with the best speed performance, is its throughput also the highest?
2. Compare the performance of the multipliers using Wallace tree reduction with 3-to-2 and 4-to-2 compressor, modified Booth encoder/decoder, and combining modified Booth encoder/decoder with Wallace tree reduction.

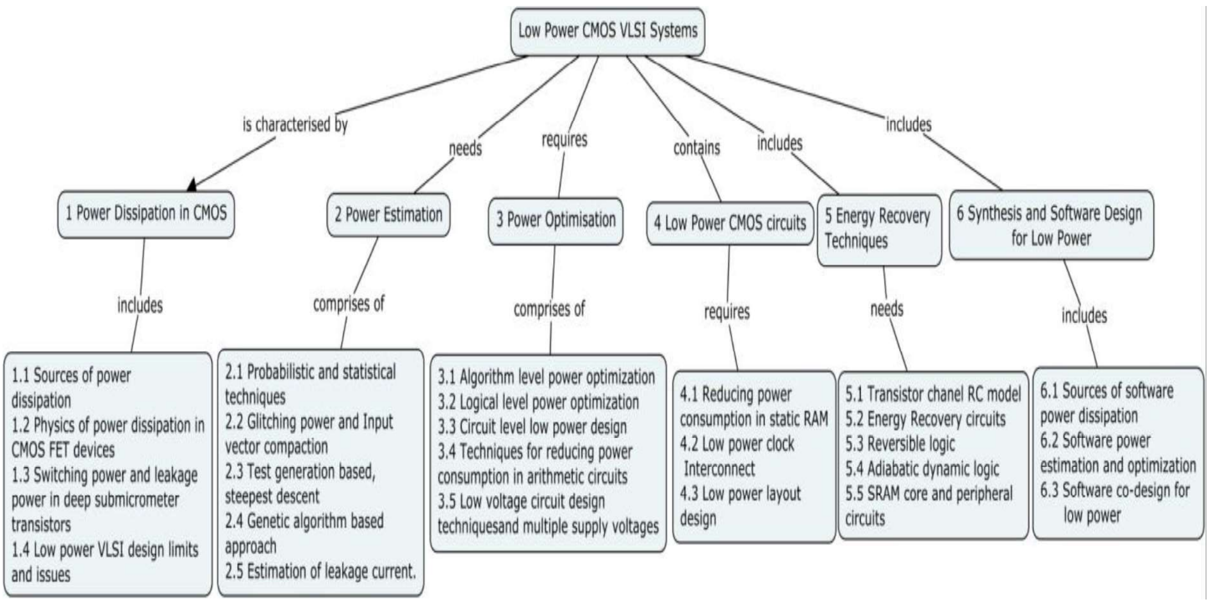
Course Outcome 6(CO6):

1. List the factors that affect the initial voltage difference in the DRAM bit lines during the read cycle of the memory circuit.
2. When the supply voltage is lowered, examine the influence of initial voltage difference in the bit lines during the read cycle?

Course Outcome 7(CO7):

1. Explain the average power dissipation associated with each instruction sequence of instruction set for ILPA.
2. Describe the instruction ordering and operand ordering techniques used for reducing the power dissipation associated with software synthesis.

Concept Map



Syllabus

Power Dissipation in CMOS: Sources of power dissipation, Physics of power dissipation in CMOS FET devices, leakage mechanism, leakage current in deep submicrometer transistors, low power VLSI design limits and issues. **Power Estimation:** Average power estimation techniques at logic level: probabilistic, statistical, Glitching power, Input vector compaction, Circuit level power estimation, Estimation of maximum power: Estimation of leakage current.
Power Optimization: Algorithm level, Logical level and Circuit level power Optimization techniques, Techniques for reducing power consumption in digital circuits, Low voltage circuit design techniques and multiple supply voltages. **Low Power Static RAM Circuits:** Reducing power consumption in static RAM: Memory cell, Bit lines, write driver circuit and sense amplifier circuits. **Energy Recovery Techniques**: Transistor channel RC model, Energy recovery circuit design, Partially reversible logic, Adiabatic Dynamic logic, Energy recovery in SRAM core and peripheral circuits. **Synthesis and Software Design for Low Power:** Sources of software power dissipation. Software power estimation, software power optimization, Co-design for low power.

Learning Resources

- Kaushik Roy and Sharat Prasad, “Low Power CMOS VLSI Circuit Design”, Wiley India, Reprint 2009.
- Gary Yeap, “Practical Low Power Digital VLSI Design”, Kluwer, 1998.
- A.P. Chandrakasan and R.W. Broadersen, “Low Power Digital CMOS Design”, Kluwer,1995.
- Abdellatif Bellaouar, Mohamed. I. Elmasry, “Low Power Digital VLSI designs” Kluwer, 1995.
- Dimitrios Soudris, Chirstian Pignet, Costas Goutis, “Designing CMOS Circuits for Low Power”,Kluwer,2002.
- J.B. Kuo and J.H Lou, “Low voltage CMOS VLSI Circuits”, Wiley, 1999.
- A. Wang, B. H. Calhoun and A. P. Chandrakasan, “Sub-threshold Design for Ultra Low-Power Systems”, Springer, 2006.

Course Contents and Lecture Schedule

Module No.	Topic	No. of Lectures	COs
1	**Power Dissipation in CMOS**		
1.1	Sources of power dissipation	1	CO1
1.2	Physics of power dissipation in CMOS FET devices	2	CO1
1.3	switching power and leakage power in deep submicrometer transistors	2	CO1
1.4	low power VLSI design limits and issues	1	CO1
2	**Power Estimation**		
2.1	Probabilistic techniques	2	CO2
2.2	Statistical techniques	2	CO2
2.3	Glitching power	1	CO2
2.4	Input vector compaction	1	CO2
2.5	Circuit level power estimation	2	CO3
2.6	Estimation of leakage current.	2	CO3
3.	**Power Optimization**		
3.1	Algorithm level power optimization	2	CO4
3.2	Logical level power optimization	2	CO4
3.3	Circuit level low power design	2	CO4
3.4	Reducing power consumption in digital circuits	2	CO4
3.5	Low voltage circuit design techniques and multiple supply voltages	2	CO4
4	**Low Power CMOS Circuits**		
4.1	Reducing power consumption in static RAM: Memory cell	2	CO5

4.2	Bit lines, write driver circuits	2	CO5
4.3	Sense amplifier circuits	2	CO5
5	**Energy Recovery Techniques**		
5.1	Transistor channel RC model	2	CO6
5.2	Energy recovery circuit design	2	CO6
5.3	Partially reversible logic	2	CO6
5.4	Adiabatic Dynamic logic	2	CO6
5.5	Energy recovery in SRAM core and peripheral circuits.	2	CO6
5	**Synthesis and Software Design for Low Power**		
5.1	Sources of software power dissipation	2	CO7
5.2	Software power estimation and software power optimization	2	CO7
5.3	Software co-design for low power	2	CO7
	Total Number of Hours	**48**	

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SYLLABI

FOR

INDUSTRY SUPPORTED COURSES

B.E. DEGREE PROGRAMME

IN

ELECTRONICS AND COMMUNICATION ENGINEERING

FOR THE STUDENTS ADMITTED IN THE

ACADEMIC YEAR 2018-19 ONWARDS

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING
THIAGARAJAR COLLEGE OF ENGINEERING
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18EC1A0	FIELD TESTS FOR A 5G FUTURE

Category	L	T	P	Credit
PEES	1	0	0	1

Preamble

The advent of the Fifth Generation of Mobile Networks is creating a huge expectation in the enhancements of mobile services regarding higher throughput, low latency, ultra-high reliability, and higher connectivity density. The goal of field test is to determine the throughput and coverage that the 5G-range transceiver can achieve under real conditions. This course aims to provide solid foundation on basic understanding of RF test and measurements for 5G, base station RF parametric test, Interference troubleshooting, electromagnetic field measurements, Over the air test and Inter-RAT (Radio access technology).

Prerequisite

NIL

Course Outcomes

On the successful completion of the course students will be able to

CO#	Course Outcome Statement	Weightage in %
CO1	Interpret RF test instruments, passive & active component test and characterization	30
CO2	Illustrate the base station test, EVM measurement, Interference troubleshooting with real time spectrum analysis	30
CO3	Illustrate the EM field measurement test, OTA, Coverage test with phased array antenna, Inter-RAT	40

CO Mapping with CDIO Curriculum Framework

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS2	Understand	Respond	-	1.2.3, 2.4.6, 3.2.3
CO2	TPS3	Apply	Value	Mechanism	1.2.1, 2.1.1, 2.1.2, 2.4.2, 2.4.6, 2.5.1, 3.1.1, 3.2.3, 4.5.5, 4.6.2
CO3	TPS3	Apply	Value	Mechanism	1.2.1, 2.1.1, 2.1.2, 2.4.2, 2.4.6, 2.5.1, 3.1.1, 3.2.3, 4.5.5, 4.6.2

Mapping with Programme Outcomes and Programme Specific Outcomes

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	M	L	-	-	-	-	-	-	-	-	-	-	M	-	L
CO2	S	M	L	-	S	-	-	-	M	M	-	-	M	M	L
CO3	S	M	L	-	S	-	-	-	M	M	-	-	M	M	L

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

Cognitive Levels	Continuous Assessment Tests			Assignment			End Semester Examination
	1	2	3	1	2	3	
Remember	-	-	-	-	-	-	0
Understand	-	-	20	-	-	20	20
Apply	-	-	80	-	-	80	80
Analyze	-	-	-	-	-	-	0
Evaluate	-	-	-	-	-	-	0
Create	-	-	-	-	-	-	0

Syllabus

RF concepts and understanding of RF Test & RF Instruments -Frequency vs Time domain analysis - testing active and passive devices **Base station RF Parametric Test** - Performance verification of gNB such as cable and antenna conditions, transmit power, RF spurious responses. **Interference troubleshooting with Real time Spectrum Analysis** - Detect 5G synchronization signals and interference with RTSA, EVM measurement, detection of SSB offset, subcarrier spacing. **Electromagnetic Field Measurement for total human RF exposure** - Measurement of total field strength, Pass/fail limit testing. **5G NR Over the air testing** - Capturing and demodulating over-the-air transmissions of 5G NR FR1 and FR2 control channels, key performance indicators, isolate power issues **Coverage test with phased array antenna** - Coverage testing of 5G base stations, collecting signal power data across azimuth and elevation. **Inter-RAT (Radio access technology) optimization** - RAT handovers between 4G and 5G networks in non-standalone (NSA) mode.

Learning Resources

- Joel P. Dunsmore, Handbook of Microwave Component Measurements: with Advanced VNA Techniques, 2nd Edition, Wiley, 2020.
- Carvalho N, Schreurs D, Microwave and Wireless Measurement Techniques, Cambridge University Press, 2013.
- Allen W. Scott, Rex Frobenius, RF Measurements for Cellular Phones and Wireless Data Systems, Wiley-IEEE Press, 2011.
- Richard Collier, Doug Skinner, Microwave Measurements, Third edition, IET, 2007.

Course Contents and Lecture Schedule

No.	Topic	No. of Hours	COs
1.	**RF concepts and basic understanding of RF Test & RF Instruments** -Frequency vs Time domain, spectrum analysis	2	CO1
2.	Testing active and passive devices, time domain analysis.	2	CO1
3.	**Base station RF Parametric Test** - Performance verification of gNB such as cable and antenna conditions, transmit power, RF spurious responses.	2	CO2
4.	**Interference troubleshooting with Real time Spectrum Analysis** - Detect 5G synchronization signals and interference with RTSA, EVM measurement, detection of SSB offset, subcarrier spacing	2	CO2
5.	**Electromagnetic Field Measurement for total human RF exposure** - Measurement of total field strength, Pass/fail limit testing.	1	CO3
6.	**5G NR Over the air testing** - Capturing and demodulating over-the-air transmissions of 5G NR FR1 and FR2 control channels, key performance indicators, isolate power issues.	2	CO3
7.	**Coverage test with phased array antenna** - Coverage testing of 5G base stations, collecting signal power data across azimuth and elevation	2	CO3
8.	**Inter-RAT (Radio access technology) optimization** - RAT handovers between 4G and 5G networks in non-standalone (NSA) mode.	2	CO3
	Total Hours	15	

Course Designers:

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18EC1B0	DEEP LEARNING WITH TENSORFLOW

Category	L	T	P	Credit
PEES	1	0	0	1

Preamble

Deep Learning has received a lot of attention over the past few years and has been employed successfully by companies like Google, Microsoft, IBM, Facebook, Twitter. Recent developments in deep learning approaches have significantly advanced the performance of many computer vision applications. This course is a deep dive into the details of deep learning architecture with a focus on learning end-to-end models for the image classification task. Students will gain a detailed understanding of neural networks and will learn to implement and train their neural networks.

Prerequisite

NIL

Course Outcomes

On the successful completion of the course students will be able to

CO#	Course Outcome Statement	Weightage in %
CO1	Illustrate the design of deep neural network architecture.	20
CO2	Explore an entire TensorFlow deep learning pipeline.	25
CO3	Construct the design of convolutional neural network architecture.	25
CO4	Make use of the Alexnet deep convolutional model for image classification.	30

CO Mapping with CDIO Curriculum Framework

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS2	Understand	Respond	-	1.3, 2.4.6
CO2	TPS3	Apply	Value	-	1.3, 3.2.4, 3.3.1, 4.1.2, 4.5.3
CO3	TPS3	Apply	Value	-	1.3, 3.2.4
CO4	TPS3	Apply	Value	-	1.3, 3.2.4, 3.3.1, 4.1.2, 4.5.3

Mapping with Programme Outcomes and Programme Specific Outcomes

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	M	L	-	-	-	-	-	-	L	-	-	M	L	L	L
CO2	S	M	L	-	M	-	-	-	M	-	-	M	M	L	M
CO3	S	M	L	-	M	-	-	-	M	-	-	M	M	L	M
CO4	S	M	L	-	M	-	-	-	M	-	-	M	M	L	M

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

Cognitive Levels	Continuous Assessment Tests	End Semester Examination
Remember	0	0
Understand	20	20
Apply	80	80
Analyse	0	0
Evaluate	0	0
Create	0	0

Assessment Pattern: Psychomotor

Psychomotor Skill			
Perception	-	-	-
Set	-	-	-

Guided Response	-	-	-
Mechanism	-	-	-
Complex Overt Responses	-	-	-
Adaptation	-	-	-
Origination	-	-	-

Syllabus

Learning Paradigms: AI, Deep learning, ANN, Designing a Deep Neural Network, Architecture with one hidden layer, Loss function **Tensor flow and its elements:** Running a simple TensorFlow net and establishing a baseline, Improving the simple net in TensorFlow with hidden layers and Dropout, Testing different optimizers in TensorFlow, Increasing the number of epochs, Controlling the optimizer learning rate **Convolutional Neural Network:** CNN Architecture: Convolution, Stride, and padding in convolutional layers, Pooling layers, FCN, activation function, Pooling layers, Normalization, FCN, CNN for classification: Training, Testing, Validation **Deep Convolutional Model:** Alexnet Architecture, Anchor boxes**,** Loss functions **Case Study:** Alexnet based Image classification by Transfer learning with TensorFlow.

Learning Resources

- Ian Goodfellow, Yoshua Benjio, Aaron Courville, “Deep Learning”, The MIT Press, 2016.
- Richard O. Duda, Peter E. Hart, David G. Stork, “Pattern Classification”, John Wiley. 2nd Edition, 2007.
- Dr.Prabir Kumar Biswas, Deep Learning, NPTEL Video Lectures: https://nptel.ac.in/courses/106/105/106105215/
- https://www.coursera.org/specializations/deep-learning
- https://online.stanford.edu/courses/cs230-deep-learning

Course Contents and Lecture Schedule

Mod. No.	Topic	No. of Hours	COs
1.	**Learning Paradigms:**		CO1
1.1	AI, Deep learning, ANN, Designing a Deep Neural Network: Neural Networks, Architecture with one hidden layer	1	CO1
1.2	Activation function, Derivatives, Gradient Descent, Batch size, Scaling features, number of epochs, Optimization, Hyperparameters tuning	1	CO1
1.3	Batch Normalization, Drop out, Learning rate, Loss function, choosing the loss function: Regression loss (MSE), Binary classification loss and Multi-classification loss (Cross entropy)	1	CO1
2.	**Simple neural network using TensorFlow:**		CO2
2.1	Running a simple TensorFlow net and establishing a baseline	1	CO2
2.2	Improving the simple net in TensorFlow with hidden layers and Dropout	1	CO2
2.3	Testing different optimizers in TensorFlow	0.5	CO2
2.4	Increasing the number of epochs, Controlling the optimizer learning rate	0.5	CO2
3.	**Convolutional Network**		CO3
3.1	CNN Architecture: The structure of a convolutional network: Convolution,	2	CO3
3.2	Stride and padding in convolutional layers, activation function, Pooling layers, Normalization, FCN	1	CO3
3.3	CNN for classification: Training, Testing, Validation	1	CO3
4.	**Deep Convolutional Model – Alexnet**		CO4

4.1	Anchor boxes, Ground Truth Anchor boxes, Loss functions	0.5	CO4
4.2	Alexnet Model Architecture	1.5	CO4
4.3	**Case Study:** Alexnet based image classification	1	CO4
4.4	Image classification by Transfer learning with TensorFlow	1	CO4

Course Designers:

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18EC1C0	SYNCHRONISATION IN 5G NEW RADIO

Category	L	T	P	Credit
PEES	1	0	0	1

Preamble

The objective of the course on “Synchronization in 5G New Radio” is to present the synchronisation signals, algorithms and their hardware realisation in the physical layer of 5G new radio standards. This course would be more helpful in carrying out projects in state of art telecommunication domains

Prerequisite

18EC530 - Analog and Digital Communication Systems

Course Outcomes

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

CO#	Course Outcome Statement	Weightage in %
CO1	Describe the synchronization signals in 5G NR	20
CO2	Design frequency and timing estimation algorithms for initial access and synchronization features of 5G NR	30
CO3	Describe the architecture and programming capabilities of Analog devices Adam Pluto Software Defined Radio (SDR) Platform	20
CO4	Implement 5G NR Synchronization Signal Block on Pluto Software Defined Radio (SDR) Platform	30

CO Mapping with CDIO Curriculum Framework

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS2	Understand	Respond	-	1.2.3, 2.4.6, 3.2.3
CO2	TPS3	Apply	Value	Mechanism	1.2.1, 2.1.1, 2.1.2, 2.4.2, 2.4.6, 2.5.1, 3.1.1, 3.2.3, 4.5.5, 4.6.2
CO3	TPS2	Understand	Respond	-	1.2.3, 2.4.6, 3.2.3
CO4	TPS3	Apply	Value	Mechanism	1.2.1, 2.1.1, 2.1.2, 2.4.2, 2.4.6, 2.5.1, 3.1.1, 3.2.3, 4.5.5, 4.6.2

Mapping with Programme Outcomes and Programme Specific Outcomes

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	M	L	-	-	-	-	-	-	-	-	-	-	L	-	-
CO2	S	M	L	-	-	-	-	-	-	-	-	-	M	-	-
CO3	M	L	-	-	-	-	-	-	-	-	-	-	L	-	-
CO4	S	M	L	-	S	-	-	-	S	S	-	-	M	M	L

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

Cognitive Levels	Continuous Assessment Tests			Assignment			End Semester Examination
	1	2	3	1	2	3	
Remember	-	-	-	-	-	-	0
Understand	-	-	20	-	-	20	20
Apply	-	-	80	-	-	80	80
Analyze	-	-	-	-	-	-	0

Evaluate	-	-	-	-	-	-	0
Create	-	-	-	-	-	-	0

Syllabus

5G NR overview: 5G NR Features, protocol stack, physical signals and procedures **Synchronization in 5G NR:** Synchronisation Signals and Algorithms **Pluto SDR Platform:** Architecture and Programming capabilities **Hardware realization:** Implementation of 5G NR SSS on Pluto SDR platform with near real time update of PSS, SSS and PBCH

Learning Resources

- Sassan Ahmadi, “5G NR Architecture, Technology, Implementation, and operation of 3GPP New Radio Standards”, Academic Press, 2019.
- Erik Dahlman, Stefan Parkvall, Johan Skold, “5G NR, The Next Generation Wireless Access Technology”, Academic Press,2018.
- 3GPP TS 23.502, Procedures for the 5G system (Release 15), April 2019.
- 3GPP TS 38.211, NR, Physical Channels and Modulation (Release 15), December 2018.
- 5G New Radio, ShareTechNote. http://www.sharetechnote.com
- https://www.analog.com/en/design-center/evaluation-hardware-and-software/evaluation-boards-kits/adalm-pluto.html
- Xingqin Lin et al.,”5G New Radio: Unveiling the Essentials of the Next Generation Wireless Access Technology”, IEEE Communications Standards Magazine, September 2019.
- A.Omri et al.,”Synchronization Procedure in 5G NR Systems”,IEEE Access,April 2019.

Course Contents and Lecture Schedule

No.	Topic	No. of Hours	COs
1	**5G Overview**		
1.1	5G NR Features and comparison with 4G features	1	CO1
1.2	Protocol stack	1	CO1
1.3	Physical signals and procedures	1	CO1
2	**Synchronization in 5G NR**		
2.1	Synchronization Signals and Algorithms	2	CO2
3	**Adam Pluto SDR Platform**		
3.1	Architecture of Pluto SDR Platform	3	CO3
3.2	Programming	3	CO3
4	**Hardware Realization**		
4.1	Implementation of 5G NR SSB on Pluto SDR platform with near real time update of PSS, SSS	2	CO4
4.2	Implementation of 5G NR SSB on Pluto SDR platform with near real time update of PBCH	2	CO4
Total		14	

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18EC1D0	SPEECH SIGNAL PROCESSING

Category	L	T	P	Credit
PEES	1	0	0	1

Preamble

This course introduces the theory and implementation of modern Automatic Speaker Recognition (ASR) system. It presents a comprehensive overview of feature extraction, acoustic modeling and data modeling. Students will learn how to simulate and implement machine learning algorithms such as Hidden Markov Models and Deep Neural Networks in ASR. This course also extends its applications to Speech to Text and Text to Speech Systems.

Prerequisite

18EC440 – Signal Processing

Course Outcomes

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

CO#	Course Outcome Statement	Weightage in %
CO1	Describe the basic architecture of ASR, Text to Speech (TTS) and Natural Language Processing.	20
CO2	Estimate and optimize the single variable and multivariable function using probability, calculus and optimization primer.	20
CO3	Classify data and training methods based on different ASR system model using kaldi toolkit	30
CO4	Develop different application of ASR system based on Weighted Finite State Transducer (WFST) and Long Short-Term Memory (LSTM) neural networks	30

CO Mapping with CDIO Curriculum Framework

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS2	Understand	Respond	-	1.2., 2.1.1, 2.1.2, 2.4.1, 2.4.2, 2.4.5, 3.2.3, 3.2.5,
CO2	TPS3	Apply	Value	Mechanism	1.2.1, 2.1.1, 2.1.2, 2.1.4, 2.1.5, 2.4.1, 2.4.2, 2.4.5, 3.2.3, 3.2.5,
CO3	TPS3	Apply	Value	Mechanism	1.2.1, 2.1.1, 2.1.2, 2.1.4, 2.1.5, 2.4.1, 2.4.2, 2.4.5, 3.2.3, 3.2.5,
CO4	TPS4	Apply	Value	Mechanism	1.2.1, 2.1.1, 2.1.2, 2.1.3, 2.1.4, 2.1.5, 2.4.1, 2.4.2, 2.4.5, 3.2.3, 3.2.5,

Mapping with Programme Outcomes and Programme Specific Outcomes

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	P O7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PSO 3
CO1	M	L	-	-	-	-	-	-	-	-	-	L	L	-	-
CO2	S	M	L	-	L	-	-	-	-	-	-	L	M	-	-
CO3	S	M	L	-	M	-	-	M	M	M	-	L	M	-	M
CO4	S	M	L	-	M	-	-	S	S	S	-	L	M	-	S

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

Cognitive Levels	Continuous Assessment Tests	Assignment	End Semester Examination
	1	**1**	
Remember	0	0	0
Understand	20	0	20
Apply	60	50	60
Analyse	20	0	20
Evaluate	0	0	0
Create	0	0	0

Assessment Pattern: Psychomotor

Psychomotor Skill	Assignment-1
Perception	-
Set	-
Guided Response	-
Mechanism	50
Complex Overt Responses	-
Adaptation	-
Origination	-

Syllabus

Speech Fundamentals: parametric modeling of quasi-stationary speech signal, Human speech production and perception mechanism, Feature extraction from speech signal: Mel-Frequency Cepstral Coefficient (MFCC), Linear Prediction Cepstral Coefficient (LPCC), natural language processing (NLP) systems. **Basics of ASR and TTS:** Evolution of ASR, Vector Quantization (VQ), Dynamic Time Warping (DTW), Hidden Markov Model (HMM), Deep Neural Network (DNN), Recurrent Neural Network (RNN), Evolution of TTS: concatenative phoneme-based model, HMM based model, Tacotron models, Vocoders for TTS. **Estimation of Single and Multivariable:** Probability Primer, Calculus and Optimization primer **Components of an ASR system:** Lexicon model, Language model, Acoustic model, context dependency model. **Data Preparation and ASR Training:** Monophone training, Triphone training, Maximum Linear transform, speaker adaptive training and DNN Training. **Weighted finite state transducers:** Types of WFST, Operations of WFST, Practical Implementation of ASR using WFST in Kaldi. ASR code walk through **Applications of ASR:** Text aligning, subtitling, pronunciation learning, Text to speech systems, Text Processing and NLP system building: word2Vec models, Internet classification, Finite state machines for chatbot modeling.

Learning Resources

- L. R. Rabiner and R. W. Schafer, “Introduction to Digital Speech Processing”, now Publishers Inc.,2007
- L. R. Rabiner and B. H. Juang, “Fundamentals of Speech Recognition”. Prentice-Hall
- Dong Yu, and Li Deng, “Automatic Speech Recognition: A Deep Learning Approach” Springer, 2014
- https://kaldi-asr.org
- https://indianinstituteofscience-my.sharepoint.com/:f:/g/personal/madhavaraja_iisc_ac_in/EoGNtOQA7TlHi9-Yh4Kch94BQkVQlQyg0E6nbLCDBdxKGg?e=1CUkxv

Course Contents and Lecture Schedule

No.	Topic	No. of Lectures	COs
1	**Speech Fundamentals**		
1.1	parametric modeling of quasi-stationary speech signal, Human speech production and perception mechanism	1	CO1

1.2	Feature extraction from speech signal: Mel-Frequency Cepstral Coefficient (MFCC), Linear Prediction Cepstral Coefficient (LPCC), natural language processing (NLP) systems.	1	CO1
1.3	Basics of ASR and TTS: Evolution of ASR, Vector Quantization (VQ), Dynamic Time Warping (DTW),	1	CO1
1.4	Hidden Markov Model (HMM), Deep Neural Network (DNN), Recurrent Neural Network (RNN), Evolution of TTS: concatenative phoneme-based model, HMM based model, Tacotron models, Vocoders for TTS.	1	
2	**Estimation of Single and Multivariable**		
2.1	Probability Primer	1	CO2
2.2	Calculus and Optimization primer	1	CO2
3	**Components of an ASR system**		
3.1	Lexicon model, Language model, Acoustic model, context dependency model.	1	CO3
3.2	Data Preparation and ASR Training: Monophone training, Triphone training, Maximum Linear transform, speaker adaptive training and DNN Training.	1	CO3
3.3	Practical Implementation of ASR, Kaldi ASR code walk-through	1	CO3
4	**Weighted finite state transducers:**		
4.1	Types of WFST, Operations of WFST: Composition, Minimization, epsilon-removal, projection, weight pushing.	1	CO4
4.2	Practical Implementation of ASR using WFST in Kaldi, ASR code walk through	1	CO4
5	**Applications of ASR**		
5.1	Text aligning, subtitling, pronunciation learning	1	CO4
5.2	Text to speech systems	1	CO4
5.3	Text Processing and NLP system building: word2Vec models, Internet classification	1	CO4
5.4	Finite state machines for chatbot modeling	1	CO4
	Total	15	

Course Designers:

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18EC1E0	VLSI IMPLEMENTATION OF COMMUNICATION TRANSCEIVERS

Category	L	T	P	Credit
PEES	1	0	0	1

Preamble

This course integrates VLSI architecture theory and algorithms for the implementation of communication transmitter and receiver. with low power consumption. This course also deals with the design of high-speed, low-area, and low-power VLSI systems for the implementation of communication systems. It covers pipelining and parallel processing architectures extensively as well as the concepts of PLL.

Prerequisite

NIL

Course Outcomes

On the successful completion of the course students will be able to

CO#	Course Outcome Statement	Weightage in %
CO1	Explain the concept of RTL coding and Canonical Signed Digit representation	20
CO2	Implement DSP algorithms using the concepts of pipelining and parallel architectures	40
CO3	Implement FM transceiver, using the digital filters and PLL	40

CO Mapping with CDIO Curriculum Framework

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psycho motor	
CO1	TPS3	Apply	Value	-	1.2.1, 2.1.1, 2.1.2, 2.1.4, 2.1.5, 2.4.1, 2.4.2, 2.4.5, 3.2.3, 3.2.5,
CO2	TPS3	Apply	Value	-	1.2.1, 2.1.1, 2.1.2, 2.1.4, 2.1.5, 2.4.1, 2.4.2, 2.4.5, 3.2.3, 3.2.5,
CO3	TPS3	Apply	Value	-	1.2.1, 2.1.1, 2.1.2, 2.1.3, 2.1.4, 2.1.5, 2.4.1, 2.4.2, 2.4.5, 3.2.3, 3.2.5.

Mapping with Programme Outcomes and Programme Specific Outcomes

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	S	M	L	L	M	-	-	-	-	-	-	-	M	L	-
CO2	S	M	L	L	M	-	-	-	-	-	-	-	M	L	-
CO3	S	M	L	M	M	-	-	-	-	-	-	-	M	L	-

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

Cognitive Levels	Continuous Assessment Tests	End Semester Examination
Remember	0	0
Understand	20	20
Apply	80	80
Analyse	-	-
Evaluate	-	-
Create	-	-

Assessment Pattern: Psychomotor

Psychomotor Skill	Assignment-1	Assignment-2	Assignment-3
Perception	-	-	-
Set	-	-	-

Guided Response	-	-	-
Mechanism	-	-	-
Complex Overt Responses	-	-	-
Adaptation	-	-	-
Origination	-	-	-

Syllabus

Communication Transceivers: introduction to communication receiver and transmitter, **Case study:** FM Transceiver with specific focus on digital filters and PLL. **Digital Design:** RTL Coding, the concepts of digital synthesis. **Examples of digital FIR filters:** RTL coding, synthesis and FPGA implementation. **Digital filters – architectures:** Pipelining of FIR digital filters, Parallel architecture, Canonical Signed Digit (CSD) implementation, Multi-rate filters – low power implementation, ALU-RAM based digital filter implementation. **PLL Basics:** Introduction - Applications in a Communication Transceiver, Integer and Fractional PLLs, Analog vs digital PLL-Tradeoffs, PLL metrics –Response time, Noise bandwidth, 1st and 2nd order PLL analysis, performance, **PLL advanced:** Specifications of PLL, Phase Noise, Reference Spurs, Phase noise in open loop and closed loop, PLL Phase noise contributors, **Building blocks:** VCO, PFD, TDC, Laboratory practices on Basic digital FIR filter FPGA emulation, Digital PLL on FPGA, ALU-RAM based multi-rate digital filter

Learning Resources

- PLL Performance, Simulation and Design Handbook 4th Edition, National Semiconductor, http://www.national.com/analog/timing/pll_designbook
- K K Parhi , “VLSI Digital Signal Processing Systems’, Wiley India Pvt Ltd, 2007,
- B Razavi, “RF Microelectronics”, Prentice Hall, 1998

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18EC1F0	EMBEDDED SYSTEM DESIGN

Category	L	T	P	Credit
PEES	1	0	0	1

Preamble

Microcontrollers are at the heart of almost every engineering system around us. It is essential that an applications engineer is equipped with the knowledge to understand and design an embedded system. This course provides insight on the key components of a microcontroller-based system, focusing on the core peripherals and their interfacing to develop a complete solution. The course aims to bring a hands-on experience to developing firmware on a microcontroller using the latest IDEs and programming/debugging tools.

Prerequisite

NIL

Course Outcomes

On the successful completion of the course students will be able to

CO#	Course Outcome Statement	Weightage in %
CO1	Explain the architecture of PIC devices, AVR devices and the working of essential peripherals	10
CO2	Develop embedded-c code for various peripherals	40
CO3	Use low power techniques, linking, compilation and start-up process	10
CO4	Implement a complete system by interfacing various peripherals, using latest development tools	40

CO Mapping with CDIO Curriculum Framework

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psycho motor	
CO1	TPS3	Understand	Respond	-	1.2.1, 2.1.1, 2.1.2, 2.1.4, 2.1.5, 2.4.1, 2.4.2, 2.4.5, 3.2.3, 3.2.5,
CO2	TPS3	Apply	Value	-	1.2.1, 2.1.1, 2.1.2, 2.1.4, 2.1.5, 2.4.1, 2.4.2, 2.4.5, 3.2.3, 3.2.5,
CO3	TPS3	Apply	Value	-	1.2.1, 2.1.1, 2.1.2, 2.1.4, 2.1.5, 2.4.1, 2.4.2, 2.4.5, 3.2.3, 3.2.5,
CO4	TPS3	Apply	Value	-	1.2.1, 2.1.1, 2.1.2, 2.1.3, 2.1.4, 2.1.5, 2.4.1, 2.4.2, 2.4.5, 3.2.3, 3.2.5.

Mapping with Programme Outcomes and Programme Specific Outcomes

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	M	L	L	L	M	-	-	-	-	-	-	-	L	L	-
CO2	S	M	L	L	M	-	-	-	-	-	-	-	M	L	-
CO3	S	M	L	M	M	-	-	-	-	-	-	-	M	L	-
CO4	S	M	L	M	M	-	-	-	-	-	-	-	M	L	-

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

Cognitive Levels	Continuous Assessment Tests	End Semester Examination
Remember	0	0
Understand	20	20
Apply	80	80
Analyse	-	-
Evaluate	-	-
Create	-	-

Assessment Pattern: Psychomotor

Psychomotor Skill	Assignment-1	Assignment-2	Assignment-3
Perception	-	-	-
Set	-	-	-
Guided Response	-	-	-
Mechanism	-	-	-
Complex Overt Responses	-	-	-
Adaptation	-	-	-
Origination	-	-	-

Syllabus

Introduction: Architecture Overview: AVR and PIC, 8-bit and 32-bit MCUs
Essential peripherals: Introduction to basic MCU peripherals and their purpose, Clocks, GPIOs, Timer and Counter, Waveform Generation (PWM), Lab-1, Serial Communication: Universal Asynchronous Receiver Transmitter (UART), Two Wire Interface (I2C), Lab-2
Low power design techniques: Sleep modes, Event System, Factors affecting low power, Lab-3**,** Hardware design considerations
Moving the design from concept to reality: Ecosystem (Development Tools), From Embedded-C to Microcontroller, Home Automation **–** Putting together a real-world application

Learning Resources

- I2C(Master):http://ww1.microchip.com/downloads/en/AppNotes/00002480A.pdf
- I2C(Slave):http://ww1.microchip.com/downloads/en/AppNotes/atmel-2565-using-the-twi-module-as-i2c-slave_applicationnote_avr311.pdf
- USART: http://ww1.microchip.com/downloads/en/AppNotes/Atmel-1451-Using-the-AVR-USART-on-tinyAVR-and-megaAVR-devices_ApplicationNote_AVR306.pdf
- Efficient C coding for VR:http://ww1.microchip.com/downloads/en/AppNotes/doc1497.pdf
- Low power techniques: http://ww1.microchip.com/downloads/en/AppNotes/00002515B.pdf
- Muhammad Ali Mazidi, The AVR microcontroller and embedded systems using assembly and C, Pearson Education,2011.
- Ajay V. Deshmukh, Microcontrollers **–**Theory and applications, TMH Publication,2005.
- Fernando E. Valdes **–**Perez, Microcontrollers-Fundamentals and applications with PIC, CRC Press, 2009.

Course Designers:

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CURRICULUM AND DETAILED SYLLABI

FOR

GENERAL ELECTIVE COURSES

OFFERED BY

ELECTRONICS AND COMMUNICATION ENGINEERING

FOR THE STUDENTS ADMITTED IN THE

ACADEMIC YEAR 2018-19 ONWARDS

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING
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18ECGA0	CONSUMER ELECTRONICS	Category	L	T	P	Credit
		GE	3	0	0	3

Preamble

This course aims to provide students to understanding the various electronic audio and video devices, smart office, digital home systems and automotive electronics systems.

Prerequisite

NIL

Course Outcomes

On the successful completion of the course students will be able to

CO Number	Course Outcome Statement	Weightage in %
CO1	Design the component value for cross over network	20
CO2	Describe various digital audio system.	10
CO3	Construct architecture of digital television system	20
CO4	Consturuct and Describe various display technologies and digital storage	20
CO5	Construct and Describe working principle and main feature of smart office and digital home systems	10
CO6	Construct automotive and consumer electronic circuits	20

CO Mapping with CDIO Curriculum Framework

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS2	Apply	Value	-	1.1.1, 2.1.5, 2.2.2, 2.3.1, 4.4.3
CO2	TPS2	Understand	Respond	-	1.1.1, 2.1.5, 2.2.2, 2.3.1,
CO3	TPS2	Apply	Value	-	1.1, 2.1.5, 2.2.2, 2.3.1, 4.4.3,
CO4	TPS2	Apply	Value	-	1.1, 2.1.5, 2.2.2, 2.3.1, 4.4.3,
CO5	TPS2	Apply	Value	-	1.1, 2.1.5, 2.2.2, 2.3.1, 4.4.3,
CO6	TPS3	Apply	Value	-	1.1.1, 2.1.5, 2.2.2, 2.3.1, 4.4.3,

Mapping with Programme Outcomes and Programme Specific Outcomes

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	S	M	L	-	-	-	-	-	-	-	-	-	M	-	-
CO2	M	L	-	-	-	-	-	-	-	-	-	-	L	-	-
CO3	S	M	L	-	-	-	-	-	-	-	-	-	M	-	-
CO4	S	M	L	-	-	-	-	-	-	-	-	-	M	-	-
CO5	S	M	L	-	-	-	-	-	-	-	-	-	M	-	-
CO6	S	M	L	-	-	-	-	-	-	-	-	-	M	-	-

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

Cognitive Levels	Continuous Assessment Tests			Assignment			End Semester Examination
	1	**2**	**3**	1	2	3	
Remember	0	0	0	0	0	0	0
Understand	20	20	20	0	0	0	20
Apply	80	80	80	100	100	100	80
Analyse	0	0	0	0	0	0	0
Evaluate	0	0	0	0	0	0	0
Create	0	0	0	0	0	0	0

Assessment Pattern: Psychomotor

Psychomotor Skill	Miniproject/Assignment/Practical Component
Perception	-
Set	-
Guided Response	-
Mechanism	-
Complex Overt Responses	-
Adaptation	-
Origination	-

Sample Questions for Course Outcome Assessment**

Course Outcome 1 (CO1):
1. Differentiate between Moving coil Microphone and Velocity Microphone.
2. An audio amplifier produces 20watt output across and 8 ohm resistance When a 5 millivolts signal is applied to its input across a 1 mega ohm resistor. Determine the decibel gain.
3. Design the component values for cross over network fs = 500 Hz and Z=8 ohms.

Course Outcome 2 (CO2):
1. Differentiate SDTV and HDTV Standards.
2. List the components of digital TV System.
3. Explain set top box, DTH and Hometheatre system

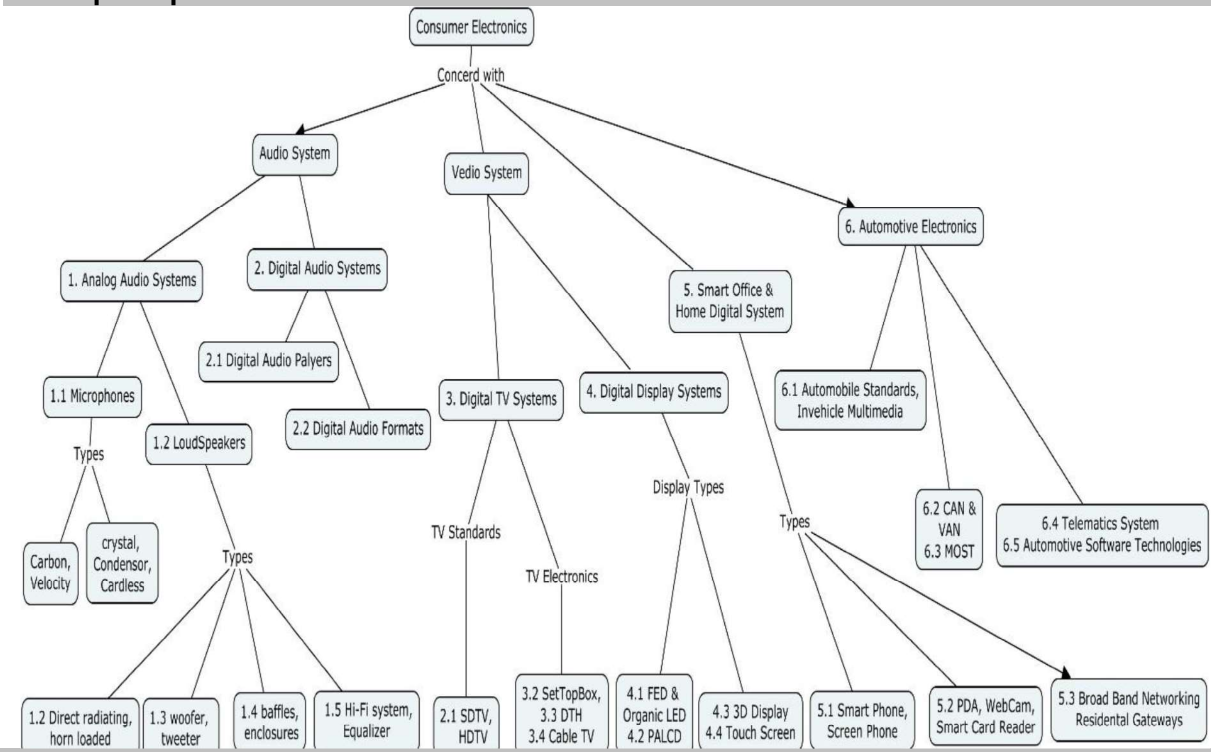
Course Outcome 3 (CO3):
1. Construct the Components of Digital audio player
2. Construct the format of internet audio and describe its function.
3. Construct the format of Digital media and describe its function.

Course Outcome 4 (CO4):
1. Draw the hardware architecture of Digital Set top Box and explain its operation.
2. Construct the cable TV and cable TV in internet and explain the operation.

Course Outcome 5 (CO5):
1. List the significance of LCD display and explain its operation
2. Construct the diagram of and describe the various addressing modes used in LED.
3. Construct the 3-D Display system and Describe its operation

Course Outcome 6 (CO6):
1. Draw and explain the block diagram of a Telematics System and explain its operation.
2. Construct the In-vehicle Networking Applications and explain operation of Buses
3. Construct the block diagram of Automotive Software technologies for Implemented in a java-enabled device and explain its operation.

Concept Map



Syllabus

Analog Audio System: Microphones, their types: Carbon, velocity, crystal, condenser, cordless, Loud Speaker**:** Direct radiating, horn loaded woofer, tweeter, mid-range, multi-speaker system, baffles and enclosures, Hi-Fi system, pre-amplifier, amplifier, Equalizer system, stereo amplifiers. **Digital Audio System:** Digital Audio player, storage audio formats, Internet Audio Formats, MP3 Portable Players, Internet Radio Digital Audio Radio Online Music Distribution, Digital Physical Media Formats. **Digital Television System:** Digital TV System and Standards, SDTV & HDTV System, MPEG-H, Hardware Architecture of a Digital Set-top Box, Home Theatre, DTH. Cable TV and Cable TV in internet and Digital Video Recorder. **Digital Display System:** Field Emission Displays, Organic LEDs, LCD, Plasma, Plasma Addressed LCD, and Liquid Crystal on Silicon, 3-D Displays, and Touch-screen standards. Digital Still Cameras, Digital Video/Versatile Disc. **Smart Office &Digital Home Systems:** Smart Phones and Screen phones, PDA, Smart Card Reader, Webcam, Broadband Networking and Residential Gateways. **Automotive Electronics:** Standards for In-vehicle Multimedia Electronics, Vehicle Area Network Bus, Car (or Controller) Area Networks, Auto SAR, Media-oriented Systems Transfer Technologies, Components of a Telematics System and Automotive Software Technologies

Learning Resources

- Bali S.P, “Consumer Electronics”, Pearson Education, 2008.
- The Digital Consumer Technology Handbook A Comprehensive Guide to Devices, Standards, Future Directions, and Programmable Logic Solutions by Amit Dhir, Xilinx Inc., Elsevier 2004.

Course Contents and Lecture Schedule

Module No.	Topic	No. of Hours	Course Outcome
1	**Microphone & Loud Speaker System**		
1.1	Microphones, their types: Carbon, velocity, crystal, condenser, cordless.	2	CO1
1.2	Loud Speaker**:** Direct radiating, horn loaded woofer,	1	CO1
1.3	tweeter, mid-range, multi-speaker system,	1	CO1
1.4	baffles and enclosures,	1	CO1

1.5	Hi-Fi system, pre-amplifier, amplifier	1	CO1
1.6	Equalizer system, stereo amplifiers	2	CO1
2	**Digital Audio System**		
2.1	Digital Audio player, storage audio formats, Internet Audio Formats,	1	CO2
2.2	MP3 Portable Players, Internet Radio Digital Audio Radio Online Music Distribution	2	CO2
2.3	Digital Physical Media Formats	1	CO2
2.	**Digital Television System**		
3.1	Digital TV System and Standards, SDTV & HDTV System	1	CO3
3.2	Hardware Architecture of a Digital Set-top Box,	2	CO3
3.3	Home Theatre, DTH.	2	
3.4	Cable TV and cable TV in internet and Digital Video Recorder	2	CO3
4	**Digital Display System**		
4.1	Field Emission Displays , Organic LEDs,	1	CO4
4.2	LCD, Plasma, Plasma Addressed LCD,	2	CO4
4.3	Liquid Crystal on Silicon, 3-D Displays ,	1	CO4
4.4	Touch-screen standards. Digital Still Cameras,	2	CO4
4.5	Digital Video/Versatile Disc	1	CO4
5	**Smart Office &Digital Home Systems**		
5.1	Smart Phones and Screen phone	1	CO5
5.2	PDA, Smart Card Reader,	1	CO5
5.3	Webcam, Broadband Networking and Residential Gateways	2	CO5
6	**Automotive Electronics**		
6.1	Standards for In-vehicle Multimedia Electronics	1	CO6
6.2	Vehicle Area Network Bus, Car (or Controller) Area Networks	2	CO6
6.3	Media-oriented Systems Transfer Technologies	1	CO6
6.4	Components of a Telematics System and Automotive Software Technologies	2	CO6
	Total No. of Hours	34	

Course Designers:

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18ECGB0	MULTIMEDIA SYSTEMS

Category	L	T	P	Credit
GE	3	0	0	3

Preamble

Multimedia has become an indispensable part of modern computer technology. In this course, students will be introduced to principles and current technologies of multimedia systems. Issues in effectively representing, processing, and retrieving multimedia data such as sound and music, graphics, image and video will be addressed. Latest Web technologies will also be discussed.

Prerequisite

NIL

Course Outcomes

On the successful completion of the course students will be able to

CO Number	Course Outcome Statement	Weightage*** in %
CO1	Describe the standards for multimedia communication and networks	10
CO2	Represent multimedia data types - Text, Image, Audio and Video using digitization principles	15
CO3	Determine the performance parameters of text and image compression techniques	25
CO4	Analyze the compression ratio and data rate for Audio and video	30
CO5	Identify the need for different multimedia networks for the given applications	10
CO6	Determine the transport protocols of real time audio and video streaming applications	10

CO Mapping with CDIO Curriculum Framework

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS2	Understand	Respond	-	2.1.1, 2.1.2, 2.4.2, 2.4.6, 2.5.1, 3.1.1, 3.2.3, 4.5.5, 4.6.2
CO2	TPS2	Understand	Respond	-	2.1.1, 2.1.2, 2.5.1, 3.1.1, 3.2.3, 4.5.5, 4.6.2
CO3	TPS3	Apply	Value	Mechanism	2.1.1, 2.1.2, 2.5.1, 3.1.1, 3.2.3, 4.5.5, 4.6.2
CO4	TPS4	Analyse	Organise	-	2.1.1, 2.1.2, 2.1.3, 2.5.1
CO5	TPS3	Apply	Value	-	2.1.1, 2.1.2, 2.1.3, 2.5.1
CO6	TPS3	Apply	Value	-	2.1.1, 2.1.2, 2.5.1

Mapping with Programme Outcomes and Programme Specific Outcomes

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	M	L	-	-	-	-	-	-	-	-	-	-	L		
CO2	M	L	-	-	-	-	-	-	-	-	-	-	L		
CO3	S	M	L	-	L	-	-	M	M	M	-	-	M	L	L
CO4	S	S	M	L	L	-	-	M	M	M	-	L	M	L	L
CO5	S	M	L	-	-	-	-	M	M	M	-	-	M	L	
CO6	S	M	L	-	-	-	-	M	M	M	-	-	M		

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

Cognitive Levels	Continuous Assessment Tests			Assignment			End Semester Examination
	1	2	3	1	2	3	
Remember	0	0	0	0	0	0	0
Understand	60	40	20	0	0	0	30
Apply	40	40	60	100	0	100	50
Analyse	0	20	20	0	100	0	20
Evaluate	0	0	0	0	0	0	0
Create	0	0	0	0	0	0	0

Assessment Pattern: Psychomotor

Psychomotor Skill	Assignment-1	Assignment-2	Assignment-3
Perception	-	-	-
Set	-	-	-
Guided Response	-	-	-
Mechanism	-	-	50
Complex Overt Responses	-	-	-
Adaptation	-	-	-
Origination	-	-	-

Sample Questions for Course Outcome Assessment

Course Outcome 1(CO1):

1. Explain why a pair of modems is required to transmit a digital signal over a PSTN. With the aid of a diagram, show the location of the two modems when two digital devices communicate over a PSTN and the types of signal analog or digital –that are used over each part of the access circuit.
2. Explain why most data networks operate in a packet mode. Hence explain why services involving audio and video are supported.
3. With the aid of a diagram, explain the function of a telephony gateway in relation to internet telephony. Hence state the origin of the term "voice over IP" (VoIP).

Course Outcome 2(CO2):

1. State the basic form of representation of: text, an image, audio, video. State the form of representation that is used when all are integrated together and give your reason.
2. State the aim of all broadcast television networks. With the aid of diagram, explain how additional services are provided with (i) a cable distributed network (ii) a satellite/ terrestrial broadcast network.
3. State the meaning of the term "dynamic range" as applied to an analog signal and show how this is expressed in decibels. How does this influence the number of bits to be used for the quantizer part of an ADC?

Course Outcome 3(CO3):

1. Assuming a quantization threshold value of 16, derive the resulting quantization error for each of the following DCT coefficients:
   127, 72, 64, 56, -56, -64, -72, -128.
2. Determine the encoded version of the following difference values which relate to the encoded DC coefficients from consecutive DCT blocks
   12, 1,-2, 0,-1
3. Derive the binary form of the following run-length encoded AC coefficients:
   (0,6) (0,7) (3,3) (0,-1) (0,0)
   Determine the Huffman-encoded version of the following difference values which relate to the encoded DCT coefficients from consecutive DCT blocks.
   12,1,-2,0,-1
   Use the default Huffman code words defined below:

Number of bits needed (SSS)	Huffman codeword

0	010
1	011
2	100
3	00
4	101
5	110
6	1110
7	11110
:	:
11	111111110

Course Outcome 4 (CO4):

1. Derive the time to transmit the following digitized images at both 64kbps and 1.5 Mbps:
   - a 640 x 480 x 8 VGA-compatible image
   - a 1024 x 768 x 24 SVGA- compatible image.
2. Assuming the bandwidth of a speech signal is from 50Hz through to 10kHz and that of a music signal is from 15Hz through to 20 kHz, derive the bit rate that is generated by the digitization procedure in each case assuming the Nyquist sampling rate is used with 12 bits per sample for the speech signal and 16 bits per sample for the music signal. Derive the memory required to store a 10 minutes passage of stereophonic music.
3. Derive the scaling factors used for both the *U* and *V* (as used in PAL) and *I* and *Q* (as used in NTSC) colour difference signals in terms of the three *R, G, B* colour signals.

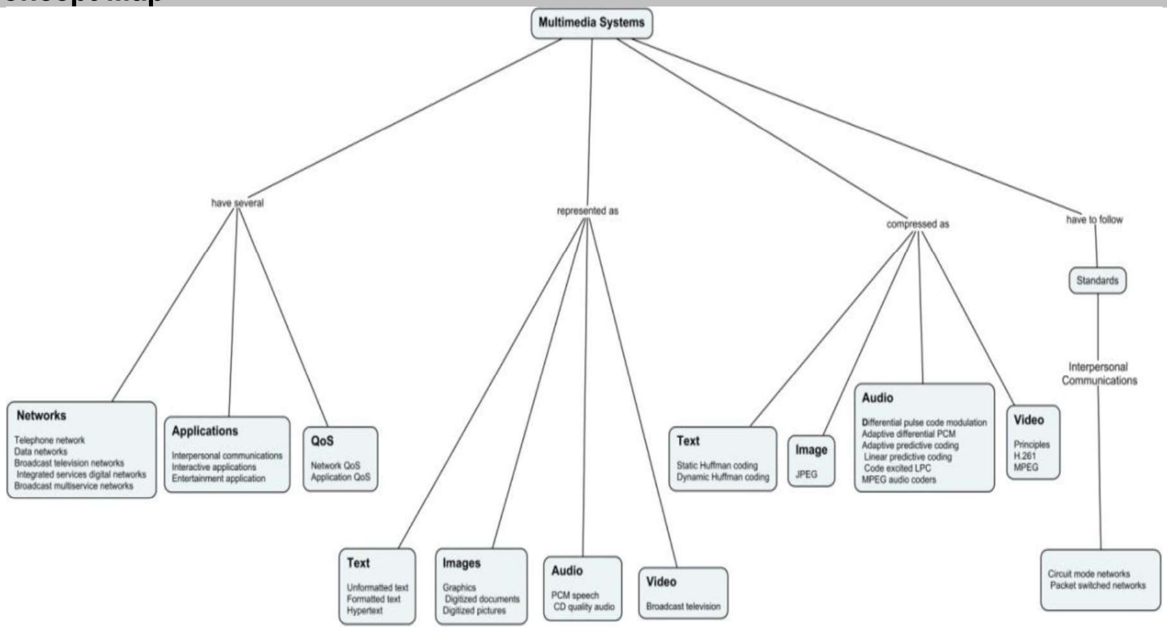
Course Outcome 5 (CO5):

4. With the aid of the diagram, explain the principle operation of movie/Video- on- demand. Identify the bandwidth requirement associated with this type of application.
5. In relation to speech only interpersonal communications involving both public (PSTN/ISDN) and private (PBX) networks, with the aid of a diagram explain how voice mail and teleconferencing are supported. Include in your descriptions the role of a voice mail server and audio bridge.
6. Explain the role of an MCU in relation to a video conferencing session involving multiple geographically distributed video conferencing studios. Quantify the bandwidth implications of locating the MCU at one of the sites.

Course Outcome 6(CO6):

4. Examine TCP state transition diagram to ensure reliable data transmission in Internet
5. How network layer limitations are overcome by transport layer protocols?
6. Identify and give a brief explanation of the four main functions performed by RTCP

Concept Map



Syllabus

Multimedia communications: Introduction, Multimedia information representation, Multimedia networks-telephone networks, data networks, broadcast television networks, integrated services digital networks, broadcast multiservice networks. Multimedia applications - interpersonal communications, interactive applications over the internet, entertainment application. Networking terminology- media types, communication modes, network types, network QoS, application QoS. **Multimedia information representation:** Digitization principles- analog signals, encoder design, decoder design. Text - unformatted text, formatted text, hypertext. Images- graphics, digitized documents, digitized pictures. Audio-PCM speech, CD quality audio, Video- Broadcast television. **Text and image compression:** Compression principles-source encoders and destination decoders, lossless and lossy compression, entropy encoding. Text compression- Huffman coding, Image compression – JPEG. **Audio and video compression:** Audio compression-differential pulse code modulation, adaptive differential PCM, adaptive predictive coding, linear predictive coding, code excited LPC, MPEG audio coders, Video compression - Principles, H.261, MPEG. **Standards for multimedia communications:** Reference models- TCP/IP reference model, protocol basics, Real time streaming transport protocols - RTP and RTCP, Standards relating to interpersonal communications-circuit mode networks, packet switched networks.

Learning Resources

- Fred Halsall, “Multimedia Communications: Applications, Networks, Protocols and Standards”, Addison-Wesley, 2012
- K. Rammohanarao, Z. S. Bolzkovic and D. A. Milanovic, “Multimedia Communication
- Ze-Nian Li and Mark S. Drew, “Fundamentals of Multimedia”, Pearson Prentice Hall, October 2011.
- Yao Wang, Joern Ostermann, and Ya-Qin Zhang, “Video Processing and Communications”, Prentice Hall, 2011.
- Stephen McGloughlin, “Multimedia: Concepts and Practice”, November 2000, Prentice Hall, 2012

Course Contents and Lecture Schedule

Module No.	Topic	No. of Hours	Course Outcome
1.	**Multimedia communications**		
1.1	Multimedia information representation, Multimedia networks-telephone networks, data networks	2	CO1
1.2	broadcast television networks, integrated services digital networks, broadcast multiservice networks.	1	CO1
1.3.	Applications: interpersonal and interactive applications over the internet, entertainment application	1	CO1
1.4	networking terminology- media types, communication modes, network types, network QoS, application QoS	2	CO1
2	**Multimedia information representation**		
2.1	Digitization principles- analog signals, encoder design, decoder design	2	CO2
2.2	Text - unformatted text, formatted text, hypertext	1	CO2
2.3	Images - graphics, digitized documents, digitized pictures	2	CO2
2.4	Audio - PCM speech, CD quality audio, Video - Broadcast television	2	CO2
3	**Text and image compression**		
3.1	Compression principles - source encoders and destination decoders, lossless and lossy compression, entropy encoding.	3	CO3
3.2	Text compression- Huffman coding	2	CO3
3.3	Image compression – JPEG	2	CO3

4	**Audio and video compression**		
4.1	Audio compression-differential pulse code modulation, adaptive differential PCM	2	CO4
4.2	adaptive predictive coding, linear predictive coding, code excited LPC	2	CO4
4.3	MPEG audio coders	2	CO4
4.4	Video compression - Principles, H.261, MPEG	3	CO4
5	**Standards for multimedia communications**		
5.1	Reference models- TCP/IP reference model, protocol basics	2	CO6
5.2	Real time streaming transport protocols - RTP and RTCP	2	CO6
5.3	Standards relating to interpersonal communications-circuit mode networks, packet switched networks	3	CO5

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18ECGC0	TELECOMMUNICATION SYSTEMS

Category	L	T	P	Credit
GE	3	0	0	3

Preamble

The objective of this course is to introduce the concepts of digital communication systems, satellite communication systems, Radio Detection and Ranging (RADAR) systems, Optical communication systems and wireless communication systems & Standards. In this course, mathematical techniques have been kept relatively at modest level, making it accessible to any discipline of Engineering.

Prerequisite

NIL

Course Outcomes

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

CO#	Course Outcome Statement	Weightage in %
CO1	Describe a communication system model in terms of wavelength, frequency, RF spectrum, modulation and demodulation, signal to noise ratio, Decibel gain and loss ratios.	10%
CO2	Determine the communication system blocks in Digital Communication, Radar Communication and Wireless Communication Systems.	20%
CO3	Determine the signal to noise ratio (SNR) at the input of a digital communication receiver and at the output of the detector.	20%
CO4	Determine a optical fiber communication link and the physical structure and guiding properties of optical fibers.	20%
CO5	Determine the operation of Satellite communication system and determine the SNR for both the uplink and downlink	20%
CO6	Describe the cellular concept of Wireless Communication Systems, 2G, 3G and 4G wireless standards for mobile communication, IEEE 802.11b, g Wireless Local area network (WLAN) standards.	10%

CO Mapping with CDIO Curriculum Framework

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS2	Understand	Respond	-	1.1.2, 2.3.1, 3.2.3
CO2	TPS3	Apply	Value	-	1.1.2, 2.3.1, 3.2.3
CO3	TPS3	Apply	Value	Guided Response	1.1.2, 2.3.1, 3.2.3
CO4	TPS3	Apply	Value	-	1.1.2, 2.3.1,2.3.2, 3.2.3
CO5	TPS3	Apply	Value	-	1.1.2, 2.3.1, 3.2.3
CO6	TPS2	Understand	Respond	-	1.1.2, 2.3.1, 3.2.3

Mapping with Programme Outcomes and Programme Specific Outcomes

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	M	L	-	-	-	-	-	L	L	L	-	L	S	-	L
CO2	S	M	L	M	-	-	-	L	M	M	-	L	S	-	L
CO3	S	S	M	M	-	-	-	L	M	M	-	L	S	L	L
CO4	S	S	M	M	-	-	-	L	M	M	-	L	S	L	L
CO5	S	S	M	M	-	-	-	L	M	M	-	L	S	L	L
CO6	M	M	L	L	-	-	-	L	L	L	-	L	S	-	L

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

Cognitive Levels	Continuous Assessment Tests			Assignment			End Semester Examination
	1	2	3	1	2	3	
Remember	20	20	20	0	0	0	20
Understand	20	20	20	40	40	40	20
Apply	60	60	60	60	60	60	60
Analyse	0	0	0	0	0	0	0
Evaluate	0	0	0	0	0	0	0
Create	0	0	0	0	0	0	0

Assessment Pattern: Psychomotor

Psychomotor Skill	Assignment-1	Assignment-2	Assignment-3
Perception	-	-	-
Set	-	-	-
Guided Response	-	30	30
Mechanism	-	-	-
Complex Overt Responses	-	-	-
Adaptation	-	-	-
Origination	-	-	-

Sample Questions for Course Outcome Assessmen

Course Outcome 1 (CO1):

1. Draw the block diagram of a simplified model of a communication system
2. Define the term co channel interference and adjacent channel interference.
3. What are the re-use factors for the wireless standards namely AMPS, GSM and IS-95 systems?

Course Outcome 2 (CO2):

1. A communication system has the following parameters:
   $P_t = 5W, G_t(dB) = 13dB, G_r(dB) = 17dB\ d = 80km\ f = 3\ GHz$
   Determine the value of the receiver power using Friis transmission formula.
2. A pulse radar system operates at a frequency of 10 GHz with a pulse repetition frequency of 2 kHZ and a pulse width of 6 µs. Determine (a) the maximum unambiguous range, and (b) the resolution or minimum range.
3. Determine Instantaneous cyclic frequency of Doppler RADAR transmitting sinusoidal cyclic frequency f_c and radian frequency $\omega_c = 2\pi f_c$ leading to Doppler shift.

Course Outcome 3 (CO3):

1. The cascade system has three components. (a) Input line amplifier with power gain G_1=5000, (b) long transmission line with a power loss factor L=2000, and (c) load amplifier with an absolute power gain G_2=400. Impedances are matched at all junctions. Determine (i) net system absolute gain, (ii) system decibel gain using the result of (i), and (iii) system decibel gain from individual decibel values.
2. An analog system requires an antenna signal power of 50pW to meet the required signal to noise ratio. Other system parameters are given as follows: $G_t(dB) = 3dB, G_r(dB) = 4dB, f = 500MHz, d = 80km$. Assuming direct ray propagation, determine the minimum value of the transmitted power required.
3. Consider a PCM TDM system in which 19 signals are to be processed. Each of the signals has a baseband bandwidth W = 5 KHz and 8 bits are to be used in each word. Conventional NRZ – L encoding will be used, and an additional 8 – bit sync word will be placed in each frame. Determine theoretical minimum bandwidth required

Course Outcome 4 (CO4):

1. A 50km long optical fiber has a total attenuation of 24dB. If $500\mu W$ of optical power get launched into the fiber, what is the output optical power level in dBm and in μW.
2. A step–index multimode fiber with numerical aperture of 0.20 supports approximately 1000 modes at an 850-nm wavelength. What is the diameter of its core? How many modes does the fiber support at 1320 nm and 1550 nm respectively?
3. Determine the normalized frequency at 820 nm for a step-index fiber having a $25\mu m$ core radius, $n_1 = 1.48$ and $n_2 = 1.46$. How many modes propagate in this fiber at 820nm, 1320nm and 1550nm respectively? What percent of the optical power flows in the cladding in each case?

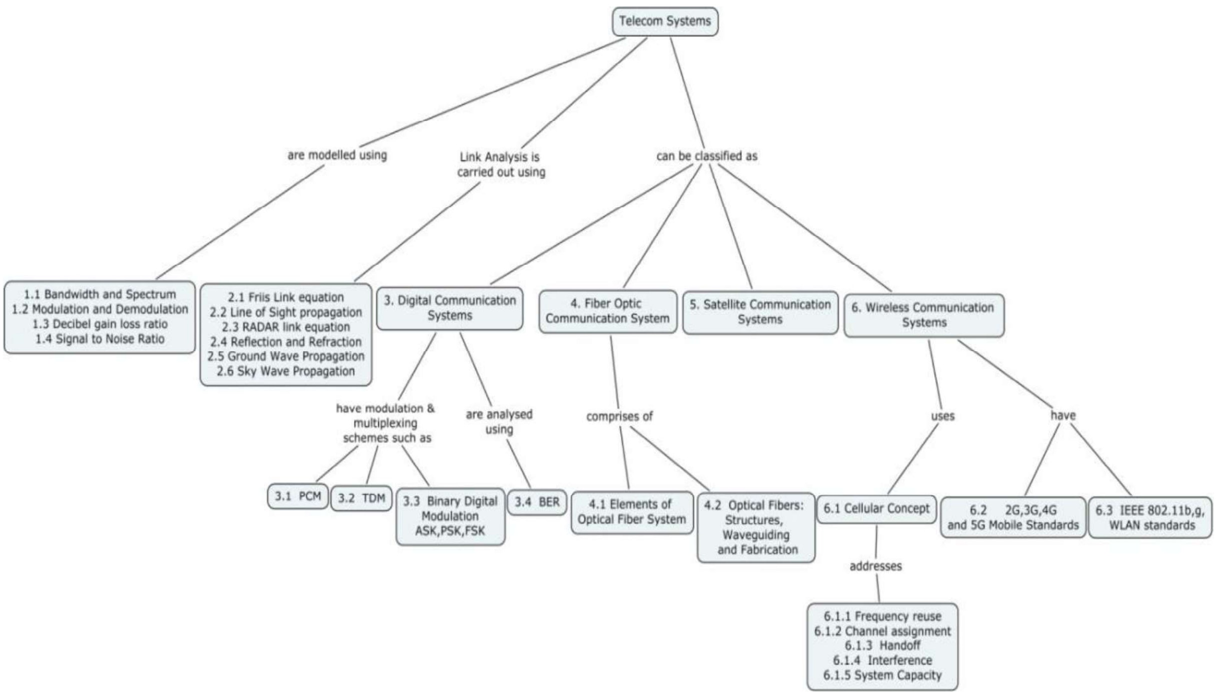
Course Outcome 5 (CO5):

1. A satellite is to be placed in an orbit 1000 km above the earth's surface. Determine (a) required velocity (b) circumference of the rotation and (c) period of the rotation.
2. In a satellite communication system the uplink portion is analyzed. The output power of the ground transmitter is 200W. This power level at the ground antenna, which has a gain of 40dB. The transmitted signal is attenuated by a path loss of 200 dB. The receiver antenna gain is 20 dB. If the total noise level at the input to the satellite receiver is 8 dBf, determine the received signal – to noise-ratio in dB.
3. The lowest downlink frequency for C band is 3.7GHz. Consider a satellite transmitter operating at this frequency providing coverage of the continental United States, which requires a 3 dB beamwidth of about 18^0. Assuming an illumination efficiency of 70%, determine the diameter and the gain of the downlink antenna.

Course Outcome 6 (CO6):

1. Consider a transmitter which radiates a sinusoidal carrier frequency of 1850 MHz for a vehicle moving 60m/hr, Compute the received carrier frequency if the mobile is moving (i) Directly towards the transmitter (ii) Directly away from the transmitter, and in a direction which is perpendicular to the direction of arrival of the transmitter signal.
2. Explain the techniques that are intended to improve coverage area and capacity of cellular system.
3. Explain in detail about Global system for mobile and also explain the Frame structure and signal Processing in GSM.

Concept Map



Syllabus

Introduction: Communication system model, Bandwidth and spectrum, modulation and demodulation, decibel gain and loss ratios, Signal to noise ratio and system level decibel analysis, **Communication Link Analysis:** Friis Link Equation, Decibel forms for the one way link equations, Line of Sight Propagation, Radar link equation, pulse radar, Doppler radar, Reflection and refraction, Ground wave propagation, Sky wave propagation **Digital Communication Systems: Pulse Code Modulation (PCM),** basic PCM encoding and quantization, companding, baseband encoding forms, Time Division Multiplexing, Binary digital modulation schemes (ASK, PSK, FSK), Bit Error rate Analysis. **Fiber Optic Communication System:** Optical Spectral bands, WDM Concepts, Key Elements of Optical Fiber Systems, Optical Fiber Modes and Configurations, Single – mode Fibers, Mechanical Properties of Fibers, Fiber Fabrication. **Satellite Communication Systems:** Orbital Mechanics, Satellite Alignment, Space craft communication Systems, Antennas Aboard Satellites and Earth Station, Satellite Link Analysis. **Wireless Communication Systems:** Cellular Concept: Frequency Reuse, Channel Assignment Strategies, Handoff Strategies, Interference, System Capacity, Wireless Standards: 2G, 3G, 4G and 5G Mobile Standards, IEEE 802.11b,g Wireless Local Area Network (WLAN) standards

Learning Resources

- William D.Stanley amd John.M. Jeffords, “ Electronic Communications Principles and Systems”, Cengage Learning, 2009 (India Edition)
- B.P.Lathi, ZhiDing, Hari Mohan Gupta, ”Modern Digital and Analog Communication Systems”, Fourth Edition, Oxford University Press, 2017.
- Theddore S.Rappaport, “Wireless Communications: Principles and Practice”, Second Edition, PHI,2006
- Gerd kaiser, “Optical Fiber Communications”, Fifth Edition, TataMcGraw – Hill Publishing Company Limited, 2013.
- George Kennedy, “Electronic Communication Systems”, Tata McGraw Hill, Third Edition, 1996.
- Wayne Tomasi, “ Advanced Electronic Communication Systems”, Prentice Hall International Inc., Fourth Edition, 1998Book1 (Author(s), Title, edition, publisher, year of publication)
- Principles of Communication Systems Part - 1 Course in NPTEL: http://www.digimat.in/nptel/courses/video/108104091/L25.html By Professor Aditya K Jagannatham, IIT Kanpur.
- Principles of Communication Systems Part - 2 Course in NPTEL: https://nptel.ac.in/courses/108104098/#, By Professor Aditya K Jagannatham, IIT Kanpur.
- Satellite Communication Systems Course in NPTEL: https://nptel.ac.in/courses/117/105/117105131/, By Professor Kalyan Kumar Bandyopadhyay, IIT Kharagpur.
- Principles and Techniques of Modern RADAR Systems Course in NPTEL: https://nptel.ac.in/courses/108105154/ By Professor Amitabha Bhattacharya, IIT Kharagpur.
- Fiber Optic Communication Systems and Techniques – Course in NPTEL: http://www.digimat.in/nptel/courses/video/117104127/L22.html By Professor Pradeep Kumar K, IIT Madras.
- Introduction to Wireless and Cellular Communications Course in NPTEL: https://nptel.ac.in/courses/106/106/106106167/ By Professor David Koilpillai, IIT Madras.

Course Contents and Lecture Schedule

Module No.	Topic	No. of Hours	Course Outcome
1.	**Introduction to Telecom Systems**		
1.1	Simplified Communication System Model	1	CO1
1.2	Bandwidth and Spectrum, Modulation and	1	CO1

	demodulation, decibel gain and loss ratios, Signal to noise ratio and system level decibel analysis		
2.	**Communication Link Analysis:**		
2.1	Friis Link Equation, Decibel forms for the one way link equations,	2	CO2
2.2	Line of Sight Propagation,	1	CO2
2.3	Radar link equation, Pulse radar, Doppler radar	2	CO2
2.4	Reflection and refraction	2	CO2
2.5	Ground wave propagation and Sky wave propagation	1	CO2
3.	**Digital Communication Systems:**		
3.1	Pulse code modulation (PCM)	1	CO4
3.2	Basic PCM encoding and quantization,	2	CO4
3.3	Companding,	1	CO4
3.4	baseband encoding forms	1	CO4
3.5	Time Division Multiplexing	1	CO4
3.6	Binary digital modulation schemes (ASK, PSK, FSK)	2	CO4
3.7	Bit Error rate Analysis.	1	CO4
4.	**Fiber Optic Communication System**		
4.1	Optical Spectral Bands	1	CO3
4.2	Key elements of Optical Fiber System	1	CO3
4.3	Optical Fiber Modes and Configurations	1	CO3
4.4	Single – Mode Fibers	1	CO3
4.5	Fiber Materials, Fiber Fabrication, Fiber Optic Cables	2	CO3
5.	**Satellite Communication Systems:**		
5.1	Orbital Mechanics	1	CO5
5.2	Satellite Alignment	1	CO5
5.3	Space craft communication Systems, Antennas Aboard Satellites and Earth Station	1	CO5
5.4	Satellite Link Analysis	2	CO5
6.	**Wireless Communication Systems:**		
6.1	Cellular Concept:	1	CO6
6.2	Frequency Reuse, Channel Assignment Strategies	1	CO6
6.3	Handoff Strategies, Interference	1	CO6
6.4	System Capacity	1	CO6
6.5	Wireless Standards: 2G, 3G, 4G and 5G Mobile Standards	1	CO6
6.6	IEEE 802.11b, g Wireless Local area network (WLAN) standards	1	CO6
	Total Number of Hours	36	

Course Designers:

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18ECGD0	APPLIED IMAGE PROCESSING	Category	L	T	P	Credit
		GE	3	0	0	3

Preamble

The course “18ECGD0: Applied Image Processing” is offered in the fifth semester. The purpose of this course is to provide the basic concepts and methodologies for digital Image Processing in three different levels. At the lower-level, the course introduces the terminology of image processing, image acquisition, digitization, formation, storage and the relationship between pixels. Further, it provides the image enhancement by improving the contrast and noise removal in spatial domain and applications of transformations for enhancement and coding. In the middle-level, it addresses region based segmentation, representation and description processes to extract meaningful information with geometrical operations. Morphological processing is introduced to clean up and cluster such regions for real world image processing applications.

Prerequisite

Nil

Course Outcomes

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

CO Number	Course Outcome Statement	Weightage %
CO1	Demonstrate the human visual perception, digital image acquisition and relationship between pixels for grayscale and color images.	20
CO2	Enhance the visual perception of the digital imagery from poor contrast and noise degradation in spatial domain.	15
CO3	Enhance the given image in frequency domain by applying image transforms such as Fourier and DCT.	15
CO4	Extract regions of interest from an image using thresholding, edge and region based segmentation algorithms.	15
CO5	Describe the segmented region using boundary as well as region representors and descriptors with the combination of morphological operations.	15
CO6	Develop image processing algorithms for detecting vehicle license plate, missing component, abnormality in CT/US images, Watermarking, fault analysis in power system, change detection in satellite images, DCT coding for image compression.	20

CO Mapping with CDIO Curriculum Framework

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	**Affective**	**Psychomotor**	
CO1	TPS2	Understand	Respond	Perception and Set	1.3, 2.4.6, 4.1.1
CO2	TPS3	Apply	Value	Mechanism	1.3, 3.2.3, 3.2.4, 3.3.1, 4.1.1, 4.1.2, 4.5.3
CO3	TPS3	Apply	Value	Mechanism	1.3, 3.2.3, 3.2.4, 3.3.1, 4.1.1, 4.1.2, 4.5.3
CO4	TPS3	Apply	Value	Mechanism	1.3, 3.2.3, 3.2.4,
CO5	TPS2	Apply	Value	Mechanism	1.3 , 3.2.3, 3.2.4,
CO6	TPS3	Apply	Value	Mechanism	1.3, 2.1.1, 2.3.1, 2.4.3, 2.4.4, 2.4.6, 2.5.1, 3.1, 3.2.3, 3.2.4, 3.2.6, 3.3.1, 4.1.1, 4.1.2, 4.5.3

Mapping with Programme Outcomes

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	M	L	-	-	-	L	-	L	-	-		-	L	-	-
CO2	S	M	L	-	L	L	-	L	-	L	-	-	M	-	L
CO3	S	M	L	-	L	L	-	L	L	L	-	-	M	-	L
CO4	S	M	L	-	-	-	-	-	-	-	-	-	M	-	-
CO5	S	M	L	-	-	-	-	-	-	-	-	-	M	-	-
CO6	S	M	L	-	L	L	-	L	-	L	-	L	M	L	L

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

Cognitive Levels	Continuous Assessment Tests			Assignment			End Semester Examination
	1	2	3	1	2	3	
Remember	10	10	0				0
Understand	10	10	20				20
Apply	80	80	80	50	50	50	80
Analyse	0	0	0				0
Evaluate	0	0	0				0
Create	0	0	0				0

Assessment Pattern: Psychomotor

Psychomotor Skill	Assignment-I	Assignment-II	Assignment-III
Perception	-	-	-
Set	-	-	-
Guided Response	-	-	-
Mechanism	50	50	50
Complex Overt Responses	-	-	-
Adaptation	-	-	-
Origination	-	-	-

Sample Questions for Course Outcome Assessment

Course Outcome 1 (CO1):

1. Distinguish CT and US imaging techniques and List the Pros and Cons.
2. Consider the image segment shown.
   Let v = {0,1}, and obtain the shortest 8 and m-path between p and q. If a particular path does not exist between these two points state the reason. Repeat the same for v {1,2}.
   3 2 1 0 (q)
   2 1 2 0
   1 1 1 1
   (p) 1 0 1 2
3. Illustrate two dimensional sampling (down sample to 2X2) and 4 bit (16 gray levels) quantization for the following 8 bit sub image and state the reasons for the effects due to these processes?

255	255	255	255	255	255	255	255
255	200	255	150	255	50	50	255
255	200	255	150	255	50	50	255
255	200	255	150	255	50	50	255
255	200	255	150	255	50	50	255

255	200	255	150	255	50	50	255
255	200	255	150	255	50	50	255
255	255	255	255	255	255	255	255

Course Outcome 2 (CO2):

1. Justify whether the image is poor in contrast. Identify the category of contrast. Is there any possibility to apply histogram equalization for the enhancement? If Yes, Justify and apply Histogram equalization for the following 6 bit image segment of size 6X6? Write the inference on image segment before and after equalization.

35	55	60	55	40	60
55	35	35	60	60	52
60	48	45	55	38	48
51	40	60	45	40	40
49	40	60	35	35	55
62	48	55	62	45	35

2. Demonstrate the following gray-level transformations for image enhancement via
   i) Gamma correction
   ii) Log transformation
   iii) Contrast Stretching
3. Suggest a suitable filter to remove noise but still preserve edges. Give the transfer function of it.

Course Outcome 3 (CO3):

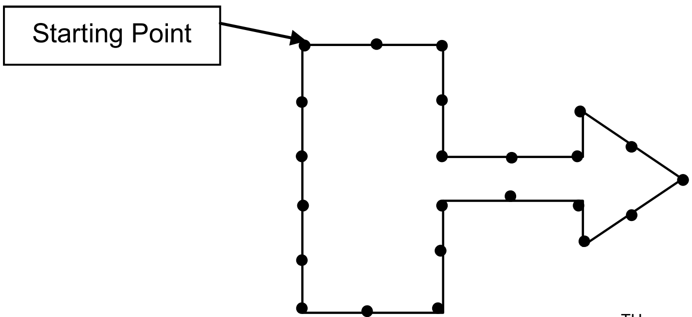
1. Illustrate the procedure step by step for JPEG image compression and write the significance of DCT.
2. Apply Discrete Fourier Transform for the following image data?
   [220 100; 120 250] [2x2] matrix. Write the significance of log function while visualizing the Fourier spectrum. Also, illustrate how Fourier transform properties are helpful in different digital image processing applications. Obtain it's inverse also.
3. Apply Discrete Cosine Transform for the following image data.
   [100 200; 150 200] [2x2] matrix. Also, illustrate how DCT is used for JPEG image Compression?

Course Outcome 4 (CO4):

1. The region-growing algorithm starts with a seed pixel. Suggest a way or gray-level range to choose the seed pixel for the following two applications.
   a. Segmenting the fractured portion of a leg in a X-Ray image
   b. Segmenting defective welds for an image captured in industry
2. Demonstrate region split and merge algorithm and apply morphological algorithms to segment the satellite image into different regions.
3. Demonstrate how global thresholding is used in industrial inspection applications and discuss the effect of illumination on global thresholding.

Course Outcome 5 (CO5):

1. Write the Euler number if the shape contains 4 edges, 3 faces and 5 vertices.
2. Obtain the shape number for the following fig. List the limitations towards boundary representation based on chain codes.

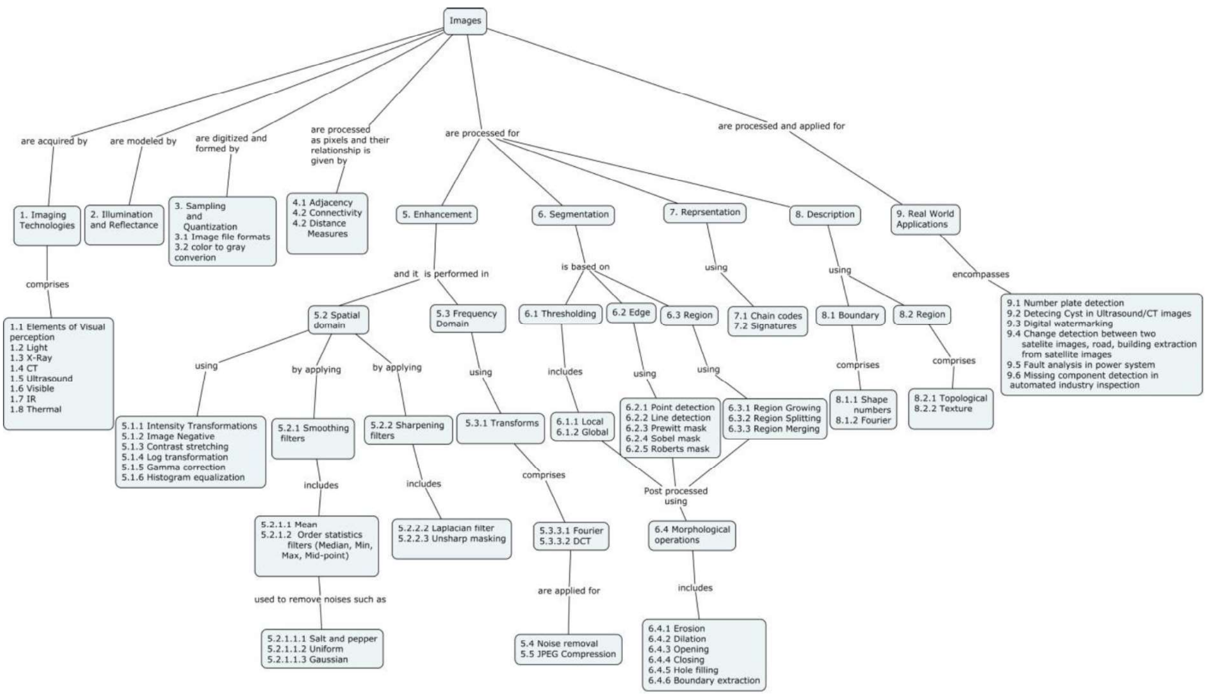


3. Sketch the signature plots for the following geometrical figures: Rectangle, Ellipse and 5- point star. How will it be Scale normalized?

Course Outcome 6 (CO6):

4. Develop an algorithm to localize the license plate using suitable preprocessing, edge detection and morphological processing for intelligent traffic surveillance system to capture the vehicles which are not following the traffic rules.
5. Suggest an algorithm to find the change between two satellite images (taken in 2004 and 2014). The image captured the Madurai area. How will you find vaigai river has been encroached and how much encroached from the change detection algorithm.
6. The region-growing algorithm starts with a seed pixel. Suggest a way or gray level range to choose the seed pixel for the following application. Segment the cyst of a US kidney image. Assume the intensity values of one cyst is 220 and for the another cyst is 90.

Concept Map



Syllabus

Theory:

Image acquisition and Fundamentals: Introduction to Image processing, Need and applications, Elements of visual perception, light and the Electromagnetic spectrum, Imaging modalities, X-Ray, Visible, Infrared, CT, Ultrasound, Thermal. Components of an Image processing system, Digital image model, Image file formats, Image Sampling and Quantization.

Basic relationship between pixels: Adjacency, Connectivity- 4, 8 and m connectivity, region, boundaries and Distance measures: Euclidean, city-block, chessboard. Full color image processing, Color model-RGB,CMY,HSI, Color space conversion, RGB to HSV and YCbCr, Extendible of grayscale methods into color.

Image Enhancement: Intensity Transformation functions, Image negatives, Contrast stretching, Log transformation, Gamma correction, Histogram Equalization, Color Histogram processing, Noise Removal: Noise models, Gaussian, Uniform, salt and pepper noise. **Spatial Filtering**: Smoothing: mean, Order statistics filter: median, min, max and mid-point filtering. Sharpening: Laplacian filter, unsharp masking.

Frequency domain filtering: Transformations:Fourier, Discrete cosine Transforms, Low pass and high pass filters in frequency domain. **Image Compression:** JPEG compression.
Segmentation: Thresholding: Local and global, Edge based: Point, Line and Edge detection, Prewitt, Sobel and Roberts operators. Region based segmentation: Region growing, Region splitting and merging. Gray-scale Morphological operations: Dilation and Erosion, Opening and Closing, Hole filling, Boundary extraction.
Representation and Description: Boundary representation: Chain codes, Signatures, Boundary descriptors: Shape numbers, Fourier descriptors, Regional Descriptors, Topological descriptors: Texture.
Real world Applications: Vehicle license plate detection, Digital image watermarking, Missing component detection for automatic industry inspection, Non-destructive testing, Detecting cyst/tumour in Ultrasound (US)/CT images, Fault analysis in power system, Remote sensing- change detection, building, road extraction in satellite images.
Sample Assignments/Mini projects:
1. Image Contrast Enhancement.
2. Noise removal in spatial/frequency domain
3. Vehicle number plate detection.
4. Detecting cyst/tumour in US/CT images.
5. Industry inspection in IR/Thermal images (Non Destructive Testing).
6. Change detection between two remotely sensed satellite images.
7. Missing component detection in an automated industrial inspection application.
8. Digital Watermarking
9. Fault analysis in power systems

Learning Resources

- Rafael.C.Gonzalez, Richard.E. Woods and Steven L. Eddins, “Digital Image Processing using Matlab”, 2nd Edition, Gatesmark Publishing, 2009, ISBN 9780982085400.
- Al.Bovik, “The Essential Guide to Image Processing”, Academic Press, 2009.
- Oge Marques, “Practical Image and Video Processing using MATLAB”, Wiley-IEEE Press, 2011, ISBN: 978-0-470-04815-3.
- Anil K.Jain, “Fundamentals of Digital Image Processing”, Pearson Education 2003.
- William K. Pratt, “Digital Image Processing”, Third Edition, John Wiley & Sons, Inc.,
  i. 2001, ISBNs: 0-471-37407-5.
- NPTEL course Digital Image Processing: https://nptel.ac.in/courses/noc18_ee40/
- www.imageprocessingplace.com/
- http://www.mathworks.com/
- https://www.coursera.org/course/images

Course Contents and Lecture Schedule

No.	Topic	No. of Lectures	CO
1	Introduction to the Course and course outcomes	1	1
1.1	Introduction to Image processing, Need and applications	1	1
1.2	Elements of visual perception	1	1
1.3	Light and the Electromagnetic spectrum	1	1
1.4	Imaging modalities- X-Ray, CT, Ultrasound, Visible, Infrared, Thermal	1	1
1.5	Components of an Image processing system	1	1
1.6	Digital image Model, Image file formats, Color space conversion	1	1
1.7	Image Sampling and Quantization	1	1
1.8	Basic relationship between pixels, Adjacency, Connectivity- 4, 8 and m connectivity, region, boundary	1	1
1.9	Distance measures- Euclidean, city-block, chessboard	1	1
1.10	Full color image processing, Color model-RGB,CMY,HSI	1	1
1.1	Color models-RGB, CMY, HSI	1	1

1			
1.1 2	HVS and color space: (RGB to HSI, YCbCr color space), Extendible of grayscale methods into color	1	1
2.	**Image Enhancement:** Intensity Transformations, Image Negative, Contrast stretching	1	2
2.1	Log transformation- Gamma correction	1	2
2.2	Histogram equalization, color histogram processing	1	2
	Assignment 1: Image contrast Enhancement		
2.3	**Noise Removal-Spatial Filtering- Smoothing**-Noise models – Salt and Pepper, Uniform, Gaussian	1	2
2.4	Mean- Order statistics filter-median filters Min, Max and Mid-point	1	2
2.5	**Spatial filtering – Sharpening**- Laplacian filter, unsharp masking	1	2
3	**Spectral representation for enhancement and coding:**		
3.1	Fourier	2	3
3.2	Discrete cosine Transform	1	3
3.4	Low pass and high pass filters in frequency domain	1	3
3.5	JPEG compression	1	3
	Assignment II: Noise removal in spatial/frequency domain		
4	**Segmentation:** Thresholding – Local and global	1	4
4.1	**Edges-** Point, line detection, Edge detection, Prewitt, Sobel and Roberts operators	1	4
4.2	Region based segmentation- Region growing, Region splitting and merging	1	4
4.3	Gray-scale Morphological operations: dilation and erosion – opening and closing, Hole filling, Boundary extraction	2	4
6.	**Representation and Description:**		
6.1	Boundary representation- Chain codes–Signatures	1	5
6.2	Boundary descriptors–Shape numbers-Fourier descriptors	1	5
6.3	Regional Descriptors-Topological descriptors-Texture	1	5
7.	**Real world Applications:**		
7.1	Vehicle number plate detection	1	6
7.2	Digital image watermarking, Missing component detection for automatic industry inspection	1	6
7.3	Detecting cyst/tumour in Ultrasound/CT images	1	6
7.4	Fault analysis in power system		6
7.5	Remote sensing- change detection, building, road extraction in satellite images	1	6
	Assignment III: Applications		
	Total	36	

Course Designers:

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CURRICULUM AND SYLLABI

FOR

ENGINEERING SCIENCE ELECTIVE COURSES

B.E. DEGREE PROGRAMME

IN

ELECTRONICS AND COMMUNICATION ENGINEERING

FOR THE STUDENTS ADMITTED IN THE

ACADEMIC YEAR 2018-19 ONWARDS

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING
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18ECEA0	MEMS TECHNOLOGY

Category	L	T	P	Credit
ES	3	0	0	3

Preamble

MEMS has been identified as one of the most promising technologies for the 21st Century and has the potential to revolutionize both industrial and consumer products by combining silicon-based microelectronics with micromachining technology. This course starts with the glimpses of MEMS covering the introduction and origin of MEMS, driving force for MEMS development, commercial applications, fabrication process and packaging techniques. The latter half of the course will be devoted to provide a thumb rule in designing, modelling of micro sensors and micro actuators. They are also exposed to the MEMS CAD tools available in the Design centre. Special weight is given to design circuits and do simulation with Comsol, Intellisuite and Coventorware. By taking this course, students can make good preparations for their research in relevant areas.

Prerequisite

Nil

Course Outcomes

On the successful completion of the course students will be able to

CO Number	Course Outcome Statement	Weightage in %
CO1	Summarize the Concept of miniaturization, need for MEMS in various applications, Micro fabrication techniques	20
CO2	Apply knowledge of micro fabrication techniques to design Micro sensors	20
CO3	Apply knowledge of micro fabrication techniques to design Micro actuators	10
CO4	Apply micro fabrication techniques to design a micro accelerometers	10
CO5	Apply the concepts of micro machining to design devices for diversifying areas	20
CO6	Acquire skills in computer aided design tools for modelling and simulating MEMS device	20

CO Mapping with CDIO Curriculum Framework

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS2	Understand	Respond	-	1.3, 2.4.6
CO2	TPS3	Apply	Value	-	1.3, 2.1.1, 2.1.2, 2.1.3, 2.5.1
CO3	TPS3	Apply	Value	-	1.3, 2.4.6
CO4	TPS3	Apply	Value	-	1.3, 2.1.1, 2.1.2, 2.5.1
CO5	TPS3	Apply	Value	-	1.3, 2.4.6
CO6	TPS3	Apply	Value	-	1.3, 2.1.1, 2.1.2, 2.5.1

Mapping with Programme Outcomes and Programme Specific Outcomes

Cos	PO1	PO2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2	PSO 3
CO1	M	L	-	-	-	-	-	-	-	-	-	-	L	L	L
CO2	S	M	L	-	L	-	-	L	-	L	-	L	L	-	-
CO3	S	M	L	-	L	-	-	L	-	L	-	L	L	-	-
CO4	S	M	L	-	L	-	-	L	-	L	-	L	L	-	-
CO5	S	M	L	-	L	-	-	L	-	L	-	L	L	-	-
CO6	S	M	L	-	L	-	-	L	-	L	-	L	L	-	-

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

Cognitive Levels	Continuous Assessment Tests			Assignment			End Semester Examination
	1	2	3	1	2	3	
Remember	0	0	0	0	0	0	0
Understand	50	40	20	50	0	0	20
Apply	50	60	80	50	100	100	80
Analyse	0	0	0	0	0	0	0
Evaluate	0	0	0	0	0	0	0
Create	0	0	0	0	0	0	0

Assessment Pattern: Psychomotor

Psychomotor Skill	Assignment-1	Assignment-2	Assignment-3
Perception	-	-	-
Set	-	-	-
Guided Response	-	-	-
Mechanism	-	-	-
Complex Overt Responses	-	-	-
Adaptation	-	-	-
Origination	-	-	-

Sample Questions for Course Outcome Assessment

Course Outcome 1(CO1):
1. Tabulate the direct analogy of electrical and mechanical domains.
2. Classify MEMS packages. Based on the need for packaging of MEMS devices classify and differentiate various packaging methodologies.

Course Outcome 2(CO2):
1. With neat diagram explain the functioning of micro pressure sensor.
2. Explain the working principle of a thermal flow sensor.

Course Outcome 3 (CO3):
1. Explain in detail the ink jet printer head and its fabrication process flow in detail.
2. Explain the working principle of micro pumps.

Course Outcome 4 (CO4):
1. Derive a formula for estimating the natural frequency of a micro accelerometer with negligible damping effect.
2. Determine the equivalent spring constant K and natural frequency Wm of a cantilever beam element in a micro accelerometer .The beam is made of silicon with a Young's modulus of 190 MPa, length of the beam is 100um, width is 10um and mass is 10 mg.

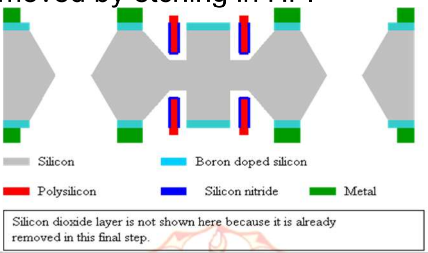
Course Outcome 5 (CO5):
1. Discuss the integration of micro optics with MEMS
2. Explain the sensing mechanism used in biomedical micro systems

Course Outcome 6(CO6):
1. Discuss the steps involved in developing a micro machined cantilever using any MEMS CAD tool (e.g. Coventorware software)
2. Given the following description of a micro machined accelerometer, draw the step-by-step process flow with cross-section diagrams. For your convenience, the cross-section of the final device is also given below.

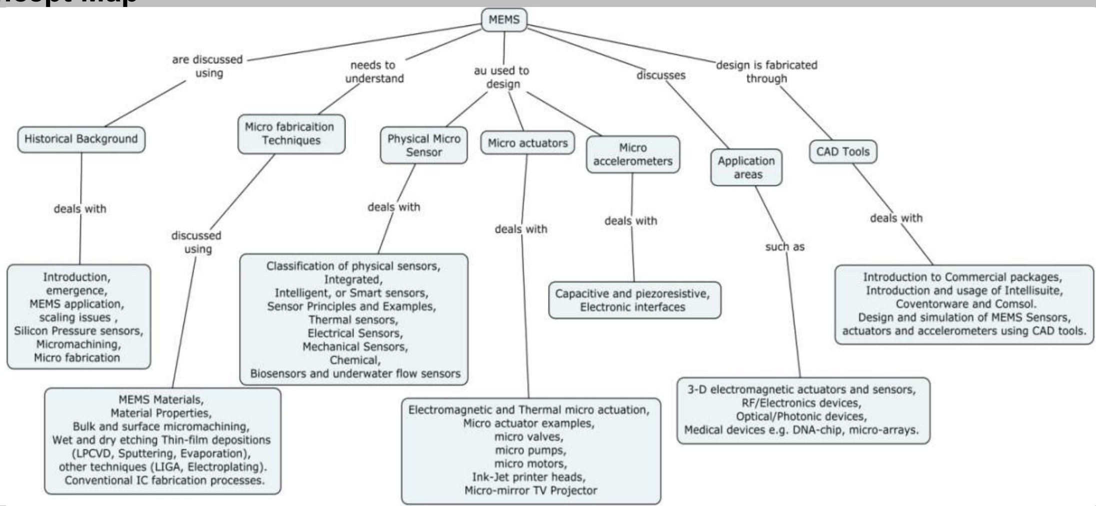
In order to micro fabricate a micro machined accelerometer, combinations of bulk and surface micromachining techniques are used. The process has seven masks and involves double-sided processing utilizing silicon dioxide as a sacrificial layer. The device structure is defined by anisotropic etching at the end of the process.

The process begins with a shallow p++ boron diffusion, defining the proof-mass and supporting rim, on a <100> silicon wafer that is polished on both the sides. Then, 60 um deep trenches are DRIE etched in the silicon and are used later to form the vertical electrodes. The trenches are then refilled completely with a combination of LPCVD silicon dioxide (sacrificial layer), silicon nitride, and doped polysilicon. The polysilicon trench refilling is used to form vertical sense/drive electrodes and high aspect ratio springs to support the proof mass. After polysilicon deposition, annealing is followed to alleviate any compressive stress in the polysilicon.

Next, the polysilicon and nitride films are etched using RIE and another LPCVD silicon dioxide (capping oxide) is deposited. The oxide is patterned to form contact openings to the bulk silicon for the subsequent etch in the EDP. Then, contact metal is electroplated. To minimize the etch-time in the EDP and help undercut the electrodes by the etchant, some of the single-crystal silicon is etched by DRIE. After the DRIE, EDP etch is followed not only to release the proof mass and the supporting rim but also to etch the unnecessary silicon around the sense/drive electrodes. This step is important to achieve high-sensitivity. Finally, the sacrificial oxide layer is removed by etching in HF.



Concept Map



Syllabus

Historical Background: Introduction, emergence, MEMS application, scaling issues, Silicon Pressure sensors, Micromachining, Micro fabrication. **Micro Fabrication Techniques:** MEMS Materials, Material Properties, Bulk and surface micromachining, Wet and dry etching Thin-film depositions (LPCVD, Sputtering, Evaporation), other techniques (LIGA, Electroplating). Conventional IC fabrication processes. **Physical Micro Sensors**: Classification of physical sensors, Integrated, Intelligent, or Smart sensors, Sensor Principles and Examples, Thermal sensors, Electrical Sensors, Mechanical Sensors, Chemical, Biosensors and underwater flow sensors. **Micro Actuators**: Electromagnetic and Thermal micro actuation, Micro actuator examples, micro valves, micro pumps, micro motors, Ink-Jet printer heads, Micro-mirror TV Projector. **Micro Accelerometer**: Capacitive and piezoresistive, Electronic interfaces. **Application Areas:** 3-D electromagnetic actuators and sensors, RF/Electronics devices, Optical/Photonic devices, Medical devices e.g. DNA-chip, micro-arrays. **Computer Aided Design of MEMS:** Introduction to Commercial packages, Introduction and usage of Intellisuite, Coventorware and Comsol, Design and simulation of MEMS Sensors, actuators and accelerometers using CAD tools.

Learning Resources

- Stephen D. Senturia, "Micro system Design" by, Kluwer Academic Publishers, 2001.

- Tai Ran Hsu, MEMS & Micro system Design and Manufacture, Tata McGraw Hill, New Delhi 2002
- Marc Madou, Fundamentals of Micro fabrication, CRC Press, 2ndEdition, 2002.
- Julian W. Gardner and Vijay K. Varadan, Micro sensors, MEMS, and Smart Devices, John Wiley & Sons Ltd, 1stEdition, reprinted 2007
- Fundamentals of Micro fabrication by, CRC Press, 1997.Gregory Kovacs, Micro machined Transducers Sourcebook WCB McGraw-Hill, Boston, 1998.
- M.-H. Bao, Micromechanical Transducers: Pressure sensors, accelerometers, and gyroscopes by Elsevier, New York, 2000.
- http://nptel.ac.in/courses/'MEMS and Micro Systems.

Course Contents and Lecture Schedule

Module No.	Topic	No. of Hours	CO
1.	**Historical Background**		
1.1	Introduction, emergence, MEMS application	1	CO1
1.2	Scaling issues, Micromachining, Micro fabrication, Conventional IC fabrication processes.	1	CO1
1.3	Silicon Pressure sensors	1	CO1
2	**Micro fabrication Techniques:**,		
2.1	MEMS Materials, Material Properties	1	CO1
2.2	Bulk and surface micromachining, Wet and dry etching	1	CO1
2.3	Thin-film depositions (LPCVD, Sputtering, Evaporation),	1	CO1
2.4	LIGA, Electroplating	1	CO1
3	**Physical Micro sensors**		
3.1	Classification of physical sensors, Integrated, Intelligent, or Smart sensors,	1	CO2
3.2	Sensor Principles and Examples, Thermal sensors	2	CO2
3.3	Electrical Sensors, Mechanical Sensors,	1	CO2
3.4	Chemical, Biosensors	1	CO2
3.5	Underwater flow sensors	2	CO2
4	**Micro actuators**		
4.1	Electromagnetic and Thermal micro actuation, Micro actuator examples	1	CO3
4.2	Micro valves, micro pumps, micro motors,3D printing	6	CO3
4.3	Ink-Jet printer heads, Micro-mirror TV Projector	2	CO3
5	**Micro accelerometer** :,		
5.1	Capacitive and piezoresistive	1	CO4
5.2	Electronic interfaces	1	CO4
6	**Application Areas:**		
6.1	3-D electromagnetic actuators and sensors,	1	CO5
6.2	RF/Electronics devices,	1	CO5
6.3	Optical/Photonic devices, Medical devices e.g. DNA-chip, micro-arrays	1	CO5
7	**Computer aided design of MEMS:**		
7.1	Introduction to Commercial packages, Introduction and usage of Intellisuite, Coventorware and Comsol.	2	CO6
7.2	Design and simulation of MEMS Sensors using CAD tools	3	CO6
7.3	Design and simulation of MEMS actuators using CAD tools	3	CO6
7.4	Design and simulation of MEMS accelerometers using CAD tools	3	CO6
	Total hrs	36	

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18ECEB0	FUNDAMENTALS OF MACHINE LEARNING	Category	L	T	P	Credit
		ES	2	1	0	3

Preamble

The objective of this course is to provide the mathematical background necessary for developing Machine Learning Algorithms. In this course, mathematical topics namely linear algebra, analytical geometry, multivariate calculus and probability theory are covered. This course also covers dimensionality reduction, classification, density estimation and regression methods which are the building blocks of machine learning.

Prerequisite

NIL

Course Outcomes

On the successful completion of the course students will be able to

CO#	Course Outcome Statement	Weightage in %
CO1	Calculate the prediction value of particular test data point using probability theory	15
CO2	Determine suitable matrix decomposition method for an intuitive interpretation of the data and more efficient learning	15
CO3	Determine the parameter that maximize the performance measure in machine learning using multivariate calculus	15
CO4	Determine the suitable linear regression function in a diverse range of research areas in machine learning.	15
CO5	Represent the data in compact form with Principal Component Analysis	15
CO6	Represent the characteristics of data compactly using probability distributions	15
CO7	Classify the data using Support Vector Machine	10

CO Mapping with CDIO Curriculum Framework

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS3	Apply	Value	-	1.3, 2.1.1, 2.1.2, 2.4.1, 2.4.2, 3.1.1, 3.1.2
CO2	TPS3	Apply	Value	-	1.3, 2.1.1, 2.1.2, 2.4.1, 2.4.2, 3.1.1, 3.1.2
CO3	TPS3	Apply	Value	-	1.3, 2.1.1, 2.1.2, 2.4.1, 2.4.2, 3.1.1, 3.1.2
CO4	TPS3	Apply	Value	Mechanism	1.3, 2.1.1, 2.1.2, 2.4.1, 2.4.2, 3.1.1, 3.1.2
CO5	TPS3	Apply	Value	Mechanism	1.3, 2.1.1, 2.1.2, 2.4.1, 2.4.2, 3.1.1, 3.1.2
CO6	TPS3	Apply	Value	Mechanism	1.3, 2.1.1, 2.1.2, 2.4.1, 2.4.2, 3.1.1, 3.1.2
CO7	TPS2	Understand	Respond	Guided Response	1.3, 2.1.1, 2.1.2, 2.4.1, 2.4.3

Mapping with Programme Outcomes and Programme Specific Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	S	M	L	-	-	-	-	-	M	-	-	-	M		L
CO2	S	M	L	-	-	-	-	-	M	-	-	-	M	-	L
CO3	S	M	L	-	-	-	-	-	M	-	-	-	M	-	L
CO4	S	M	L	-	M	-	-	-	S	-	-	-	M	-	M
CO5	S	M	L	-	M	-	-	-	S	-	-	-	M	-	M

CO6	S	M	L	-	M	-	-	-	S	-	-	-	M	-	M
CO7	M	L	-	-	M	-	-	-	S	-	-	-	M	-	M

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

Cognitive Levels	Continuous Assessment Tests			Assignment			End Semester Examination
	1	2	3	1	2	3	
Remember	0	0	0	0	0	0	0
Understand	20	20	20	0	0	0	20
Apply	80	80	80	100	50	50	80
Analyse	0	0	0	0	0	0	0
Evaluate	0	0	0	0	0	0	0
Create	0	0	0	0	0	0	0

Assessment Pattern: Psychomotor

Psychomotor Skill	Assignment-1	Assignment-2	Assignment-3
Perception	-	-	-
Set	-	-	-
Guided Response	-	-	-
Mechanism	-	50	50
Complex Overt Responses	-	-	-
Adaptation	-	-	-
Origination	-	-	-

Sample Questions for Course Outcome Assessment

Course Outcome 1 (CO1):

1. Consider a statistical experiment where we model a funfair game consisting of drawing two coins from a bag (with replacement). There are coins from USA (denoted as $) and UK (denoted as £) in the bag, and since we draw two coins from the bag, there are four outcomes in total. Let us assume that the composition of the bag of coins is such that a draw returns at random a $ with probability 0:3. Find the the probability mass function
2. Consider two random variables X and Y, where X has five possible states and Y has three possible states, as shown in Figure.1. We denote by n_{ij} the number of events with state $X = x_i$ and $Y = y_j$ and denote by N the total number of events. The value c_i is the sum of the individual frequencies for the ith column, that is, $c_i = \sum_{j=1}^{3} n_{ij}$. Similarly, the value r_j is the row sum, that is, $r_j = \sum_{i=1}^{5} n_{ij}$. Using these definitions, compactly express the distribution of X and Y .

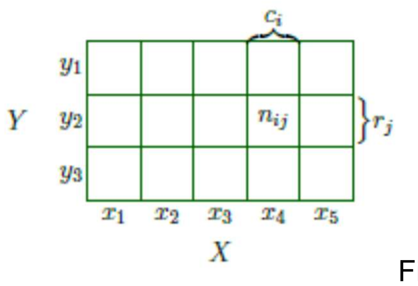


Figure.1

3. Consider a random variable X with zero mean and also $E\left[x^3\right] = 0$. Let $y = x^2$ (hence, Y is dependent on X). Compute the covariance between X and Y .

Course Outcome 2 (CO2):

1. Compute the determinant of $A=\begin{bmatrix}1&2&3\\3&1&2\\0&0&1\end{bmatrix}$ using the Laplace expansion along the first row.
2. Compute the Eigen values, Eigen vectors and Eigen spaces of the 2×2 matrix $A=\begin{bmatrix}4&2\\1&3\end{bmatrix}$.
3. Determine the orthogonal basis function for the matrix $A=\begin{bmatrix}3&2&2\\2&3&2\\2&2&3\end{bmatrix}$

Course Outcome 3 (CO3):

1. Consider the function in Figure.2 given by $f(x)=\sin(x)+\cos(x)\in C^{\infty}$. Find the Taylor series expansion of f at $x_0=0$.

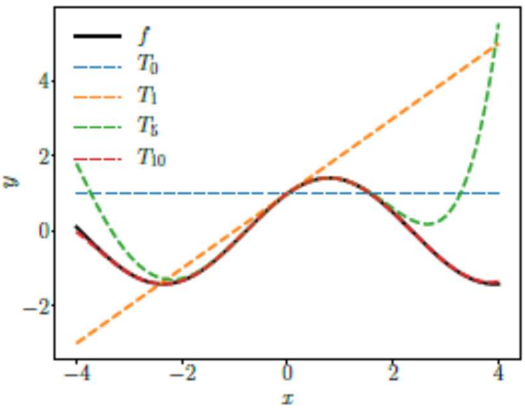


Figure.2

2. Find the gradient for the function $f(x_1,x_2)=x_1^2x_2+x_1x_2^3 \quad \in\mathbb{R}$.
3. Prove the negative entropy of $f(x)=x\log_2 x$ is convex for $x>0$.

Course Outcome 4 (CO4):

1. Find the feature matrix for a second-order polynomial and N training points $x_n\in\mathbb{R}, n=1,\cdots N$.
2. Let $b\in\mathbb{R}^m-\{\mathbf{0}_m\}$ and $y\in\mathbb{R}^m$. Prove that $\|\mathbf{b}r-\mathbf{y}\|$ is minimal when $r=\dfrac{(\mathbf{y}.\mathbf{b})}{\|\mathbf{b}\|^2}$.
3. Let $B=(\mathbf{b}^1,\cdots\mathbf{b}^n)\in\mathbb{R}^{m\times n}$ be a matrix having orthogonal columns (in other words, $i\neq j$ implies $(b^i,b^j)=0$) such that $m>n$. Prove that
   i. Matrix $\mathbf{B}$ has full rank, that is $rank(\mathbf{B})=n$.
   ii. If $\mathbf{r}$ is the solution of the optimization problem that consists in minimizing the function $f(r)=\|\mathbf{Br}-\mathbf{y}\|^2$, then $r_j=\dfrac{(\mathbf{y}.\mathbf{b}^j)}{\|\mathbf{b}^j\|^2}, 1\le j\le n$. In other words, the components of the solution of linear regression do no influence each other.

Course Outcome 5 (CO5):

1. Let us analyze the following 3-variate dataset with 10 observations. Each observation consists of 3 measurements on a wafer: thickness, horizontal displacement, and vertical displacement. $\mathbf{x} = \begin{bmatrix} 7 & 4 & 3 \\ 4 & 1 & 8 \\ 6 & 3 & 5 \\ 8 & 6 & 1 \\ 8 & 5 & 7 \\ 7 & 2 & 9 \\ 5 & 3 & 3 \\ 9 & 5 & 8 \\ 7 & 4 & 5 \\ 8 & 2 & 2 \end{bmatrix}$. Compute the principal factors.

2. Consider a small 3 x 2 matrix, $\begin{bmatrix} 1 & 2 \\ 3 & 4 \\ 5 & 6 \end{bmatrix}$, centers the data in the matrix, calculates the covariance matrix of the centered data, and then the eigen decomposition of the covariance matrix. The eigen vectors and eigen values are taken as the principal components and singular values and used to project the original data.

3. Write a program in python to calculate the Principal Component Analysis on a dataset using the PCA () class in the scikit-learn library.

Course Outcome 6 (CO6):

1. Compute the responsibilities $r_{n,k}$ for the given Figure.3.

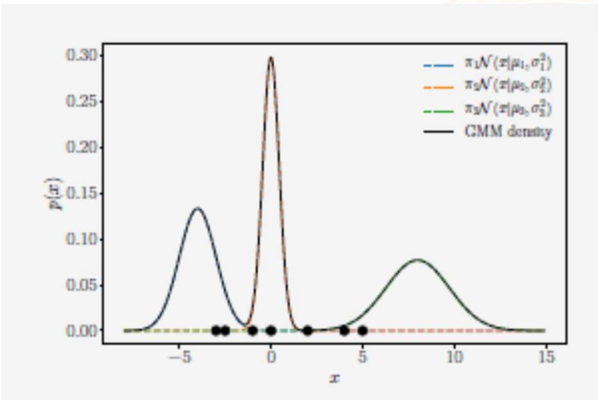


Figure.3

2. Prove the update of the mean parameters $\mu_k, k = 1, \cdots K$ of the Gaussian Mixture Model given by $\mu_k = \dfrac{\sum_{n=1}^{N} r_{nk} x_n}{\sum_{n=1}^{N} r_{nk}}$, where r_{nk} is the responsibilities.

3. Prove the update of the covariance parameters $\Sigma_k, k = 1, \cdots K$ of the Gaussian Mixture Model given by $\Sigma_k^{new} = \dfrac{1}{N_k} \sum_{n=1}^{N} r_{nk} \left(\mathbf{x}_n - \mu_k\right)\left(\mathbf{x}_n - \mu_k\right)^T$.

Course Outcomes 7 (CO7):

1. What is the distance between two parallel Hyperplanes $\left\{x \in \Re^n \middle| a^T x = b_1\right\}$ and $\left\{x \in \Re^n \middle| a^T x = b_2\right\}$?
2. Consider the data set D in $\mathbb{R}^2$ shown in Figure.4, where C is a circle centred in (6,4) having radius 3. Define a transformation $\phi : \mathbb{R}^2 \rightarrow \mathbb{R}^2$ such that $\phi(D)$ is linearly separable.

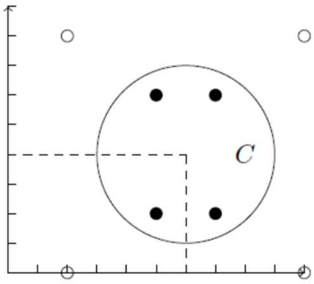
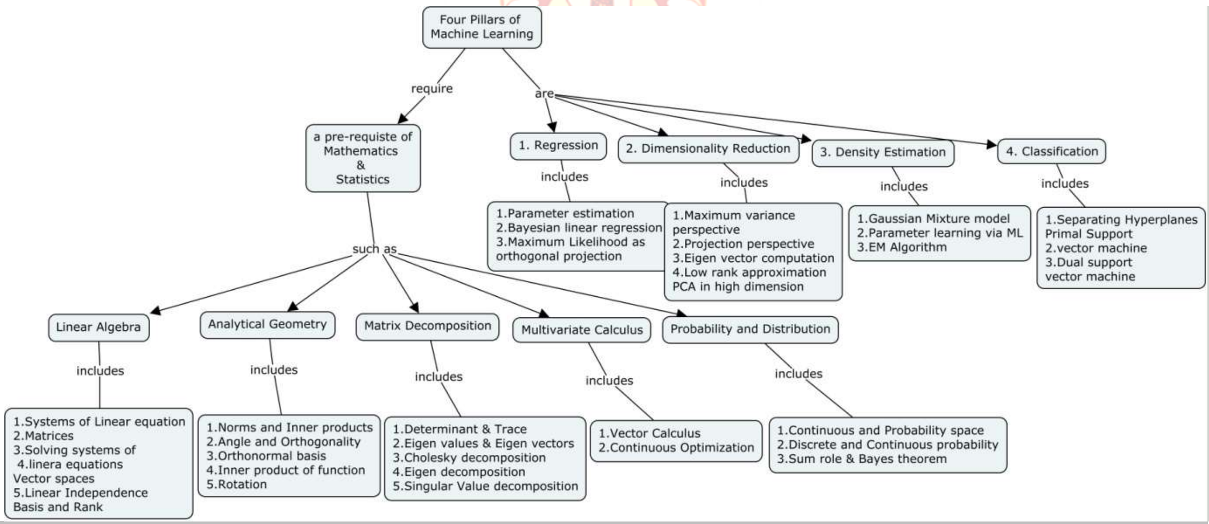


Figure.4

3. Prove that if K is not linearly separable, then K is summable.

Concept Map



Syllabus

Probability and Distribution – Continuous and probability space, Discrete and continuous probability, Sum rule, product rule and Bayes Theorem **Matrix Decomposition-**Determinant and trace, Eigen values and Eigen vectors, Cholesky decomposition, Eigen decomposition, Singular value decomposition **Multivariate Calculus-** Vector Calculus, Continuous optimization **Regression –** Parameter estimation, Bayesian linear regression, Maximum Likelihood as Orthogonal Projection **Dimensionality Reduction with Principal Component Analysis (PCA)** Maximum Variance perspective, Projection perspective, Eigenvector computation and low-rank approximations, PCA in high dimensions **Density Estimation with Gaussian Mixture Models** Gaussian mixture, Parameter learning via Maximum likelihood, EM algorithm **Classification with Support Vector Machines** Separating Hyperplanes, Primal support vector machine, dual support vector machine

Learning Resources

- Marc Peter Deisenroth, A. Aldo Faisal and Cheng Soon Ong , “ Mathematics for Machine Learning”, Cambridge University Press, 2019
- Jason Brownlee, “ Basics of Linear Algebra for Machine Learning”, ebook, 2018
- Alpaydin, Ethem. “Introduction to Machine Learning”, MIT Press, 2010.

- Dan Simovice, "Mathematical Analysis for Machine Learning and Data Mining", World Scientific, 2018.
- Mehryar Mohri, Afshin Rostamizadeh and Ameet Talwalkar, "Foundations of Machine Learning" MIT Press, 2018.

Course Contents and Lecture Schedule

No.	Topic	No. of Hours	COs
1	**Probability and Distribution**		
1.1	Continuous and probability space	1	CO1
1.2	Discrete and continuous probability	1	CO1
1.3	Sum rule, product rule and Bayes Theorem	1	CO1
1.4	Tutorial	1	CO1
2	**Matrix Decomposition**		
2.1	Determinant and trace	1	CO2
2.2	Eigen values and Eigen vectors	1	CO2
2.3	Cholesky decomposition	1	CO2
2.4	Eigen decomposition	1	CO2
2.5	Singular value decomposition	1	CO2
2.6	Tutorial	1	CO2
3	**Multivariate Calculus-**,		
3.1	Vector Calculus	2	CO3
3.2	Continuous optimization	2	CO3
3.3	Tutorial	1	CO3
4	**Regression**,		
4.1	Parameter estimation	1	CO4
4.2	Bayesian linear regression	1	CO4
4.3	Maximum Likelihood as Orthogonal Projection	2	CO4
4.4	Tutorial	1	CO4
5	**Dimensionality Reduction with Principal Component Analysis (PCA)**		
5.1	Maximum Variance perspective	1	CO5
5.2	Projection perspective	1	CO5
5.3	Eigenvector computation and low-rank approximations	2	CO5
5.4	PCA in high dimensions	1	CO5
5.6	Tutorial	1	CO5
6.	**Density Estimation with Gaussian Mixture Models**		
6.1	Gaussian mixture	1	CO6
6.2	Parameter learning via Maximum likelihood	2	CO6
6.3	EM algorithm	1	CO6
6.4	Tutorial	1	CO6
7	**Classification with Support Vector Machines**		
7.1	Separating Hyperplanes	1	CO7
7.2	Primal support vector machine	2	CO7
7.3	dual support vector machine	1	CO7
7.4	Tutorial	1	CO7
	Total	36	

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18ECEC0	IOT SENSORS AND DEVICE	Category	L	T	P	Credit
		ES	3	0	0	3

Preamble

This course aims to provide students to course learn about the ‘things’ that get connected in the Internet of Things to sense and interact with the real world environment, and to explore and interact with the IoT bridge betweenthe cyberand physical worlds.

Prerequisite

NIL

Course Outcomes

On the successful completion of the course students will be able to

CO Number	Course Outcome Statement	Weightage in %
CO1	Describe the IoT and Embedded hardware and software.	10
CO2	Demonstrate the ability to incorporate sensors and actuators into a circuit.	20
CO3	Consturuct the IoT Intermediary devices and internet capable link.	10
CO4	Design and sketchprograms using IoT Virtual tool.	20
CO5	Apply the open and closed loop system transfer functions forIoT based system	20
CO6	Design and Test the IoT based system using use case and test case.	20

CO Mapping with CDIO Curriculum Framework

CO#	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS2	Understand	Respond	-	1.3, 2.1.5, 2.2.2, 2.3.1,
CO2	TPS3	Apply	Value	-	1.3, 2.1.5, 2.2.2, 2.3.1, 4.4.3
CO3	TPS2	Understand	Respond	-	1.3, 2.1.5, 2.2.2, 2.3.1,
CO4	TPS3	Apply	Value	-	1.3, 2.1.5, 2.2.2, 2.3.1, 4.4.3
CO5	TPS3	Apply	Value	-	1.3, 2.1.5, 2.2.2, 2.3.1, 4.4.3
CO6	TPS3	Apply	Value	-	1.3, 2.1.5, 2.2.2, 2.3.1, 4.4.3

Mapping with Programme Outcomes and Programme Specific Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	M	L	-	-	-	-	-	-	-	-	-	-	L	-	-
CO2	S	M	L	-	L	-	-	-	L	-	-	L	M	-	-
CO3	M	L	-	-	-	-	-	-	-	-	-	-	L	-	-
CO4	S	M	L	-	L	-	-	-	L	-	-	L	M	-	-
CO5	S	M	L	-	L	-	-	-	L	-	-	L	M	-	-
CO6	S	M	L	-	L	-	-	-	L	-	-	L	M	-	-

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

Cognitive Levels	Continuous Assessment Tests			Assignment			End Semester Examination
	1	2	3	1	2	3	
Remember	0	0	0	0	0	0	0
Understand	40	40	40	0	0	0	20
Apply	60	60	60	100	100	100	80
Analyse	0	0	0	0	0	0	0
Evaluate	0	0	0	0	0	0	0
Create	0	0	0	0	0	0	0

AssessmentPattern: Psychomotor

Psychomotor Skill	Miniproject/Assignment/Practical Component
Perception	-
Set	-
Guided Response	-
Mechanism	-
Complex Overt Responses	-
Adaptation	-
Origination	-

Sample Questions for Course Outcome Assessment

Course Outcome1 (CO1):

1. Explain the range of IoT and Embedded System.
2. Describe the IoT hardware and software component.
3. Explain the role of an operating system in an IoT device.

Course Outcome2 (CO2):

1. Design a circuit that lights an LED when it is sufficiently dark in a room. Demonstrate the circuit by covering the photo-resistor to darkness.
2. Design a grade separation a highway junction and a pedestrian road junction with a redundant audio alarm and a time and requests the green light by pressing the button the train can be detected by a special optical sensor.
3. Design a mobile robot, which can shoot objects in a basket at different angles in proper selection of sensor and motors and IoT Board.

Course Outcome 3 (CO3):

1. List the Microcontroller based on a set of requirements,
2. Explain the architecture of Microcontroller to Microcontroller communication.
3. Explain the communication between Microcontrollers to Computer/Cloud.

Course Outcome 4 (CO4):

1. Design a circuit and write a program that causes the built-in LED connected to pin 13 on the Arduino to blink, alternating between fast blinks and slow blinks.
2. Design a circuit and write a program that allows the user to control the LED connected to pin 13 of the Arduino. If the user sends the character '1' through the serial monitor then the LED should turn on. If the user sends the character '0' through the serial monitor then the LED should turn off.
3. Design a circuit that contains two push buttons, an LED, and any other basic components, the LED should turn on when either the first button or the second button is pressed.

Course Outcome 5 (CO5):

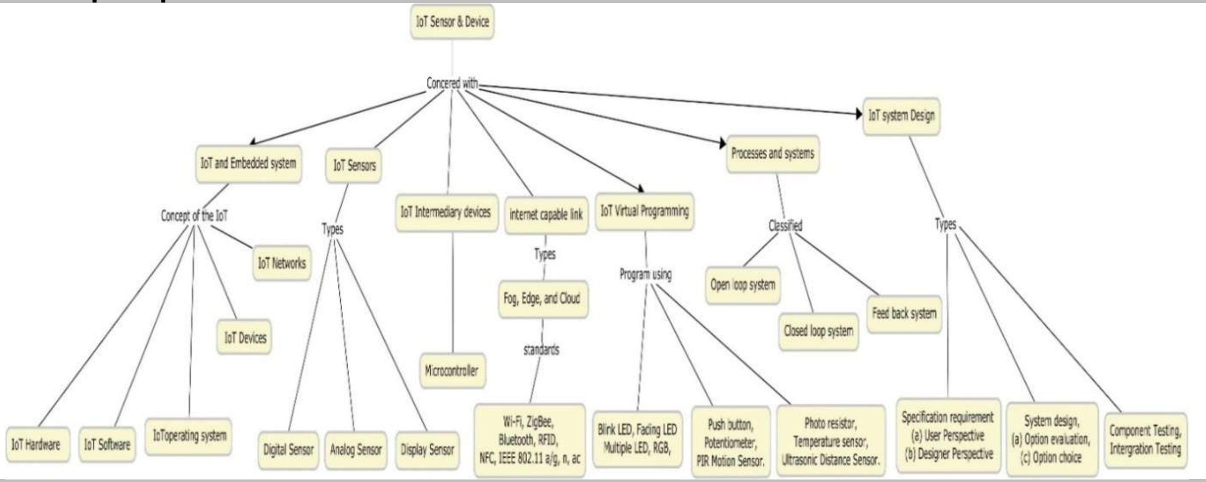
1. Design of an Unmanned Aircraft Vehicle (UAV) apply the both Yaw and Roll, pitch control and find step response, nyquist diagram, and magnitude and phase plot using open loop and closed loop system.
2. Design of an IoT based Temperature monitoring system the different ways IoT systems are controlled using open loop and closed loop system.

Course Outcome 6(CO6):

1. Design of an IoT based agricultural storage monitoring system with block diagram of following draft
    - Specification requirement document in user perspective and designer Perspective.
    - System design and option evaluation, option choice document.
    - Testing of Components and Integration testing document.
2. Design of an IoT based Implementation of Traffic Intersection Interface system with block diagram of following draft
    - Specification requirement document in user perspective and designer Perspective.
    - System design and option evaluation, option choice document.
    - Testing of Components and Integration testing document.
3. Design of an IoT based Temperature monitoring system with block diagram of following draft
    - Specification requirement document in user perspective and designer Perspective.

- System design and option evaluation, option choice document.
- Testing of Components and Integration testing document.

ConceptMap



Syllabus

IoT and Embedded system: Concept of the Internet of Things, Structure of embedded systems and interactions with the physical world, IoT hardware and software component, Role of an operating system in an IoT device, Networking enables devices and small local networks of IoT devices. **IoT Sensors:** Differentiate between different sensor types and application areas for a selected range of sensors and actuators, Incorporation sensors and actuators into a circuit. **IoT Intermediary devices and internet capable link:** Microcontroller based on a set of requirements, Communication protocols, Microcontroller to Microcontroller communication, Microcontroller to Computer/Cloud communication, Fog, Edge, and Cloud processing, Cellular networks, **IoT Virtual Programming:** Blink an LED with digital output, Blink multiple LED, Fading LED with Analog outputs, RGB LED Colour Mixing, Digital Input / Analog output, Push button, Potentiometer using serial monitor, PIR Motion Sensor, Photo resistor, Temperature sensor, Ultrasonic Distance Sensor. **Processes and systems:** Concept of both open loop and closed loop systems, Inputs, outputs, control and feedback for a system, Different ways that systems are controlled. **IoT based system Design:** Specification requirement document in user perspective and designer Perspective, System design and option evaluation, option choice document, Testing of Components and Integration testing, virtual circuit software tool to solve IoT problems.

Learning Resources

- Adrian McEwen, Hakim Cassimally "Designing the Internet of Things", Wiley Publishing,2015
- Arshdeep Bahga and Vijay Madisetti, "Internet of Things: A Hands-on Approach", 2015 Web link : https://www.universitiespress.com/details?id=9788173719547
- Sudip Misra, IIT- Kharagpur, swayam course on " Introduction to Internet of Things" https://swayam.gov.in/nd1_noc20_cs66/preview
- Ian Harris, Professor, University of California, Irvine, Coursera, Course on "Introduction to the Internet of Things and Embedded Systems"
- Iain Murray, Cesar Ortega-Sanchez, Sivas' Khaksar, Curtin University, Perth, Edx course on "IOT2x – IoT Devices and Sensors"
- Online-Virtual circuit software tool web link: https://www.tinkercad.com/learn/project-gallery;collectionId=OMOZACHJ9IR8LRE
- Kallol Bosu Roy Choudhuri "Learn Arduino Prototyping in 10 days - Your crash course to build innovative devices" Packt Publishing, 2017.

Course Contents and Lecture Schedule

Module No.	Topic	No. of Hours	Course Outcome
1	**IoT and Embedded system**		
1.1	Concept of the Internet of Things.	1	CO1
1.2	Structure of embedded systems.	1	CO1
1.3	IoT Interactions with the physical world.	1	CO1
1.4	IoT hardware and software component.	1	CO1
1.5	Role of an operating system in an IoT device.	1	CO1
1.6	Networking enables devices.	1	CO1
1.7	Small local networks of IoT devices.	1	CO1
2	**IoT Sensors**		
2.1	Differentiate between different sensor types	3	CO2
2.2	Application areas for a selected range of sensors and actuators	3	CO2
2.3	Incorporate sensors and actuators into a circuit	3	CO2
3.	**IoT Intermediary devices and internet capable link**		
3.1	Microcontroller based on a set of requirements.	1	CO3
3.2	Communication protocols.	1	CO3
3.3	Microcontroller to Microcontroller communication.	1	CO3
3.4	Microcontroller to Computer/Cloud communication.	1	CO3
3.5	Fog, Edge, and Cloud processing.	2	CO3
4	**IoT Virtual Programming**		
4.1	Blink an LED with digital output, Blink multiple LED.	1	CO4
4.2	Fading LED with Analog outputs, RGB, LED Colour Mixing.	1	CO4
4.3	Digital Input / Analog output, Push button, Potentiometer using serial monitor.	1	CO4
4.4	PIR Motion Sensor and Photo resistor, Temperature sensor, Ultrasonic Distance Sensor	2	CO4
5	**Processes and systems**		
5.1	Concept of open loop and closed loop systems, Inputs, outputs, control and feedback for a system.	2	CO5
5.2	Different ways that systems are controlled	1	CO5
6	**IoT system Design**		
6.1	Specification requirement in user and designer perspective,	2	CO6
6.2	System design and option evaluation, option choice and Testing of Components and Integration testing.	2	CO6
6.3	Virtual circuit software tool to solve IoT problems.	2	CO6
	Total No. of Hours	36	

Course Designers:

- Mr.M.Senthilnathan msnece@tce.edu

18ECED0	BLOCKCHAIN TECHNOLOGY	Category	L	T	P	Credit
		ES	3	0	0	3

Preamble

Blockchain is an emerging technology platform for developing decentralized applications and data storage. This course includes the fundamental design and architectural primitives of Blockchain, the system and the security aspects, along with consensus mechanisms, crypto currencies, smart contracts, and problems of blockchain. The applications of Blockchain have now spread from crypto-currencies to various other domains, including business process management, smart contracts, IoT, trustworthy e-governance and so on.

Prerequisite

NIL

Course Outcomes

On the successful completion of the course students will be able to

CO Number	Course Outcome Statement	Weightage in %
CO1	Determine the role of Hash functions, digital signature and distribution systems as blockchain primitives	15
CO2	Describe the operations of crypto-currencies, Bitcoin and Ethereum	10
CO3	Apply the distributed consensus mechanisms of proof of work and proof of stake	15
CO4	Use the scripting language to write smart contracts and blockchain platforms to develop hyperledgers	20
CO5	Analyze the privacy, security and scalability problems of blockchain	20
CO6	Build the Blockchain use cases in finance, industry, IoT and e-governance,	20

CO Mapping with CDIO Curriculum Framework

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS3	Apply	Value	-	1.3, 2.1.1, 2.1.5
CO2	TPS2	Understand	Respond	-	1.3, 2.2.2
CO3	TPS3	Apply	Value	-	1.3, 2.1.1, 2.1.5
CO4	TPS3	Apply	Value	-	1.3, 2.1.1, 2.3.1, 3.2.4
CO5	TPS4	Analyze	Organise	-	1.3, 2.1.1, 2.1.5, 2.2.2, 2.3.1, 3.2,6
CO6	TPS3	Apply	Value	-	1.3, 2.1.5, 2.2.2, 3.2.6

Mapping with Programme Outcomes and Programme Specific Outcomes

Cos	PO 1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	S	M	L	-	-	-	-	-	-	-	-	L	M	-	-
CO2	M	L	-	-	-	-	-	-	-	-	-	-	L	-	-
CO3	S	M	L	-	-	-	-	-	-	-	-	L	M	-	-
CO4	S	M	L	-	S	-	-	-	-	L	-	L	M	-	L
CO5	S	S	M	L	-	-	-	-	-	L	-	M	S	-	L
CO6	S	M	L	-	L	-	-	-	-	M	-	L	M	-	M

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

Cognitive Levels	Continuous Assessment Tests			Assignment			End Semester Examination
	1	2	3	1	2	3	
Remember	15	0	0	0	0	0	0
Understand	25	40	30	0	0	0	30
Apply	60	60	50	100	100	70	50
Analyse	0	0	20	0	0	30	20
Evaluate	0	0	0	0	0	0	0
Create	0	0	0	0	0	0	0

Assessment Pattern: Psychomotor

Psychomotor Skill	Assignment-1	Assignment-2	Assignment-3
Perception	-	-	-
Set	-	-	-
Guided Response	-	-	-
Mechanism	-	-	-
Complex Overt Responses	-	-	-
Adaptation	-	-	-
Origination	-	-	-

Sample Questions for Course Outcome Assessment

Course Outcome 1 (CO1):

1. Describe the requirements and characteristics of hash function.
2. User A wants to digitally sign his/her document to user B by using the global parameters, prime number p = 71 and its primitive root, alpha = 2. The signed document needs to be verified by user B. Assume that user A's private key, X_A is 7, the random value k is 3 and its message is 10. Verify user A's digital signature in user B using appropriate public key method.
3. Consider an Elliptic Curve signature scheme. We have a global elliptic curve, prime p, and "generator" G. Alice picks a private signing key X_A and forms the public verifying key $Y_A = X_AG$. To sign a message M: Alice picks a value k. Alice sends Bob M, k and the signature $S = MkX_AG$. Bob verifies that $M = S + kY_A$.
   a. Show that this scheme works. That is, show that the verification process produces equality if the signature is valid.
   b. Show that the scheme is unacceptable by describing a simple technique for forging a user's signature on an arbitrary message.

Course Outcome 2 (CO2):

1. Explain design principles of Bitcoin and Ethereum.
2. Compare Blockchain, Crypto-currency and Token.
3. How to find a transaction in Blockchain and compare the types on blockchains.

Course Outcome 3 (CO3):

1. Design and deploy a distributed application.
2. Distinguish between proof-of-work and proof-of-stake consensus and write their security implications.
3. Explain the process of mining and how do miners make money?

Course Outcome 4 (CO4):

1. Write smart contracts for various transactions and explain why this is revolutionary and different from legal documents?
2. Develop a simple application using Solidity.
3. Develop projects using Hyperledger fabric platform, Plug-and-play platform

Course Outcome 5 (CO5):

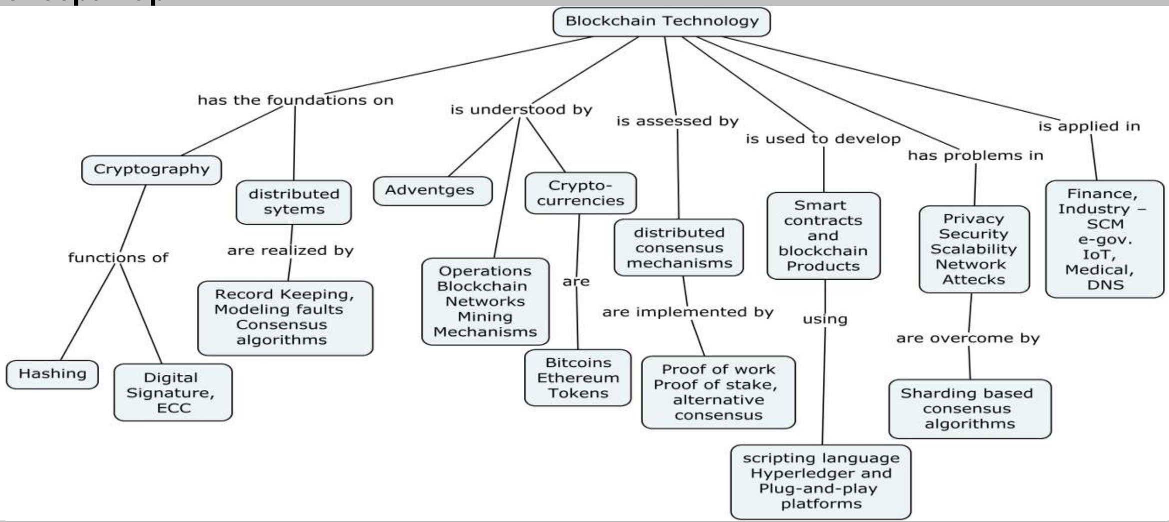
1. How is scalability problem resolved?
2. Examine the security issues, failed currencies & blockchains and protection from attackers.

3. Evaluate security, privacy, and efficiency of a given blockchain system.

Course Outcome 6 (CO6):

1. How will you create your own blockchain and explain the necessary steps needed.
2. Design a use case for blockchain in a business case or area of interest. What problem is this trying to solve? What is the value proposition of solving this problem? How will a blockchain be applied to this use case? Which component pieces will be utilized?
3. Design Blockchain use cases for the following:
   i. Digital Rights - ownership and accessibility, education
   ii. Industry - healthcare, identity, finance
   iii. Paradigm shift/future/big picture
   iv. Elections and Voting: Auto execution of contracts, escrow, etc.

Concept Map



Syllabus

Cryptographic primitives in Blockchain: Secure, Collision-resistant hash functions, digital signature, public key cryptosystems - encryption schemes and elliptic curve cryptography, verifiable random functions, zero-knowledge proof systems **Distributed System concepts:** Need for Distributed Record Keeping, Modeling faults and adversaries, Consensus algorithms - scalability problems and distributed consensus **Blockchain 1.0:** Advantages over conventional distributed database, Blockchain Network, private and public, Mining Mechanism, Bitcoin blockchain, the challenges, operations and solutions, contemporary proof-of-work based consensus mechanisms, Proof of stake, alternatives to Bitcoin consensus, crypto-currency, Bitcoin scripting language and their use **Blockchain 2.0:** Ethereum and smart contracts and Turing complete blockchain scripting – Solidity, issues of correctness and verifiability, Ethereum platform and its smart contract mechanism **Blockchain 3.0:** Hyperledger fabric platform, Plug-and-play platform and mechanisms for consensus and smart contract evaluation engines **Beyond Crypto-currency:** Privacy, Security issues in Blockchain: Pseudo-anonymity vs. anonymity, Zcash and Zk-SNARKS for anonymity preservation, attacks on Blockchains – Sybil attacks, selfish mining and Sharding based consensus algorithms **Blockchain Use Cases:** Finance, Industry – supply chain management, e-governance, Land Registration, Internet of Things, Medical Record Management System, and Domain Name Service

Learning Resources

- Arvind Narayanan, Joseph Bonneau, Edward Felten, Andrew Miller, and Steven Goldfeder, “Bitcoin and Cryptocurrency Technologies: a comprehensive introduction”, Princeton University Press, 2016.
- S.Shukla, M.Dhawan, S.Sharma, S.Venkatesan, “Blockchain Technology: Cryptocurrency and Applications”, Oxford University Press, 2019.

- Josh Thompson, “Blockchain: The Blockchain for beginners guide to Blockchain technology and Blockchain programming”, Create Space Independent Publishing Platform, 2017.
- Andreas M. Antonopoulos, “Mastering Bitcoin: Unlocking Digital Cryptocurrencies”, O'Reilly Media, 2014.
- Gavin Wood, “ETHEREUM: A Secure Decentralized Transaction Ledger”, Yellow paper, 2014.
- Nicola Atzei, Massimo Bartoletti, and Tiziana Cimoli, “A survey of attacks on Ethereum smart contracts” IACR Cryptology ePrint Arch., 2016.
- NPTEL Course on Blockchain architecture design and use cases:
- https://nptel.ac.in/courses/106/105/106105184/
- NPTEL Course on Introduction to Blockchain technology and applications: https://nptel.ac.in/courses/106/104/106104220/#
- Virtual Lab: http://vlabs.iitb.ac.in/vlabs-dev/labs/blockchain/

Course Contents and Lecture Schedule

No.	Topic	No. of Hours	COs
1	**Primitives in Blockchain**		
1.1	Secure, Collision-resistant hash functions, Properties	1	CO1
1.2	Hash Algorithms	1	CO1
1.3	Digital Signature, public key cryptosystems - encryption schemes	2	CO1
1.4	Elliptic Curve Cryptography	1	CO1
1.5	verifiable random functions, zero-knowledge proof systems	1	CO1
1.6	Distributed System concepts - Need for Distributed Record Keeping,	2	CO1
1.7	Modeling faults and adversaries,	1	CO1
1.8	Consensus algorithms - scalability problems and distributed consensus	1	CO1
2	**Blockchain 1.0**		
2.1	Blockchain Networks - private and public	1	CO2
2.2	Mining Mechanism, Bitcoin blockchain, the challenges, operations and solutions	2	CO2
2.3	contemporary proof-of-work based consensus mechanisms, Proof of stake	2	CO3
2.4	alternatives to Bitcoin consensus, crypto-currency	1	CO2
2.5	Bitcoin scripting language and their use	1	CO2
3	**Blockchain 2.0**		
3.1	Ethereum and smart contracts	1	CO3
3.2	Turing complete blockchain scripting – Solidity	2	CO3
3.3	Issues of correctness and verifiability	1	CO3
3.5	Ethereum platform and its smart contract mechanism	1	CO3
4	**Blockchain 3.0**		
4.1	Hyperledger fabric platform	2	CO4
4.2	Plug-and-play platform	1	CO4
4.3	mechanisms for consensus and smart contract evaluation engines	1	CO4
5	**Beyond Crypto-currency**		
5.1	Privacy, Security issues in Blockchain, Pseudo-anonymity vs. anonymity	1	CO5
5.2	Zcash and Zk-SNARKS for anonymity preservation	1	CO5
5.3	Attacks on Blockchains – Sybil attacks, selfish mining	1	CO5
5.4	Sharding based consensus algorithms	2	CO5

6.	**Blockchain Use Cases**		
6.1	Finance, Industry – supply chain management	2	CO6
6.2	e-governance, Land Registration	1	CO6
6.3	IoT, Medical Record Management System, and Domain Name Service	2	CO6
	Total Hours	36	

Course Designers:

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- Dr. M.S.K. Manikandan manimsk@tce.edu
- Dr. S. Ponmalar spmece@tce.edu

18ECEE0	5G WIRELESS NETWORKS	Category	L	T	P	Credit
		ES	3	0	0	3

Preamble

The objective of this course is to introduce the students with a comprehensive understanding of current and 5G wireless Networks that includes 5G Fundamentals with its architecture, small cells, 5G Internets with Internet of Things and Software Defined Network. This course also includes cloud network and Security challenges in 5G network

Prerequisite

NIL

Course Outcomes

On the successful completion of the course students will be able to

CO#	Course Outcome Statement	Weightage in %
CO1	Discuss the concepts of current mobile networks and 5G networks	10
CO2	Demonstrate the ten pillars of 5G	10
CO3	Use the role play of Internet of Things and Software Defined Network and Resource Provisioning in 5G Technology	30
CO4	Determine capacity limits and Data Demands to identify the characteristics of small cells in 5G Networks.	20
CO5	Describe the concepts behind Mobile clouds and Mobile cloud enablers	15
CO6	Examine the Security Issues and Challenges in 5G Systems	15

CO Mapping with CDIO Curriculum Framework

CO #	TCE Proficiency Scale	Learning Domain Level			CDIO Curricular Components (X.Y.Z)
		Cognitive	Affective	Psychomotor	
CO1	TPS2	Understand	Respond	-	1.3, 2.1.1, 2.1.5
CO2	TPS3	Apply	Value	-	1.3, 2.1.1, 2.2.2, 2.1.5, 3.2.6
CO3	TPS3	Apply	Value	-	1.3, 2.1.1, 2.2.2, 2.1.5, 3.2.6
CO4	TPS3	Apply	Value	-	1.3, 2.1.1, 2.2.2, 2.1.5, 3.2.6
CO5	TPS2	Understand	Respond	-	1.3, 2.2.2, 2.3.1
CO6	TPS4	Analyze	Organise	-	1.3, 2.1.1, 2.1.5, 3.2.6

Mapping with Programme Outcomes and Programme Specific Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	M	L	-	-	-	-	-	-	-	-	-	-	L	-	-
CO2	S	M	L	-	-	-	-	-	-	L	-	-	M	-	-
CO3	S	M	L	-	-	-	-	-	-	L	-	-	M	-	-
CO4	S	M	L	-	-	-	-	-	-	-	-	-	M	-	-
CO5	M	L	-	-	-	-	-	-	-	-	-	-	L	-	-
CO6	S	S	M	L	-	-	-	-	-	L	-	-	S	-	-

S- Strong; M-Medium; L-Low

Assessment Pattern: Cognitive Domain

Cognitive Levels	Continuous Assessment Tests			Assignment			End Semester Examination
	1	2	3	1	2	3	
Remember	30	20	0	0	0	0	0
Understand	40	40	50	0	0	0	40
Apply	30	40	30	100	100	70	40
Analyse	0	0	20	0	0	30	20
Evaluate	0	0	10	0	0	0	10
Create	0	0	0	0	0	0	0

Assessment Pattern: Psychomotor

Psychomotor Skill	Assignment-1	Assignment-2	Assignment-3
Perception	-	-	-
Set	-	-	-
Guided Response	-	-	-
Mechanism	-	-	-
Complex Overt Responses	-	-	-
Adaptation	-	-	-
Origination	-	-	-

Sample Questions for Course Outcome Assessment

Course Outcome 1(CO1):
1. Determine the challenges posed by these 5G wireless systems?
2. Discuss the specifications of different generation of wireless Systems.
3. Explain how cellular systems evaluate towards 5G communication systems?

Course Outcome 2(CO2):
1. Explain the ten pillars of 5G wireless Networks
2. Discuss the evolution of Existing RATs.
3. How Self organizing networks work in 5G Networks?

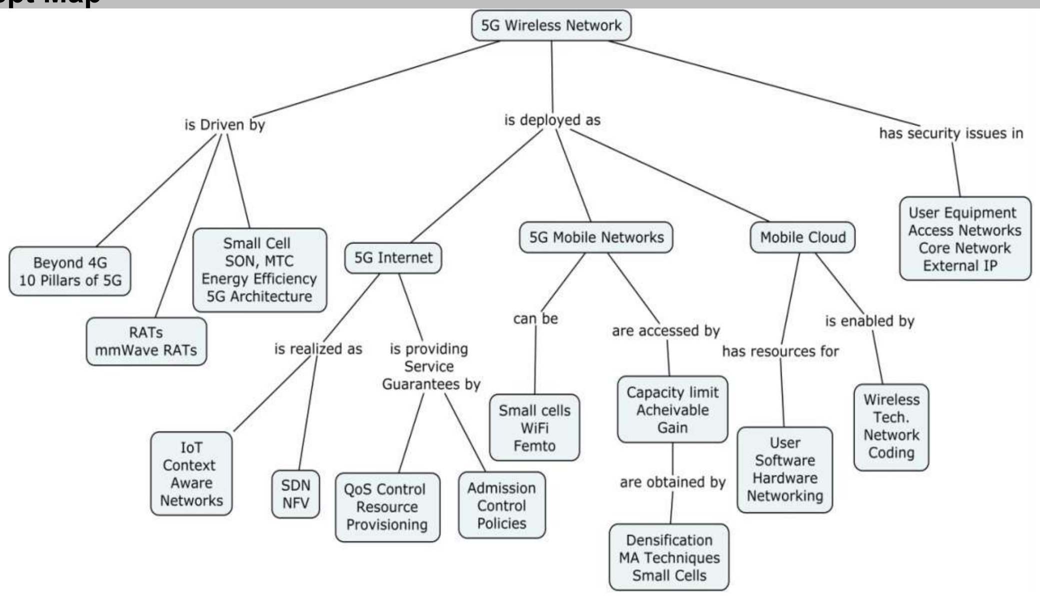
Course Outcome 3(CO3):
1. Using IoT, how 5G network is enabled?
2. Discuss the operation of SDN with example
3. How Network function virtualization works in 5G Networks?

Course Outcome 4 (CO4):
1. Compare different small cells types
2. Based on deployments, how cells are works in 5G networks?
3. Why Wi-Fi and Femto cells as candidates for 5G technology?

Course Outcome 5 (CO5):
1. How cooperation modes work in mobile user domain?
2. Examine wireless technologies from short range to wide area.
3. Explain with example, how mobile cloud participants share their resources in 5G Networks?

Course Outcome 6(CO6):
1. Discuss the security challenges in 5G Networks
2. How Mobile Botnets are functioning in 5G Networks?
3. How Femto cells attacks are overcome in 5G Networks?

Concept Map



Syllabus

Drivers for 5G: Historical Trend of Wireless Communications, Evolution of LTE Technology to Beyond 4G 5G Roadmap, 10 Pillars of 5G- Evolution of Existing RATs, Hyperdense Small Cell Deployment, Self Organising Network, Machine Type Communication, Developing Millimetre Wave RATs, Redesigning Backhaul Links, Energy Efficiency, Allocation of New Spectrum for 5G, Spectrum Sharing, 5G Architecture. **The 5G Internet:** Internet of Things - Context Awareness Networking Reconfiguration and Virtualisation Support -Software Defined Networking ,Network Function Virtualisation , Mobility-An Evolutionary Approach from the Current Internet, A Clean Slate Approach Quality of Service Control-Network Resource Provisioning, Aggregate Resource Provisioning, Emerging Approach for Resource Over Provisioning -Control Information Repository, Service Admission Control Policies ,Network Resource Provisioning ,Control Enforcement Functions Network Configurations , Network Operations **Small Cells for 5G Mobile Networks:** Small Cells- Wi-Fi and Femto cells as Candidate Small Cell Technologies, Wi-Fi and Femto Performance – Indoors Vs. Outdoors, Capacity Limits and Achievable Gains with Densification- Gains with Multi Antenna Techniques, Gains with Small Cells, Mobile Data Demands-Approach and Methodology, Demand vs Capacity, Small Cell Challenges **Mobile Clouds: Technology and Services for Future Communication Platforms:** The Mobile Cloud-User Resources, Software Resources, Hardware Resources, Networking Resources, Mobile Cloud Enablers-The Mobile User Domain, Wireless Technologies Software and Middleware, Network Coding. **Security for 5G Communications:** Overview of a Potential 5G Communications System Architecture , Security Issues and Challenges in 5G Communications Systems- User Equipment, Access Networks, Mobile Operator's Core Network , External IP Networks
.

Learning Resources

- Jonathan Rodriguez, Fundamentals of 5G Mobile Networks, Wiley,2015
- Stefan Rommer, Peter Hedman, Magnus Olsson, Lars Frid, Shabnam Sultana, Catherine Mulligan, 5G Core Networks, Elsevier, 2020.
- Savo Glisic, Advanced Wireless Networks, Technology and Business Models, Wiley 2012
- Fei Hu, "Opportunities in 5G Networks", CRC press 2016.
- Hrishikesh Venkatarman and Ramona Trestian, "5G Radio Access Networks: Centralized RAN, Cloud-RAN, and Virtualization of Small Cells", CRC press 2017.
- Yang Yang, Jing Xu, Guang Shi, Cheng-Xiang Wang, "5G Wireless Systems Simulation and Evaluation Techniques", Springer International Publishing AG 2018.
- Sassan Ahmadil, "LTE-Advanced: A Practical Systems Approach To Understanding 3gpp LTE Releases 10 And 11 Radio Access Technologies", Academic Press 2013.

Course Contents and Lecture Schedule

Module No.	Topic	No. of Hours	Course Outcome
1.	**Drivers for 5G**		
1.1	Historical Trend of Wireless Communications, Evolution of LTE Technology to Beyond 4G	1	CO1
1.2	Roadmap, 10 Pillars of 5G- Evolution of Existing RATs, Hyperdense Small Cell Deployment, Self Organising Network	1	CO1
1.3	Machine Type Communication, Developing Millimetre Wave RATs	1	CO1
1.4	Redesigning Backhaul Links, Energy Efficiency, Allocation of New Spectrum for 5G	1	CO1
1.5	Spectrum Sharing, 5G Architecture	2	CO1
2.	**The 5G Internet**		
2.1	Internet of Things - Context Awareness Networking Reconfiguration and Virtualisation Support	2	CO2

2.2	Software Defined Networking ,Network Function Virtualisation, Mobility-An Evolutionary Approach from the Current Internet	3	CO2
2.3	A Clean Slate Approach Quality of Service Control-Network Resource Provisioning	1	CO3
2.4	Aggregate Resource Provisioning, Emerging Approach for Resource Over Provisioning	2	CO3
2.5	Control Information Repository, Service Admission Control Policies ,Network Resource Provisioning	1	CO3
2.6	Control Enforcement Functions ,Network Configurations , Network Operations	1	CO3
3.	**Small Cells for 5G Mobile Networks**		
3.1	Small Cells- Wi-Fi and Femtocells as Candidate Small Cell Technologies,	1	CO4
3.2	Wi-Fi and Femto Performance – Indoors vs Outdoors,	1	CO4
3.3	Capacity Limits and Achievable Gains with Densification- Gains with Multi Antenna Techniques,	1	CO4
3.4	Gains with Small Cells, Mobile Data Demands - Approach and Methodology, Demand vs Capacity, Small Cell Challenges	1	CO4
4.	**Mobile Clouds: Technology and Services for Communication Platforms**		
4.1	The Mobile Cloud-User Resources, Software Resources, Hardware Resources	1	CO5
4.2	Networking Resources, Mobile Cloud Enablers-	1	CO5
4.3	The Mobile User Domain, Wireless Technologies	1	CO5
4.4	Software and Middleware, Network Coding	1	CO5
5	**Security for 5G Communications**		
5.1	Overview of a Potential 5G Communications System Architecture	1	CO6
5.2	Security Issues and Challenges in 5G Communications Systems	2	CO6
5.3	User Equipment, Access Networks, Mobile Operator's Core Network	2	CO6
5.4	External IP Networks	1	CO6
	Total Hours	**36**	

Course Designers:

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DETAILED SYLLABI

FOR

NEW ELECTIVE COURSE

21ECRG0 Satellite Remote Sensing

B. E. DEGREE PROGRAMME
(Electronics and Communication Engineering)

FOR THE STUDENTS ADMITTED IN THE

ACADEMIC YEAR 2020-21

THIAGARAJAR COLLEGE OF ENGINEERING
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21ECRG0	SATELLITE REMOTE SENSING

Category	L	T	P	Credit
PSE	3	0	0	3

Preamble

In this course the students will learn about the basic concepts and principles of various components of remote sensing, Data acquisition platforms, sensors and their characteristics. They will able to apply image processing algorithms that perform analysis on satellite images They will able to disseminate concepts and algorithms to real world applications.

Prerequisite

NIL

Course Outcomes

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

CO	Course Outcome	TCE Proficiency Scale	Expected Proficiency in %	Expected Attainment Level %
CO1	Explain the concepts of Electromagnetic energy, spectrum and spectral signature curves in the practical problems.	TPS2	70	70
CO2	Interpret Multispectral, Thermal and Hyperspectral Images	TPS3	70	70
CO3	Interpret SAR (Microwave) and LIDAR Images	TPS3	70	70
CO4	Interpret the concepts of satellite and sensor parameters and characteristics of different platforms.	TPS3	70	70
CO5	Apply Image processing algorithms to process satellite images	TPS3	70	70
CO6	Choose appropriate satellite data and apply the concepts for different applications	TPS3	70	70

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO1 1	PO1 2	PSO 1	PS O 2	PS O 3
CO1	M	L	-	-	-	-	-	M	M	L	-	-	M	L	L
CO2	S	M	L	-	M	M	-	M	M	L	-	-	M	L	L
CO3	S	M	L	L	M	M	-	M	M	L	-	-	M	-	L
CO4	S	M	L	L	-	-	-	M	M	L	-	-	M	-	L
CO5	S	M	L	-	-	-	-	M	M	L	-	-	M	-	L
CO6	S	M	L	L	L	M	-	M	M	L	-	M	M	-	L
Over all	3	2	1	1	1	1.5		2	2	1			2	0	1
	S	M	L	L	L	M	-	M	M	L	-	-	M	-	L

S- Strong; M-Medium; L-Low

Assessment Pattern

	Assessment - I						Assessment - II						Terminal Exam (%)		
	CAT – I (%)			Assg. I * (%)			CAT – II (%)			Assg. II * (%)					
CO \ TPS Scale	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
CO1	-	10	10	100			-						-	4	6
CO2	-	10	20				-						-	4	14
CO3	-	10	40				-						-	4	15
CO4	-						-	8	25	100			-	4	15
CO5	-						-	4	30				-	-	20
CO6	-						-	8	25				-	4	10
Total	**-**	**30**	**70**	**100**			**-**	**20**	**80**	**100**			**-**	**20**	**80**

Syllabus

Fundamentals: Remote Sensing Process- Image Resolution Types- Image Resolution Types - False Color Images and Band Combinations - Radiometric and Geometric Errors **Types**: Multi Spectral Sensing –Along Track &Across Track scanning - Thermal Remote Sensing – Radiation Principles, Interpretations- Hyperspectral Sensing– Dimensionality Reduction, Analysis Techniques- Microwave Sensing–Side looking Radar Systems, Synthetic Aperture Radar (SAR), Radar Image Characteristics, Radar Image Interprétation- LIDAR Remote Sensing– Data Characteristics, Point Cloud Processing. **Sensors & Platforms**: Multi Spectral: Landsat, SPOT, and IRS Programmes- Thermal: AVHRR, ASTER, ATLAS, MODIS- Hyper Spectral: Hyperion, HySIS, Enmap, PROBA, Microwave: RISAT, RADARSAT, TerraSAR, TanDEM- LIDAR: ICESat2, CALIPSO- High Resolution Satellites: GeoEye, IKONOS, QuickBird- Remote Sensing Data Providers. **Processing:** Visual Image Interpretation- Image Enhancement- Image Rectification- Georeferencing- Supervised Classification-Unsupervised Classification- Accuracy Assessment. **Applications:** Land Use Land Cover Change Detection (MSS)- Mineral exploration & Agricultural Crop Detection (HS)- Temperature Mapping, Forest Fire Detection (TRS)- Snow Cover Studies (SAR)- 3D Reconstruction (LIDAR)

Text Book

- T.M. Lillesand and R.W. Kiefer "Remote Sensing and Image Interpretation (7th Edition)", John Wiley,2015.

Reference Books& web resources

- R.A. Schowengerdt "Remote Sensing – Models and Methods for Image Processing", Academic Press, 2006
- John R. Jensen, "Introductory Digital Image Processing | A Remote Sensing Perspective", 4^{th} Edition, Pearson Education, 2017.
- J.R. Jensen "Remote Sensing of the Environment – An Earth Resources Perspective", 2^{nd} Edition, Pearson Education, 2013

Course Contents and Lecture Schedule

Module No.	Topic	No. of Periods
1	**Fundamentals**	
1.1	Remote Sensing Process	1
1.2	Spectral Reflectance Curve	1
1.3	Image Resolution Types	1
1.4	False Color Images and Band Combinations	1
1.5	Radiometric and Geometric Errors	1
2	**Types**	
2.1	Multi Spectral Sensing –Along Track &Across Track scanning	1
2.2	Thermal Remote Sensing – Radiation Principles, Interpretations	2
2.3	Hyperspectral Sensing– Dimensionality Reduction, Analysis Techniques	2
2.4	Microwave Sensing–Side looking Radar Systems, Synthetic Aperture Radar (SAR), Radar Image Characteristics, Radar Image Interpretation,	2
2.5	LIDAR Remote Sensing– Data Characteristics, Point Cloud Processing	1
3	**Sensors & Platforms**	
3.1	Multi Spectral: Landsat, SPOT, and IRS Programmes	1
3.2	Thermal: AVHRR, ASTER, ATLAS, MODIS	1
3.3	Hyper Spectral: Hyperion, HySIS, Enmap, PROBA,	1
3.4	Microwave: RISAT, RADARSAT, TerraSAR, TanDEM	1
3.5	LIDAR: ICESat2, CALIPSO	1
3.6	High Resolution Satellites: GeoEye, IKONOS, QuickBird	1
3.7	Remote Sensing Data Providers	1
4	**Processing**	
4.1	Visual Image Interpretation	1
4.2	Image Enhancement	1
4.3	Image Rectification- Georeferencing	1
4.4	Supervised Classification	2
4.5	Unsupervised Classification	1
4.6	Accuracy Assessment	1
5	**Applications**	
5.1	Land Use Land Cover Change Detection (MSS)	2
5.2	Mineral exploration & Agricultural Crop Detection (HS)	2
5.3	Temperature Mapping, Forest Fire Detection (TRS)	2
5.4	Snow Cover Studies (SAR)	2
5.5	3D Reconstruction (LIDAR)	1
	Total Periods	**36**

Course Designer(s):

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