CURRICULUM AND DETAILED SYLLABI

FOR

M.E. DEGREE (Communication Systems) PROGRAM

FOR THE STUDENTS ADMITTED FROM THE

ACADEMIC YEAR 2014-2015 ONWARDS

THIAGARAJAR COLLEGE OF ENGINEERING
(A Government Aided ISO 9001-2000 certified
Autonomous Institution affiliated to Anna University)

MADURAI – 625 015, TAMILNADU

Phone: 0452 – 2482240, 41
Fax: 0452 2483427
Web: www.tce.edu

Vision

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

Mission

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

Programme Educational Objectives

I. Graduates will be capable of developing and providing optimal solutions to subsystems like RF, baseband of modern communication systems and networks.

II. Graduates will be capable of carrying out multidisciplinary scientific research in allied areas of Communication Engineering through advanced research, personal success and life long learning.

III. Graduates will be able to identify and analyze societal problem and can provide technological solutions in a cost effective manner.

   – 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

1. Scholarship of Knowledge

Acquire in-depth knowledge of various aspects of communication systems namely RF, baseband and networks in wider and global perspective, with an ability to evaluate, analyze and synthesize the existing and evolving applications.

2. Critical Thinking

Analyse complex engineering problems in modern communication systems pertaining to challenges in RF, baseband and networking and apply the acquired knowledge for conducting research in a wider theoretical and practical context.

3. Problem Solving

Model complex engineering problems in communication systems and evaluate a wide range of potential solutions for those problems and provide optimal solutions after considering public health and safety, cultural, societal and environmental factors.

4. Research Skill

Conduct literature survey, apply appropriate research methodologies, design algorithms/circuits, validate through simulation/prototype for complex engineering problems in communication systems.

5. Usage of modern tools

Create, select, learn 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. Collaborative and Multidisciplinary work

Possess knowledge and understanding of group dynamics, recognize opportunities and contribute positively to collaborative-multidisciplinary scientific research, demonstrate a capacity for self-management and teamwork, decision-making based on open-mindedness, objectivity and rational analysis in order to achieve common goals and further the learning of themselves as well as others.

7. Project Management and Finance

Demonstrate knowledge and understanding of engineering and management principles and apply the same to one's own work, as a member and leader in a team, manage projects efficiently in respective disciplines and multidisciplinary environments after considerisation of economical and financial factors.

8. Communication

Communicate with the engineering community, and with society at large, regarding complex engineering activities confidently and effectively, such as, being able to comprehend and write effective reports and design documentation by adhering to appropriate standards, make effective presentations, and give and receive clear instructions.

9. Life-long Learning

Recognize the need for, and have the preparation and ability to engage in life-long learning independently, with a high level of enthusiasm and commitment to improve knowledge and competence continuously.

10. Ethical Practices and Social Responsibility

Acquire professional and intellectual integrity, professional code of conduct, ethics of research and scholarship, consideration of the impact of research outcomes on professional practices and an understanding of responsibility to contribute to the community for sustainable development of society.

11. Independent and Reflective Learning

Observe and examine critically the outcomes of one's actions and make corrective measures subsequently, and learn from mistakes without depending on external feedback.

THIAGARAJAR COLLEGE OF ENGINEERING, MADURAI-625015

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

SCHEDULING OF COURSES

Semester	**Theory**						**Laboratory/ Project**
1st (24)	14CN110 Linear Algebra and Optimization 3:1	14CN120 Digital Communication Techniques 3:1	14CN130 Communication Networks 3:1	14CN140 Microwave Circuits and Systems 3:1	14CN150 Image Processing and Recognition 3:0	14CN160 Digital Integrated Systems 3:1	14CN170 Communication Systems Laboratory 0:1
2nd (24)	14CN210 Baseband Communication System 3:1	14CN220 Optical Communication and Networking 3:1	14CN230 Antenna Technologies and Design 3:0	14CNPX0 Elective I 3:1	14CNPX0 Elective II 3:1	14CNPX0 Elective III 3:1	14CN270 RF Systems Laboratory 0:1
3rd (16)	14CN310 Modeling and Simulation of Communication Systems 3:1	14CNPX0 Elective – IV 3:1	14CNPX0 Elective – V 3:1				14CN340 Project 0:4
4th (12)							14CN410 Project 0:12

Total No. of credits to be earned for the award of degree: 76

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015
(An Autonomous Institution Affiliated to Anna University)
CURRICULUM
(For the Students admitted from the academic year 2014- 2015)

Name of the Degree: ME (Communication Systems)
COURSES OF STUDY

I SEMESTER
Theory:

Course Code	Name of the Course	Regulation			
		L	T	P	C
14CN110	Linear Algebra and Optimization	3	1	0	4
14CN120	Digital Communication Techniques	3	1	0	4
14CN130	Communication Networks	3	1	0	4
14CN140	Microwave Circuits and Systems	3	1	0	4
14CN150	Image Processing and Recognition	3	0	0	3
14CN160	Digital Integrated Systems	3	1	0	4

Practical

14CN170	Communication Systems Laboratory	0	0	2	1

Total Credits 24

II SEMESTER
Theory:

Course Code	Name of the Course	Regulation			
		L	T	P	C
14CN210	Baseband Communication System	3	1	0	4
14CN220	Optical Communication and Networking	3	1	0	4
14CN230	Antenna Technologies and Design	3	0	0	3
14CNPX0	Elective I	3	1	0	4
14CNPX0	Elective II	3	1	0	4
14CNPX0	Elective III	3	1	0	4

Practical

14CN270	RF Systems Laboratory	0	0	2	1

Total Credits 24

III SEMESTER
Theory:

Course Code	Name of the Course	Regulation			
		L	T	P	C
14CN310	Modeling and Simulation of Communication Systems	3	1	0	4
14CNPX0	Elective – IV	3	1	0	4
14CNPX0	Elective – V	3	1	0	4

Practical

14CN340	Project I	0	0	8	4

Total Credits 16

IV Semester:
Practical:

Course Code	Name of the Course	Regulation			
		L	T	P	C
14CN410	Project II	0	0	24	12

Total Credits 12

Total No. of credits to be earned for the award of degree: 76

List of Electives:

14CNPA0	Radio Frequency Integrated Circuits	
14CNPB0	Radar Signal Processing	(Common with 14WTPB0)
14CNPC0	Multimedia Communication Systems	(Common with 14WTPC0)
14CNPD0	Analog CMOS Circuit Design	(Common with 14WTPR0)
14CNPE0	Real Time Embedded Systems	(Common with 14WTPE0)
14CNPF0	Estimation and Detection Algorithms	
14CNPG0	Satellite Remote Sensing and Data Analysis	(Common with 14WTPQ0)
14CNPH0	Wireless Network Security	(Common with 14WT220)
14CNPI0	MIMO OFDM Systems	(Common with 14WTPH0)
14CNPJ0	Physical Layer LTE Systems	(Common with 14WTPI0)
14CNPK0	RF MEMS	(Common with 14WTPJ0)
14CNPL0	Video Surveillance Systems	(Common with 14WTPK0)
14CNPM0	Network Management	(Common with 14WTPL0)
14CNPN0	Baseband Algorithms on FPGA	(Common with 14WTPM0)
14CNPO0	RF Test and Measurement	(Common with 14WTPN0)
14CNPP0	Medical Imaging and Classification	
14CNPQ0	Software and Cognitive Radio Systems	
14CNPR0	Computer Vision	
14CNPS0	Antennas for Wireless Applications	(Common with 14WTPA0)
14CNPT0	CMOS ASIC Design	(Common with 14WTPF0)
14CNPU0	Nano MOSFET Modeling	
14CNPV0	Nano Scale Transistors	
14CNPW0	Solid State Device Modeling and Simulation	
14CNPX0	Photonic Crystals - Principles And Applications	
14CNRA0	Telehealth Technology	(Common with 14WTPV0)
14CNRB0	Radio Frequency Integrated Circuit SytemDesign	(Common with 14WTPW0)

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015
M.E Degree (Communication Systems) Program
SCHEME OF EXAMINATIONS
(For the candidates admitted from 2014-2015 onwards)

FIRST SEMESTER

Course code	Name of the Course	Duration of Terminal Exam\ in Hrs.	Marks			Min. Marks for Pass	
			Continuous Assessment	Terminal Exam	Max. Marks	Terminal Exam	Total
THEORY							
14CN110	Linear Algebra and Optimization	3	50	50	100	25	50
14CN120	Digital Communication Techniques	3	50	50	100	25	50
14CN130	Communication Networks	3	50	50	100	25	50
14CN140	Microwave Circuits and Systems	3	50	50	100	25	50
14CN150	Image Processing and Recognition	3	50	50	100	25	50
14CN160	Digital Integrated Systems	3	50	50	100	25	50
PRACTICAL							
14CN170	Communication Systems Laboratory	3	50	50	100	25	50

SECOND SEMESTER

Course code	Name of the Course	Duration of Terminal Exam\ in Hrs.	Marks			Min. Marks for Pass	
			Continuous Assessment	Terminal Exam	Max. Marks	Terminal Exam	Total
THEORY							
14CN210	Baseband Communication System	3	50	50	100	25	50
14CN220	Optical Communication and Networking	3	50	50	100	25	50
14CN230	Antenna Technologies and Design	3	50	50	100	25	50
14CNPX0	Elective I	3	50	50	100	25	50
14CNPX0	Elective II	3	50	50	100	25	50
14CNPX0	Elective III	3	50	50	100	25	50
PRACTICAL							
14CN270	RF Systems Laboratory	3	50	50	100	25	50

THIRD SEMESTER

Course code	Name of the Course	Duration of Terminal Exam\ in Hrs.	Marks			Min. Marks for Pass	
			Conti-nuous Assess-ment	Termi-nal Exam	Max. Marks	Termi-nal Exam	Total
THEORY							
14CN310	Modeling and Simulation of Communication Systems	3	50	50	100	25	50
14CNPX0	Elective – IV	3	50	50	100	25	50
14CNPX0	Elective – V	3	50	50	100	25	50
PRACTICAL							
14CN340	Project I	-	150	150	300	75	150

FOURTH SEMESTER

Course code	Name of the Course	Duration of Terminal Exam\ in Hrs.	Marks			Min. Marks for Pass	
			Conti-nuous Asses-sment	Termi-nal Exam	Max. Marks	Termi-nal Exam	Total
PRACTICAL							
14CN410	Project II	-	150	150	300	75	150

* 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.

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

14CN110	LINEAR ALGEBRA AND OPTIMIZATION	Category	L	T	P	Credit
		BS	3	1	0	4

Preamble

The operations of addition and scalar multiplication are used in many diverse contexts in mathematics. These operations follow the same set of arithmetic rules. A general theory of mathematical systems involving addition and scalar multiplication has applications to many areas of communication systems. Mathematical systems of this form are called Vector spaces or linear spaces. Optimization is the art of obtaining the best result under given circumstances. In design, construction and maintenance of any engineering system, engineers have to take many technological and managerial decisions at several stages. The ultimate goal of all such decision is to either minimize the effort required or maximize the desired benefit. At times certain restrictions or constraints are imposed on the decision variables. Optimization can be defined as the process of finding the conditions that give the maximum or minimum value of a function with or without attendant constraints.

Prerequisite

Nil

Course Outcomes

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

CO1. Determine the dimension of vector space.	Understand
CO2. Predict orthonormal basis.	Understand
CO3. Perform diagonalization of a given matrix.	Understand
CO4. Apply linear programming techniques to optimize problems arising in communication engineering.	Apply
CO5. Determine the optimum values of non-linear programming problems using Kuhn tucker conditions, elimination method.	Apply
CO6. Determine the optimum values of non-linear programming problems using search methods.	Apply

Mapping with Programme Outcomes

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

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	10	10	0	0
Understand	30	30	30	30
Apply	60	60	70	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. Let x,y,z be vectors in a vector space V. If $x+y=x+z$, then prove that y = z
2. Show that $\{e_1, e_2, e_3, (1,2,3)^T\}$ is a spanning set for R^3
3. State Cauchy-Schwarz inequality in an inner product space
4. State the parallelogram law in an inner product space
5. Define unimodal function
6. Describe random search method.
7. Show that $\left\{\frac{(1,1,1)^T}{\sqrt{3}}, \frac{(2,1,-3)^T}{\sqrt{14}}, \frac{(4,-5,1)^T}{\sqrt{42}}\right\}$ is an orthonormal set in R^3

Course Outcome 2 (CO2):

1. Estimate the row space and column space of the matrix $A=\begin{pmatrix}1 & 0 & 0\\ 0 & 1 & 0\end{pmatrix}$
2. Estimate the dimension of the row space of the matrix $A=\begin{pmatrix}1 & -2 & 3\\ 2 & -5 & 1\\ 1 & -4 & -7\end{pmatrix}$
3. Estimate the best quadratic least square fit to the data

x	0	3	6
y	1	4	5

4. Estimate the angle between vectors $(-2,3,1)^T$ and $(1,2,4)^T$ in R^3

Course Outcome 3 (CO3):

1. Compute the dimension of the subspace of R^4 spanned by

$$X_1=\begin{pmatrix}1\\2\\-1\\0\end{pmatrix}, X_2=\begin{pmatrix}2\\5\\-3\\2\end{pmatrix}, X_3=\begin{pmatrix}2\\4\\-2\\0\end{pmatrix}, X_4=\begin{pmatrix}3\\8\\-5\\4\end{pmatrix}$$

2. Calculate the best quadratic least squares fit to the data

x	-1	0	1	2
y	0	1	3	9

3. Consider the vector space $C[-1,\ 1]$ with inner product defined by

$< f, g >= \int_{-1}^{1} f(x)g(x)dx$ Calculate orthonormal basis for subspace spanned by $\{1, x, x^2\}$

1. Calculate the minimum of $f(x_1,x_2)=x_1-x_2+2\ x_1^2+2x_1x_2+x_2^2$, starting from the origin, using the conjugate gradient method.
5. Calculate the minimum of $f=\lambda^5-5\lambda^3-20\lambda+5$, using Quadratic interpolation method.

Course Outcome 4 (CO4):

1. Solve the following using simplex method:
   Maximize Z = $45x_1+80x_2$
   Subject to $5x_1+20x_2 \leq 400$; $10x_1+15x_2 \leq 450$: x_1 ,x_2 ≥ 0
2. Use Graphical method to solve the LPP
   Maximize Z = $5x_1+x_2$
   Subject to $5x_1+2x_2 \leq 20$; $x_1+3x_2 \leq 50$: x_1 ,x_2 ≥ 0

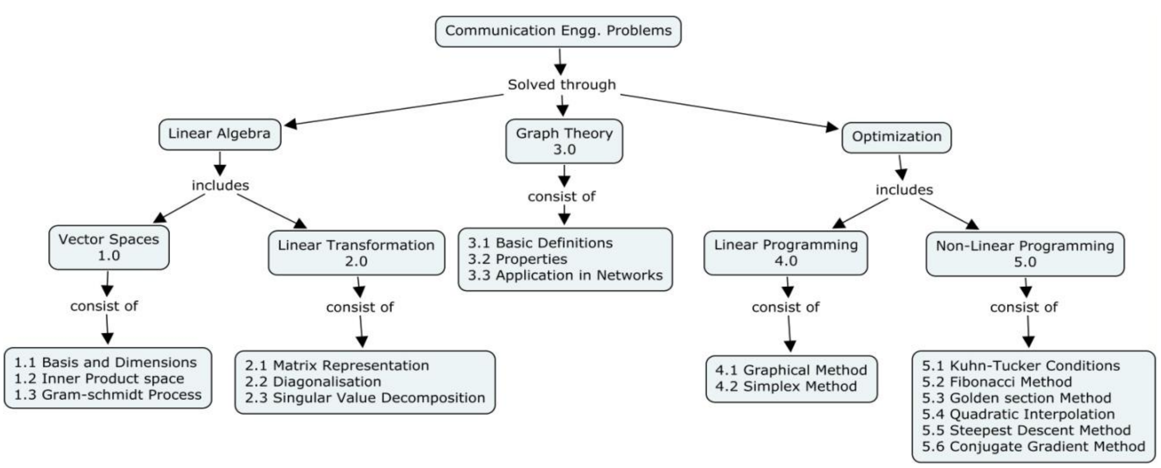
Course Outcome 5 (CO5):

1. Determine the maximum value of the non-linear programming problem using Kuhn-tucker conditions, Max Z = $8x_1+10x_2-x_1^2-x_2^2$
   Subject to $3x_1+2x_2 \leq 6$; x_1 ,x_2 ≥ 0
2. Calculate the minimum value of f(x) = x(1.5-x) in the interval [0,3] with n=6 by Fibonacci method and golden section method.

Course Outcome 6 (CO6):

1. Calculate the minimum of $f(x_1, x_2) = x_1 - x_2 + 2\ x_1^2 + 2x_1x_2 + x_2^2$, starting from the origin, using conjugate gradient method.
2. Calculate the minimum of $f(x_1, x_2) = x_1 - x_2 + 8\ x_1^2 + 2x_1x_2$, starting from the origin, using the steepest descent method.

Concept Map



Syllabus

VECTOR SPACES AND ORTHOGONALITY: Spaces of vectors- the null space- the rank and the row reduced form, independence, basis, dimension, dimension of the four subspaces, projections, least square approximations, orthogonal bases and Gram Schmidt.
LINEAR TRANSFORMATIONS: Linear transformation, Matrix of linear transformation, diagonalization, applications to differential equations, symmetric matrices, positive definite matrices, similar matrices, singular value decomposition pseudo inverse. **APPLICATIONS:** Graphs and networks, Markov matrices, Linear programming, Simplex method.
NONLINEAR PROGRAMMING: Kuhn Tucker conditions, Elimination methods, Fibonacci, Golden section, Quadratic interpolation. Direct search method, Random search method, Pattern search method, Steepest descent method, Conjugate gradient method.

Reference Books

1. Gilbert Strang, "Introduction to Linear Algebra", Third edition, Wellesley, Cambridge Press,2003
2. S.S. Rao, "Optimization", Wiley Eastern Limited, New Delhi-1990.
3. Steven J. Leon," Linear Algebra with Applications", Macmillan publishing company, New York, 1990.
4. K.V. Mittal," Theory of Optimization", Wiley Eastern Limited, New Delhi,1988

Course Contents and Lecture Schedule

Sl No	Topics	No. of Periods
	Vector Spaces and Orthogonality	
1	Vector spaces: axioms; properties examples of vector spaces	1
2	Sub-spaces: Null space of matrix examples	1
3	Linear combinations; span of a set properties; Examples, Linear independence and dependence-definition	2
4	Basis and dimension; properties; examples	1
5	The row and column space	1
6	Orthogonal subspaces-inner product space, normed linear space; orthogonal complements-properties	1
7	Orthogonal matrices-properties.	1
8	Orthogonal bases: Gram Schmidt orthonormalisation process	2
	Linear Transformation	
9	Linear transformation: Image and kernel properties; Examples	2
10	Matrix representation of linear transformation Representation theorem; Examples	1
11	Eigen values and eigenvectors : Diagonalisation of matrices	2
12	Eigen values and eigenvectors: Applications to differential equations.	1
13	Systems of linear diff. Equation using eigen values and eigenvectors	1
14	Symmetric matrices, positive definite matrices ,similar matrices	1
15	Pseudoinverse : Singular value decomposition	2
	Applications	
16	Graphs and networks	2
17	Markov processes, Markov matrices	2
18	Linear programming- Formulation, Canonical and standard forms-simplex method	2
19	Simplex method	3
	Nonlinear Programming	
20	Non-linear programming- Kuhn Tucker conditions	2
21	Problems in Non-linear programming	1
22	Non-linear programming(one dimensional minimization methods): Unimodal functions	1
23	NLP(Without constraints) Elimination methods	1
24	Fibonacci method- Exercise problems	2
25	Golden section method: Golden number	1

26	Interpolation methods: quadratic interpolation method	1
27	Problems in interpolation methods	1
	Applications	
28	NLP (Unconstrained, multi dimension) Direct search methods:	2
29	Pattern search method	2
30	Steepest descent	3
31	Conjugate gradient method	3

Course Designers:

1. Dr.V.Mohan vmohan@tce.edu
2. Dr.G.Jothilakshmi gjlmat@tce.edu

14CN120	DIGITAL COMMUNICATION TECHNIQUES	Category	L	T	P	Credit
		PC	3	1	-	4

Preamble

Digital transmission of information has sufficiently overwhelming advantages that it increasingly dominates communication systems, and certainly all new designs. The course "14CN120: Digital Communication Systems" concentrates on the techniques that are used to design a digital communication systems.

Prerequisite

NIL

Course Outcomes

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

CO1. Apply the theory of probability and stochastic processes in the design of digital communication systems.	Apply
CO2. Determine the minimum number of bits per symbol required to represent a source and maximum rate at which reliable communication can take place over the channel.	Apply
CO3. Describe and determine the performance of different error control coding schemes for the reliable transmission of digital information over the channel.	Apply
CO4. Describe a mathematical model of a digital communication system, characterize the influence of the channel and determine its bit error rate performance analysis.	Analyze
CO5. Design Digital Communication Systems as per given specifications.	Apply

Mapping with Programme Outcomes

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

S- Strong; M-Medium; L-Low

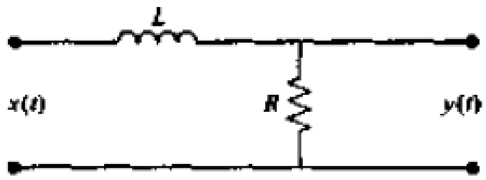
Assessment Pattern

	Bloom's category	Continuous Assessment Tests			End Semester Examinations
		1	2	3	
1	Remember	20	0	0	0
2	Understand	20	20	20	20
3	Apply	60	60	60	60
4	Analyze	0	20	20	20
5	Evaluate	0	0	0	0
6	Create	0	0	0	0

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Assume that X is a random variable with mean μ_x and variance σ_x^2 . If a linear transformation $Y = aX + b$ is applied, find the values of a and b such that the mean of Y is $\mu_y = 0$ and variance $\sigma_y^2 = 1$.
2. Assume that random processes $X(t)$ and $Y(t)$ are individually and jointly stationary. What is the autocorrelation function of $Z(t) = X(t) + Y(t)$ when $X(t)$ and $Y(t)$ are uncorrelated and have zero means.
3. Suppose that the low pass filter shown in figure. is excited by a stochastic process $x(t)$ having power density spectrum $\Phi_{xx}(f) = \frac{1}{2}N_0 \quad \textit{for all } f$.



4. Find the power spectral density of the output sequence $y(t)$ and find the autocorrelation sequence of $y(t)$.

Course Outcome 2 (CO2):

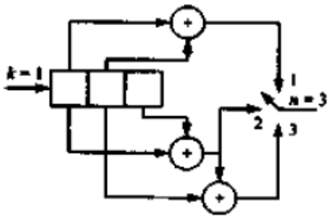
1. A Discrete memory less source has an alphabet of x=[x_1 x_2 x_3 x_4 x_5 x_6 x_7] with the statistics P=[.35 .3 .2 .1 .04 .005 .005].
   a. Compute the Huffman code and its average length.
   b. Compute the entropy of the sou rce
   c. Compute the efficiency of the code.
2. Compute the differential entropy of a random variable x, distributed over the interval [0,a].
3. The optimum four level non-uniform quantizer for a Gaussian distributed signal amplitude results in the four levels a_1, a_2, a_3 and a_4, with corresponding probabilities of occurrences p_1=p_2=0.3365 and p_3=p_4=0.1635.
   a. Design a Huffman code that encodes a single level at a time and determine the average bit rate
   b. Design a Huffman code that encodes two output levels at a time and determine the average bit rate

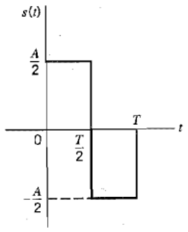
Course Outcome 3 (CO3):

1. 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.

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





3. 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.
   c. Find the error correcting capabilities of this code

Course Outcome 4 (CO4):

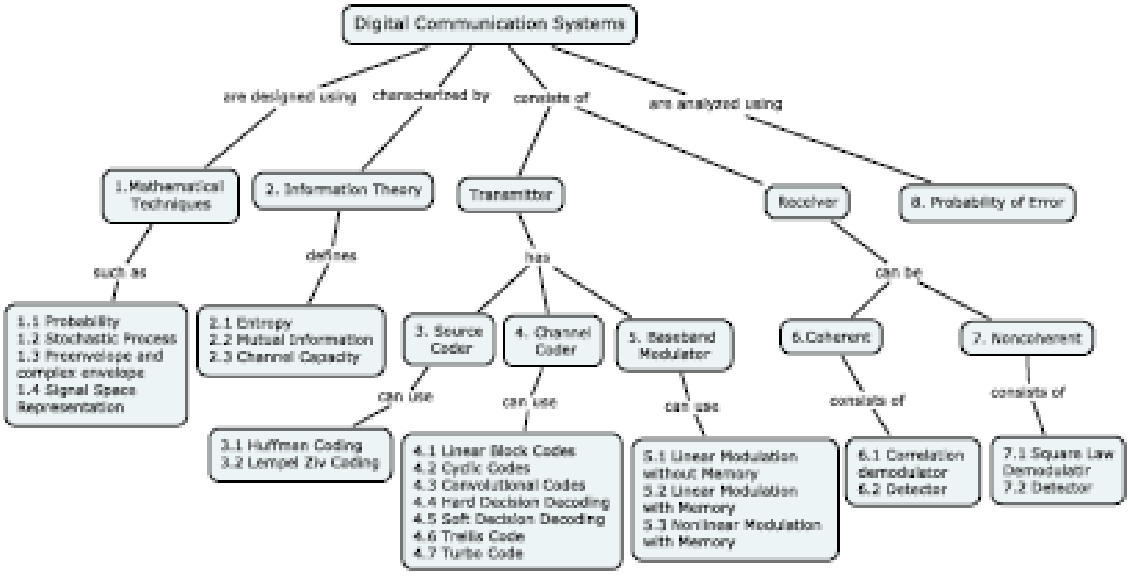
1. A Binary wave uses on – off signaling to transmit symbols 1 and 0. The symbol 1 is represented by a rectangular pulse of amplitude A and duration T_b sec. The additive noise at the receiver input is white and Gaussian with zero mean and Power spectral density $N_O/2$.Assuming that symbols 1 and 0 occur with equal probability. Analyze the BER performance of this system.
2. A BPSK signal is applied to a correlation demodulator supplied with a phase reference that lies within ϕ radians of the exact carrier phase. Determine the effect of the phase error ϕ on the average probability of error of the system.
3. In coherent FSK system, the signals $s_1(t), s_2(t)$ representing symbols 1 and 0 respectively, are defined by $s_1(t), s_2(t) = A\cos\left[2\pi\left(f_c \pm \frac{\Delta f}{2}\right)t\right], \quad 0 \le t \le T_b$.
   a. show that the correlation coefficient is $\rho = \dfrac{\int_0^{T_b} s_1(t)s_2(t)dt}{\int_0^{T_b} s_1^2(t)dt} = \sin c\left(2\Delta f T_b\right)$

   What is the value of $f_c > \Delta f$ for which $s_1(t), s_2(t)$ are orthogonal and minimizes the probability of symbol error?

Course Outcome 5 (CO5):

1. A voice of bandwidth 3 KHz is to be transmitted over a wireless link. The wireless link can support a data rate of 4Kbps. Design a baseband digital communication transceiver to transmit the voice. The required bit error rate is 10^{-6} at 8.9dB
2. A video of bandwidth 6MHz is to be transmitted over a wireless link. The wireless link can support a data rate of 1.5M samples/sec. Design a baseband digital communication transceiver to transmit the voice.
3. A audio of bandwidth 6KHz is to be transmitted over a wireless link. The wireless link can support a data rate of 16Kbps. Design a baseband digital communication transceiver to transmit the audio.

Concept Map



Syllabus

Mathematical Techniques: Probability: Functions of Random Variables – statistical averages of Random variables, Stochastic Process: Statistical averages, power density spectrum, Response of LTI system, Preenvelope and complex envelope, Signal Space Representations, **Information Theory:** Information, self Information, Entropy- Mutual Information, Differential Mutual Information – Channel Capacity: Channel Capacity Theorem, **Source Coder:** Huffman Coding, Lempel Ziv Coding, Source Coding Theorem, **Channel Coder**: Channel Coding Theorem, Linear Block Codes, Cyclic Codes, Convolutional Codes, Hard Decision Decoding, Soft Decision Decoding, Trellis codes, Turbo Codes **Baseband Modulator:** Linear Modulation without memory, Linear Modulation with memory, nonlinear modulation with memory, **Coherent Receiver:** Correlation demodulator: Matched Filter Demodulator Detector: MAP and ML Detector, **Noncoherent Receiver:** Square law demodulator and ML detector, **Probability of Error:** BER Analysis for PSK, ASK, FSK, QPSK, - Comparison of Binary and Quarternary Modulation - M-ary Modulation Techniques - Bit Vs Symbol Error Probabilities - Bandwidth Efficiency.

Reference Books

1. John G. Proakis: “Digital Communications”, McGraw Hill International Edition, Fourth Edition, 2001.
2. Simon Haykin: Digital Communications”, John Wiley & Sons Pvt. Ltd., 2001
3. Simon Haykin: “Communication Systems” 3rd Edition, PHI, 1996.
4. Bernard Sklar: “Digital Communications: Fundamentals and Applications”, 2nd Edition, Prentice Hall, 2001
5. John R Barry, Edward Lee and David G. Messerschmitt: “Digital Communication”, 3rd Edition. Springer, 2003.

Course Contents and Lecture Schedule

No.	Topic	No. of Lectures
1.	**Mathematical Techniques**	
1.1	Probability: Functions of Random Variables – statistical averages of Random variables	1
1.2	Stochastic Process: Statistical averages, power density spectrum,	3

No.	Topic	No. of Lectures
	Response of LTI system	
1.3	Preenvelope and complex envelope	1
1.4	Signal Space Representations	2
2	**Information Theory**	
2.1	Information, self Information, Entropy	1
2.2	Mutual Information, Differential Mutual Information	2
2.3	Channel Capacity: Channel Capacity Theorem,	2
3	**Source Coder**	
3.1	Source Coding Theorem: Huffman Coding	2
3.2	Lempel Ziv Coding	1
4	**Channel Coder**	
4.1	Channel Coding Theorem: Linear Block Code	2
4.2	Cyclic Codes	2
4.3	Convolutional Codes	2
4.4	Hard Decision Decoding	2
4.5	Soft Decision Decoding	1
4.6	Trellis Codes	1
4.7	Turbo Code	1
5	**Baseband Modulator**	
5.1	Linear Modulation Without Memory	3
5.2	Linear Modulation With Memory	2
5.3	Nonlinear Modulation with memory	3
6	**Coherent Receiver**	
6.1	Correlation Demodulator: Matched Filter Demodulator	3
6.2	ML Detector	2
7	**Noncoherent Receiver**	
7.1	Square Law Demodulator	2
7.2	Detector	1
8	**Probability of Error**	
8.1	BER Analysis of Baseband digital modulation schemes in AWGN environment	3
	Total	45

Course Designers:

1. Dr.S.J. Thiruvengadam sjtece@tce.edu
2. Dr. M.N.Suresh mnsece@tce.edu

14CN130	COMMUNICATION NETWORKS	Category	L	T	P	Credit
		PC	3	1	-	4

Preamble

This course presents both fundamental networking concepts and analysis of communication networks, such as error control and Media access control techniques along with Queuing models. Also, this course addresses internetworking concepts such as unicast, multicast and mobile IP routing. It also introduces the students with upcoming network technologies.
Prerequisite: Computer Networks.

Prerequisite

NIL

Course Outcomes

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

CO1	Analyze the performance of the data network based on queuing model	Analyze
CO2	Identify the need for WLAN	Remember
CO3	Classify and describe the operation of the routing in unicast, multicast and mobile IP	Remember
CO4	Identify the requirements of optical networking	Remember
CO5	Identify the requirements of storage area network, home network and intelligent networks	Remember

Mapping with Programme Outcomes

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

S- Strong; M-Medium; L-Low

Assessment Pattern

	Bloom's category	Continuous Assessment Tests			End Semester Examinations
		1	2	3	
1	Remember	20	20	0	0
2	Understand	40	20	30	30
3	Apply	40	30	40	40
4	Analyze	0	30	30	30
5	Evaluate	0	0	0	0
6	Create	0	0	0	0

Course Level Assessment Questions

COURSE OUTCOME 1(CO1):

1. What are the design issues in data link layer?
2. List out the multi access techniques
3. State Little's theorem.
4. What is called optical layer?
5. What is the purpose of using DSL cable modem?
6. What do you mean by photonic packet switching?

COURSE OUTCOME 2(CO2):

1. Identify an example of a pattern of six errors that can not be detected by the use of horizontal and vertical parity checks, if each row with errors and each column with errors will contain exactly two errors.
2. Describe the reversibility to characterize the departure process of the M/M/1/m queue.
3. What is the role of Kleinrock independence approximation to find the average number of packets in the system?
4. Justify the arrival theorem for closed networks by inserting a very fast M/M/1 queue between every pair of queues.
5. Compare Aloha system and slotted Aloha system with 'perfect capture'.
6. Describe the FCFS splitting algorithm with one example.

COURSE OUTCOME 3 & 4(CO3 and CO4):

1. Consider a parity check code with 3 data bits and 4 parity checks. Suppose that 3 of the code words are 1001011, 0101101, and 00111110. Find the rule for generating each of the parity checks and find the set of all 8 code words. What is the minimum distance of this code?
2. Give an example in which Go back n will deadlock if receiving DLCs ignore the request number in each frame not carrying the awaited packet.
3. Two nodes 1 and 2 send files to another node 3. Files from 1 and 2 require on the average R_1 and R_2 time units for transmission, respectively. Node3 processes a file of node i (i=1,2) in an average of Pi time units and then requests another file from either node 1 or node2. If Y_i is the throughput of node i in files sent from unit time, what is the region of all feasible throughput pairs (y1, Y2) for this system?
4. Consider a system which is the same as M/M/1 except that whenever there are n customers in the system there are all served simultaneously at an equal rate 1/n per unit time. Argue that the steady state occupancy distribution is same as for the M/M/1 system.
5. Derive the stationary distribution of an M/M/2 system where the 2 servers have different service rates. A customer that arrives when the system is empty is routed to the faster server.
6. Consider a system that is identical to M/G/1 except that when the system empties out, service does not begin again unil k customers are present in the system. Once service begins, it proceeds normally until the system becomes empty again. Verify that the average length of a busy period is equal to avege time between the arrival and start of service of the first customer in a busy period, plus k times the average length of a busy period for the corresponding M/G/1 system.

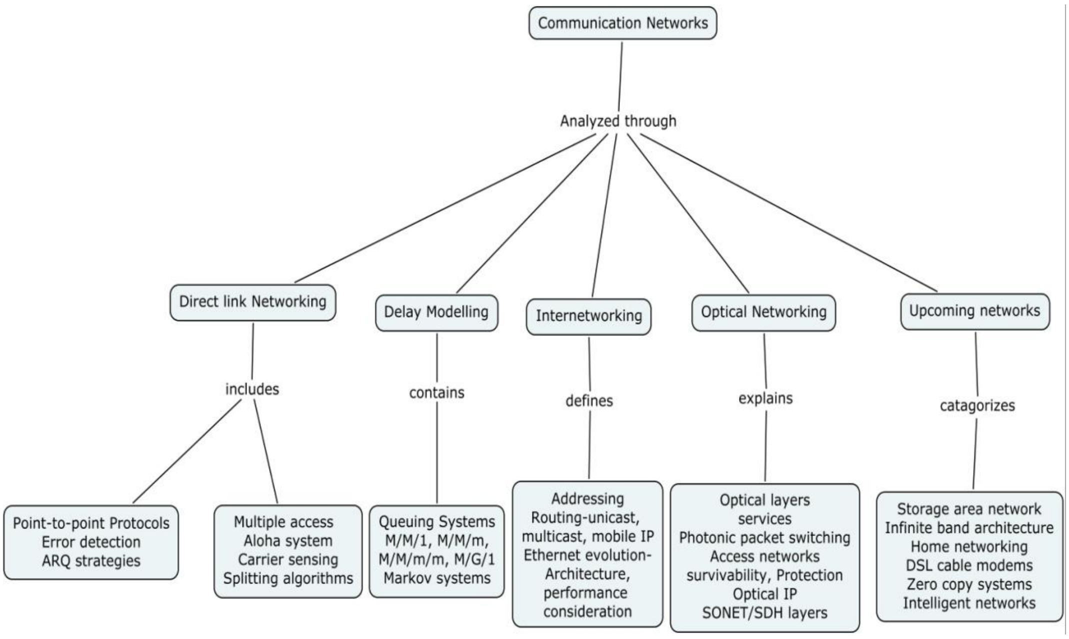
COURSE OUTCOME 5(CO5):

1. Calculate the expected time to transmit a frame on a 9600 bps link, if the expected frame length on a link is 1000 bits and the standard deviation is 500 bits.
2. Let T_{min} be the minimum transmission time for data frames and T_d be the propagation and processing delay in each direction. Find the maximum allowable value T_{max} for frame

transmission time such that a Go back n ARQ system will never have to go back or wait in the absence of transmission errors or lost frames.

3. Consider a datagram network and assume that M is the maximum number of packets that can be sent by a session while a given packet still exists within the network. Assume that selective repeat ARQ is used for the session with the window size of n. Show that the modulus of m must satisfy m≥2n+M
4. Consider a packet stream whereby packets arrive according to a poisson process with rate 10packets/sec. If the interarrival time between any two packets is less than the transmission time of the first to arrive the 2 packets are said to collide. Find the probabilities that packet does not collide with either its predecessor or successor and that packet dose not collide with another packet assuming all packets have transmission time of 20ms.
5. Consider M/M/1/m system which is the same as M/M/1 except that there can be no more than m customers in the system and customers arriving when the system is full are lost. Determine the steady state occupancy probabilities.
6. Consider the non pre-emptive priority queuing system for the case where the available capacity is sufficient to handle the highest priority traffic but can not handle the traffic of all priorities, that is, p1<1<p1+p2+...+pn.

Concept Map



Syllabus

Introduction: Overview of network architecture, Point-to –point protocols and links – Error detection, ARQ retransmission strategies, Multi access communication – Slotted multi access and the Aloha system, splitting algorithms and carrier sensing **Delay Models In Data Networks:** Introduction, Queuing models: Little's Theorem, M/M/1 Queuing system, M/M/m, M/M/m/m and other Markov systems and M/G/1 systems **Internetworking:** VLAN-Addressing and routing-network layer protocols-unicast and multicast routing-Mobile IP routing -Evolution in the Ethernet-Switched and fast Ethernet-Infrastructure-Scaling to Gigabit architectures-Performance consideration-Physical components and wire protocols **Optical Networks:** Optical layers- Services and interfacing- Photonic packet switching-Access networks-Network survivability- Protection- Optical IP- OTN/SONET/SDH layers structure and design relation to 10 Gigabps Ethernet **Network Technologies:** SAN (Storage Area Networks) and Infinite band architectures-Home networking- DSL cable modems- Zero copy systems-Intelligent networks.

Reference Books

1. Dimitri Bertsekas and Robert Gallager, ‘Data Networks’, PHI, 2009.
2. Ramaswami R and Sivarajan K, ‘Optical Networks: A Practical Perspective’, Morgan Kaufmann, 2001.
3. Clark T, ‘IP SANs’, Addison Wesley, 2002.
4. Kurose J.F, Ross K. W, ‘Computer Networking, Top-down Approach Featuring the Internet’, Addison Wesley, 2005.

Course Contents and Lecture Schedule

No.	Topics	No of Lectures
1	**Introduction**	
1.1	Overview of network architecture	2
1.2	Point-to –point protocols and links – Error detection, ARQ retransmission strategies	3
1.3	Multi access communication – Slotted multi access and the ALOHA system, splitting algorithms and carrier sensing	3
2	**Delay Models In Data Networks**	
2.1	Introduction, Queuing models: Little’s Theorem	3
2.2	M/M/1 Queuing system, M/M/m, M/M/ꭤ and other Markov systems and M/G/1 systems	4
3	**Internetworking**	
3.1	VLAN-Addressing and routing	3
3.2	network layer protocols-unicast and multicast routing-Mobile IP routing	3
3.3	Evolution in the Ethernet-Switched and fast Ethernet	3
3.4	Infrastructure-Scaling to Gigabit architectures-Performance consideration-Physical components and wire protocols	4
4	**Optical Networks**	
4.1	Optical layers- Services and interfacing- Photonic packet switching	3
4.2	Access networks-Network survivability- Protection	3
4.3	Optical IP- OTN/SONET/SDH layers structure and design relation to 10 Gigabps Ethernet	4
5	**Network Technologies**	
5.1	SAN (Storage Area Networks) and Infinite band architectures	2
5.2	Home networking- DSL cable modems- Zero copy systems	3
5.3	Intelligent networks	2
	Total Number of Hours	45

Course Designers:

1. Dr.R. Sukanesh rsece@tce.edu
2. Dr.M. Suganthi msece@tce.edu
3. Dr.M.S.K. Manikandan manimsk@tce.edu
4. Mrs. E. Murugavalli murugavalli@tce.edu

14CN140	MICROWAVE CIRCUITS AND SYSTEMS	Category	L	T	P	Credit
		PC	3	1	-	4

Preamble

The unprecedented success of wireless communications created an unexpected demand for RF/Microwave communications engineers. This program aims to provide students with the technological skills needed in the design and engineering of modern Microwave systems and subsystems. This course focuses on the learning of characterization of two port networks, planar transmission lines, impedance matching concepts, passive circuit design, active circuit design and microwave applications.
Prerequisite: Electromagnetic fields.

Prerequisite

NIL

Course Outcomes

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

CO1. Characterize the reciprocal networks, lossless networks in terms of S-Parameters	Remember
CO2. Understand the behaviour of planar transmission lines such as microstrip line, stripline, cpw line and slotline	Understand
CO3. Design of lumped and distributed impedance matching networks	Create
CO4. Design and operation of passive microwave devices such as power dividers, couplers and filters	Create
CO5. Design and operation of active microwave devices such as amplifiers, mixers and oscillators	Create
CO6. Understand the concept of wireless transceiver architecture	Understand

Mapping with Programme Outcomes

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

S- Strong; M-Medium; L-Low

Assessment Pattern

	Bloom's category	Continuous Assessment Tests			End Semester Examinations
		1	2	3	
1	Remember	10	10	10	10
2	Understand	20	20	10	10

3	Apply	40	40	60	60
4	Analyze	0	0	0	0
5	Evaluate	0	0	0	0
6	Create	30	30	20	20

Course Level Assessment Questions

Course Outcome 1

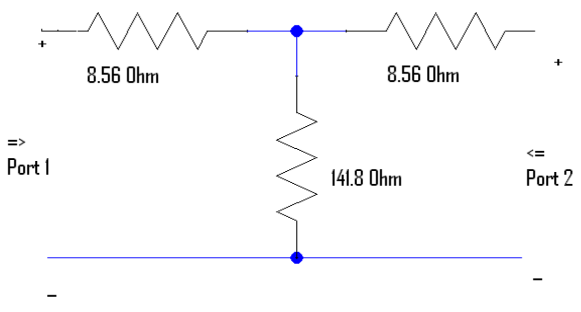
1. State Kroneckor delta property.
2. List the factors which are responsible for impedance matching
3. What is a stub?
4. Mention the quantities used to characterize a directional coupler.
5. Define coupling factor, directivity.
6. Verify that the given matrix [S] = $\begin{bmatrix} 011 \\ 101 \\ 110 \end{bmatrix}$ is not an unitary matrix.

Course Outcome 2 (CO2 &CO6)

1. Why quarter wave transformer is essential?
2. What is the need for tapered line?
3. What is even and odd mode excitation?
4. Explain the concept of coupled lines.
5. A maximally flat low pass filter is to be designed with a cut off frequency of 8 GHz and a minimum attenuation of 20 dB at 11 GHz. How many filter elements are required?.
6. Justify that any three port network cannot be lossless, reciprocal and matched at all ports.
7. Justify that Quadrature couplers are capable of producing 90 degree phase shift in the output port and the power available is 3dB.

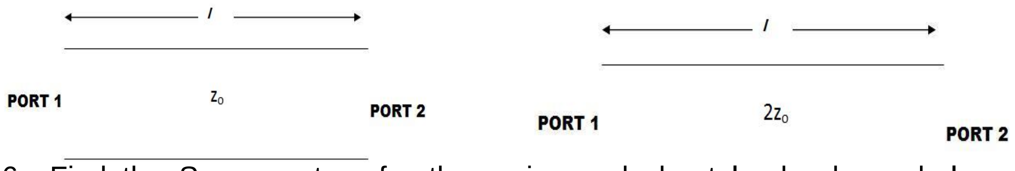
Course Outcome 3

1. Find the S parameters of the 3 dB attenuator circuit shown in figure

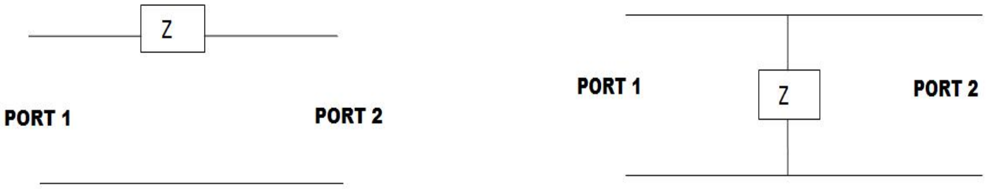


2. A certain two port network is measured and the following scattering matrix is obtained:
   i. [S] = $\begin{bmatrix} 0.1\angle 0 & 0.8\angle 90^\circ \\ 0.8\angle 90^\circ & 0.2\angle 0 \end{bmatrix}$
   ii. From this data determine whether the network is reciprocal or lossless.
3. A lossless T junction 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.

4. The S parameters for the HP HFET-102 GaAS FET at 2 GHz with the bias voltage Vgs=0 are given as follows: S_{11}=0.894$\angle -60.6^{\circ}$,S_{21}=3.122$\angle 123.6^{\circ}$,S_{12}=0.020 $\angle 62.4^{\circ}$,S_{22}=0.781$\angle -27.6^{\circ}$. Determine the stability of this transistor by calculating K and $|\Delta|$.
5. Determine the scattering matrix for each of the lossless transmission lines shown below, relative to a system impedance of Zo. Verify that each matrix is unitary.



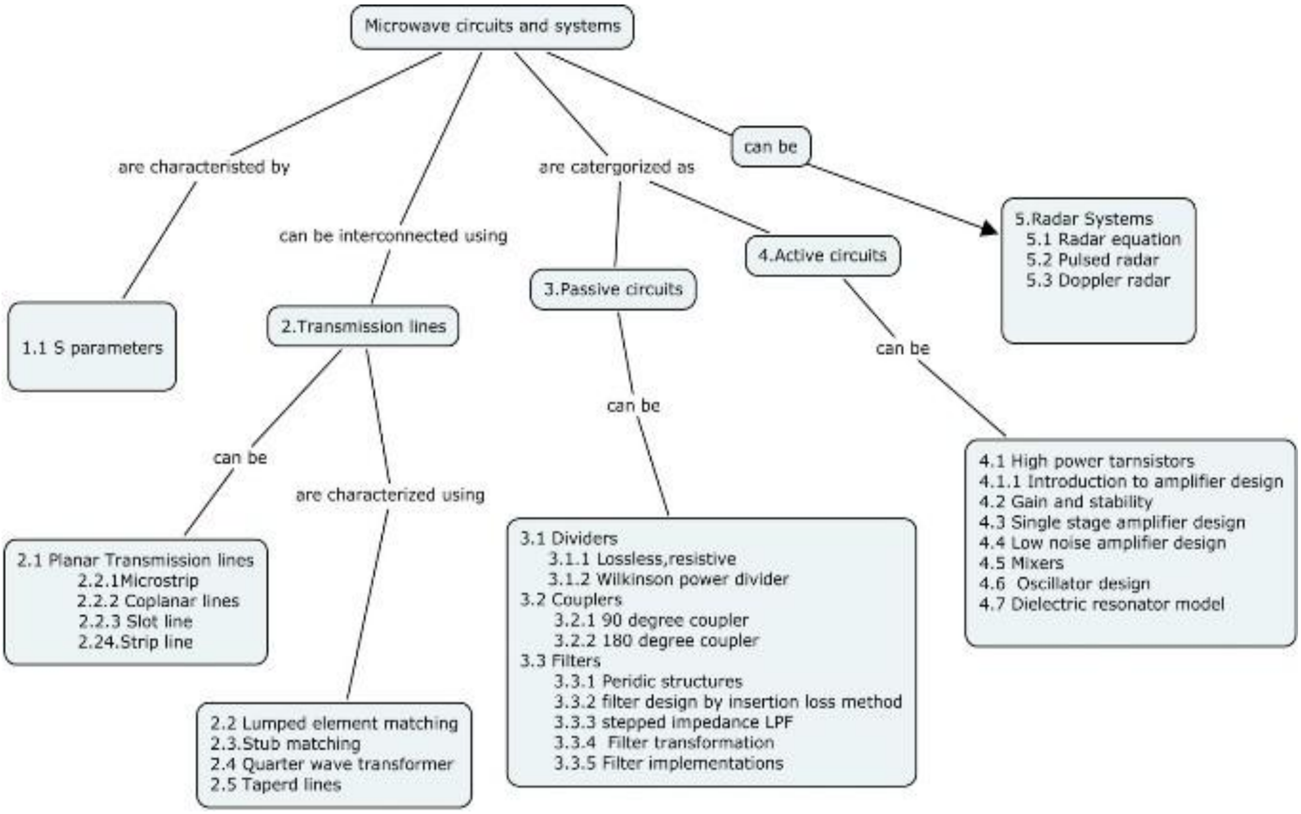
6. Find the S parameters for the series and shunt loads shown below. Show that S12=1-S11 for the series case and that S12=1+S11 for the shunt case. Assume characteristic impedance Zo.



Course Outcomes (CO4 and CO5)

1. Design an L section matching network to match a series RC load with an impedance ZL=200-j100 Ω to a 100 Ω line, at a frequency of 500 MHz.
2. 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.
3. Design a double stub shunt tuner to match a load impedance ZL=60-j80 Ω to a 50Ω line. The stubs are to be short circuited stubs and are spaced λ/8 apart. Assume that this load consists of a series resistor and capacitor and the match frequency is 2 GHz.
4. 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.
5. 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 50 Ω, the highest impedance is 150 Ω and the lowest is 10 Ω.

Concept Map



Syllabus

Microwave Circuits: **S parameters**: reciprocal networks, Lossless networks, **Planar transmission Lines:** Micro strip, Slot line, Strip and coplanar lines. **Impedance matching:** Matching with lumped elements, Stub matching- Single and double stub using Smith chart solutions, Quarter wave transformer, tapered lines- Exponential taper, triangular taper. **Passive circuit design:** Dividers**:** Lossless divider, Resistive divider, Wilkinson power divider, Couplers**:** even odd mode excitation**,**90 degree Hybrid Coupler,180 degree coupler, Filter design: Periodic structures, Insertion loss method, maximally flat low pass filter, stepped impedance low pass filter, filter transformation, filter implementation, **Active Circuit Design:** High power transistors, Introduction to amplifier design**,** Gain and stability, single stage amplifier design, LNA amplifier design, Concepts of mixers, Single ended mixers, Single balanced mixers, oscillator design, Dielectric resonator model **Microwave systems:** Radar systems: Radar equation, pulse radar, Doppler radar, A typical wireless transceiver.

Reference Books

1. David M. Pozar," Microwave Engineering," John Wiley & Sons, 1998.
2. David M. Pozar," Microwave & RF Design of Wireless Systems," John Wiley & Sons, 1998.
3. R.E.Collin," Foundations of Microwave Engineering," Tata McGraw Hill, 1995.
4. www.agilent.com

Course Contents and Lecture Schedule

Sl.No:	Topic	No. of Lectures
	Microwave Circuits and System	
1	**S parameters**	
1.1	Scattering parameters	1
1.2	Reciprocal and Lossless networks	2
2	**Transmission Lines**	1
2.1	**Planar Transmission Lines**	

2.1.1	Microstrip	0.5
2.1.2	Coplanar wave guide	0.5
2.1.3	Strip line	0.5
2.1.4	Slot line	0.5
	Impedance Matching	
	Review of Smith chart	1
2.2	Lumped element matching	2
2.3	Stub matching	
2.3.1	Single stub matching –Series	2
2.3.2	Single stub matching –shunt	2
2.3.3	Double stub matching	2
	Problems on Smith chart	2
2.4	Quarter wave Transformer	1
2.5	Tapered Lines	1
3	**Passive circuit design**	
3.1	**Dividers** –Properties	2
3.1.1	Lossless and resistive dividers	1
3.1.2	Wilkinson power divider	1
3.2	Couplers –Even and odd mode excitation	1
3.2.1	90 degree Hybrid couplers	2
3.2.2	180 degree coupler	2
3.3	**Filters**	
3.3.1	Periodic structures	2
3.3.1	Filter design by insertion loss method	2
3.3.2	Stepped impedance LPF	2
3.3.3	Filter transformations	2
3.3.4	Filter implementations	2
4	**Active circuit design**	
4.1	High power transistors	1
4.1.1	Introduction to amplifier design	1
4.2	Gain and stability	4
4.3	Single stage amplifier design	4
4.4	Low Noise amplifier design	4
4.5	Mixer concepts	1
4.5.1	Single ended and balanced mixers	2
4.6	Oscillator design	2
4.7	Dielectric resonator model	1
5	**Microwave systems**	
5.1	**Radar systems**	1
5.1.1	Radar equation	1
5.1.2	Pulse radar	1
5.1.3	Doppler radar	1
5.2	**Wireless Transceiver architecture**	1

Course Designers:

1. Dr. V.Abhaikumar principal@tce.edu
2. Dr. S.Kanthamani skmece@tce.edu

14CN150	IMAGE PROCESSING AND RECOGNITION	Category	L	T	P	Credit
		PC	3	0	-	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 lowest level, the course introduces the terminology of image processing, different imaging technologies and the algorithms deal directly with the raw pixel values. In the middle level, it addresses the Quality improvement techniques like enhancement and restoration approaches, segmentation and image representation techniques for analysis purpose. At the highest level, it addresses the classification using statistical decision making and it includes the image processing applications with few case studies.

Prerequisite

NIL

Course Outcomes

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

CO1. Enhance and Restore images in spatial as well as frequency domains	Apply
CO2. Segment given images in terms of edge, threshold and region	Apply
CO3. Apply morphological operations like dilation, erosion, opening and closing on given images	Apply
CO4. Represent , recognize and classify objects from the given images	Apply
CO5. Analyze different case studies like Face image feature extraction, video Motion imaging, watermarking.	Analyze

Mapping with Programme Outcomes

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

S- Strong; M-Medium; L-Low

Assessment Pattern

	Bloom's category	Continuous Assessment Tests			End Semester Examinations
		1	2	3	
1	Remember	20	20	20	20
2	Understand	40	40	20	20
3	Apply	40	40	40	40
4	Analyze	0	0	20	20
5	Evaluate	0	0	0	0

6	Create	0	0	0	0

Course Level Assessment Questions

COURSE OUTCOME 1(CO1):

1. List the properties of first and second order derivatives.
2. Give the PDF of Erlang noise and sketch the PDF.
3. Explain sharpening in frequency domain filters.
4. Consider two 8-bit images whose gray levels span the full range from 1 to 255. Will reversal of the order of the images yield a different result?
5. For a 5 bit input matrix perform histogram equalization.

10	10	15	0	0
5	0	10	10	15
15	15	2	0	10
5	5	0	10	30

6. Find the filter output using Alpha trimmed mean filter for the following matrix. Assume d=10.

5	10	15	20	5
10	10	15	20	5
5	10	20	5	5
20	15	15	10	0
15	0	5	15	20

7. Suppose that you form a low pass spatial filter that averages the four immediate neighbors of a point (x, y) but excludes the point itself.
   a) Find the equivalent filter H(u, v) in the frequency domain.
   b) Show that your result is low pass filter.

COURSE OUTCOME 2(CO2):

1. Write the masks to detect horizontal and vertical lines in an image
2. State convolution and correlation.
3. A binary image contains straight lines oriented horizontally, vertically, at 45^o and -45^o. Give a set of 3X3 masks that can be used to detect one pixel long breaks in these lines. Assume that the gray level of the line is 1 and that the gray level of the background is 0.
4. With reference to this equation

$$\nabla^2 h(r) = -\left[\frac{r^2-\sigma^2}{\sigma^4}\right] e^{\frac{-r^2}{2\sigma^2}}$$

   a. Show that the average value of the laplacian Δ^2h=0
   b. Prove that the average value of any image convolved with this operator is also zero.

COURSE OUTCOME 3(CO3):

1. (i) Give a morphological algorithm for converting an 8-connected binary boundary to an m-connected boundary. you may assume that the boundary is fully connected.
   a. Does the operation of your algorithm require more than one iteration with each Structuring element? Explain your reasoning.
   b. Is the performance of your algorithm independent of the order in which the Structuring elements are applied? if your answer is yes, prove it. otherwise give an example that illustrates the dependence of your procedure on the order of application of the structuring elements.
2. Erode the region consisting of 1's in the following image using the operator

2	3

.The '*' denotes the region of the operator.

0	0	1	0	0	0
0	1	1	1	0	0
0	1	0	1	1	0

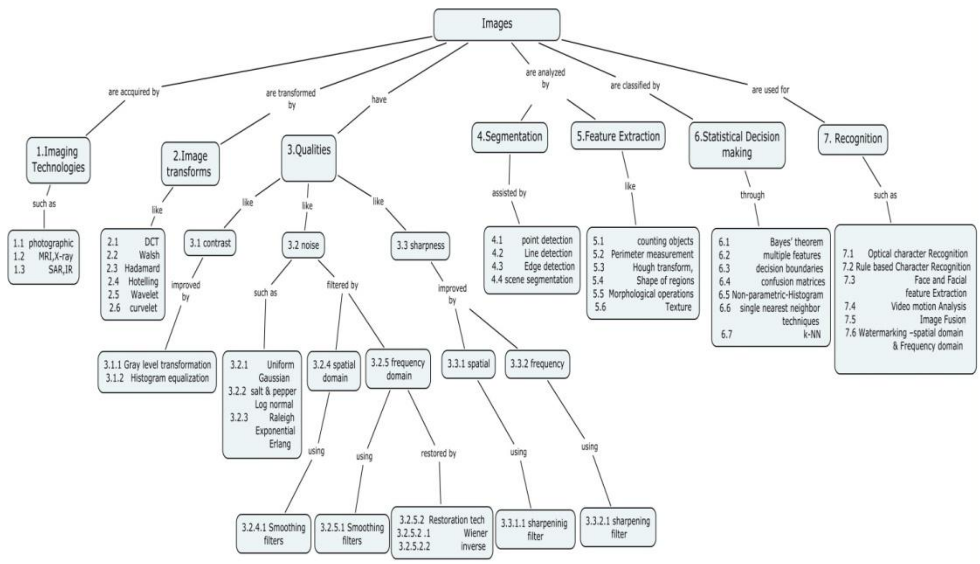
COURSE OUTCOME 4(CO4):

1. Differentiate KNN Decision making and Bayesian Decision making?
2. The Bayes decision functions $d_j(x)=p(x/\omega_j)p(\omega_j)$, j=1,2,…W, were derived using a 0-1 loss function. Prove that these decision functions minimize the probability of error.(Hint: The probability of error p(e) is 1-p(c) where p(c) is the probability of being correct. For pattern vector x belonging to class ω_j $p(c/x)=p(\omega_j/x)$. Find p(c) and show that p(c) is maximum (p(e) is minimum when $p(x/\ \omega_j)\ p(\omega_j)$is maximum)
3. Specify the structure and weights of a neural network capable of performing exactly the same function as a minimum distance classifier for two pattern class in N-dimensional place. Obtain the signatures for a pentagon and a rectangle.
4. What is the use of Bayesian Decision Making?
5. Specify the structure and weights of a neural network capable of performing exactly the same function as a bayes classifier for two pattern classes in n-dimensional space. The classes are Gaussian with different means but equal covariance matrices.
6. Explain the system flow for the character recognition.

COURSE OUTCOME 5(CO5):

1. You are contracted to design a image processing system for detecting imperfection on the inside of certain solid plastic wafers. The wafers are examine using an X-ray imaging system which yields 8-bit images of 512×512 resolution. In the absence of imperfection the images appear "bland" having a mean gray level of 100 and variance 400.The imperfection appear as blob like regions in which 70% of the pixels have excursion in intensity of 50 gray levels or less about a mean of 100.A wafer is considered defective such a region occupies an area exceeding 20 ×20 pixels in size. Propose a system based on texture analysis.
2. Evaluate the performance of spatial domain and frequency domain Watermarking
3. Analyze the various steps involved to extract facial features for recognizing

Concept Map



Syllabus

Imaging Fundamentals: Introduction to Imaging Technologies-Photographic- X-Ray-MRI-SAR-IR imaging–Image Representations- Image Transforms- DCT- Walsh-Hadamard-Hotelling- Wavelet–Curvelet. **Image Quality Enhancement**: contrast- noise- Sharpness – Gray level Transformation – Histogram processing –**Spatial Domain** spatial filtering – smoothing, sharpening filters- **Frequency Domain** Smoothing, sharpening Image Restoration Techniques – Inverse-Wiener **Processing and Analyzing Images**: Point Detection- Line Detection – Edge Detection – Scene Segmentation and labeling – Counting objects – Perimeter measurement- Hough Transform – Shape of Regions- Morphological operations –Texture **Statistical Decision Making:** Bayes Theorem – Multiple features- Decision Boundaries- Confusion matrices- Non parametric Histogram-Single nearest neighbor technique-K-NN **Imaging Applications:** System design**-** Optical character Recognition- Rule based Character Recognition- Face and Facial feature Extraction - Video motion Analysis- Image Fusion- Watermarking – spatial & frequency domain.

Reference Books

1. Rafael.C.Gonzalez and Richard.E. Woods, "Digital Image Processing", Pearson Education, 2003
2. Earl Gose, Richard Johnson Baugh, "Pattern Recognition and Image analysis", Prentice Hall India Pvt Ltd, 2004
3. William.K.Pratt, "Digital Image Processing", Fourth edition, A John Wiley and Publications.
4. G.W.Awcock & R.Thomas, "Applied Image Processing" McGraw-Hill Inc..
5. Frank.Y.Shih, " Image Processing and Pattern Recognition Fundamentals and Techniques" , A John Wiley & sons publication

Course Contents and Lecture Schedule

No.	Topic	No. of Lectures
1.	**Introduction to Imaging Technologies**	
1.1	Photographic	1
1.2	X-Ray, MRI,	1
1.3	SAR, IR, Image Representations	1
2.0	**Image Transforms**	
2.1	Discrete CosineTransform	1
2.2	Walsh	1
2.3	Hadamard	1
2.4	hotelling	1
2.5	Wavelet	1
2.6	curvelet	1
3.0	**Qualities**	
3.1	contrast	1
3.1.1	Gray level Transformation	1
3.1.2	Histogram Processing	1
3.2	Noise	
3.2.1 3.2.2 3.2.3	Uniform, Gaussian, Salt & pepper , Log normal, Rayleigh , Exponential ,Erlang	1
3.2.4	Spatial domain	
3.2.4.1	Smoothing filter	1
3.2.5	Frequency domain	
3.2.5.1	Smoothing filter	1
3.2.5.2	Restoration Techniques	1

3.2.5.2.1, 3.2.5.2.2	Wiener and Inverse	1
3.3	Sharpness	1
3.3.1	Spatial domain	
3.3.1.1	Sharpening filters	1
3.3.2	Frequency domain	
3.3.2.1	Sharpening filters	1
4.0	**Segmentation**	
4.1 4.2	Point detection Line detection	1
4.3	Edge detection	1
4.4	Scene Segmentation and labelling	1
5.0	**Feature Extraction**	
5.1	Counting objects	1
5.2	perimeter measurement	1
5.3,5.4	Hough transforms, shape of regions	1
5.5	morphological operations	1
5.6	Texture	1
6.0	**Statistical decision making**	
6.1	Bayes' theorem	1
6.2	multiple features	1
6.3	decision boundaries	1
6.4	confusion matrices	1
6.5	Non-parametric-Histogram,	2
6.6	single nearest neighbor techniques	1
6.7	k-NN	1
7.0	**Applications**	
7.1	Optical character Recognition	1
7.2	Rule based Character Recognition	1
7.3	Face and Facial feature Extraction	1
7.4	Video motion Analysis	1
7.5	Image Fusion	1
7.6	Watermarking –spatial domain & Frequency domain	2

Course Designers:

1. Dr. S.Md.Mansoor Roomi, smmroomi@tce.edu
2. Dr. A.Banumathi, au_banu@tce.edu

14CN160	DIGITAL INTEGRATED SYSTEMS	Category	L	T	P	Credit
		PC	3	1	-	4

Preamble

The proposed course is offered in the first semester. This course ‘14CN160: Digital Integrated Systems’, a departmental core course, is prerequisites are undergraduate course on Digital Circuits and Systems, Electrical circuit theory and CMOS VLSI Systems. This course will be followed by a elective course: ASIC Design. The course aims at understanding the engineering and design principles of VLSI (Very Large Scale Integration) CMOS technology for application in digital integrated circuits and subsystems.

Prerequisite

Nil

Course Outcomes

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

CO1. Design combinational logic gates including static CMOS and dynamic CMOS	Apply
CO2. Design sequential logic circuits including static and dynamic latches/registers	Create
CO3. Model interconnect parasitics	Analysis
CO4. Design arithmetic building blocks including adder, multiplier and shifters	Create
CO5. Design memory array structures including peripheral memory circuits and power dissipation in memories	Create

Mapping with Programme Outcomes

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

S- Strong; M-Medium; L-Low

Assessment Pattern

	Bloom’s category	Continuous Assessment Tests			End Semester Examinations
		1	2	3	
1	Remember	20	10	0	0
2	Understand	30	30	20	20
3	Apply	30	40	50	50
4	Analyze	0	0	0	0
5	Evaluate	0	0	0	0
6	Create	20	20	30	30

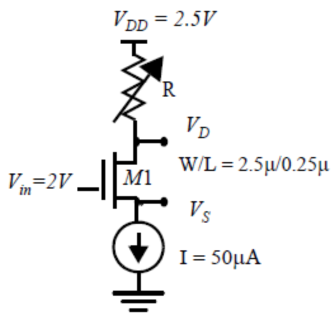
Course Level Assessment Questions

Course Outcome 1 (CO1):

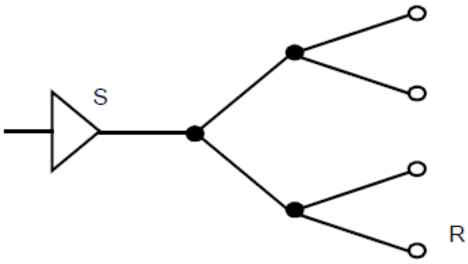
1. Design a static CMOS inverter that meets the following requirements:
   Matched pull-up and pull-down times (i.e., *tpHL* = *tpLH*).
   tp = 5 nsec (± 0.1 nsec).
   The load capacitance connected to the output is equal to 4 pF. Notice that this capacitance is substantially larger than the internal capacitances of the gate. Determine the *W* and *L* of the transistors. To reduce the parasitics, use minimal lengths (*L* = 1.2 mm) for all transistors.
2. Implement the equation *X* = ((*A' + B'*) (*C' + D' + E'*) + *F'*) *G'* using complementary CMOS. Size the devices so that the output resistance is the same as that of an inverter with an NMOS *W/L* = 2 and PMOS *W/L* = 6. Which input pattern(s) would give the worst and best equivalent pull-up or pull-down resistance?
3. Implement the following expression in a full static CMOS logic fashion using no more than 10 transistors:
   Y' = (*A* . *B*) + (*A* . *C* . *E*) + (*D* . *E*) + (*D* . *C* . *B*)
4. Implement *F = AB'C' + A'CD* (and *F'*) in DCVSL. Assume *A*, *B*, *C*, *D,* and their complements are available as inputs. Use the minimum number of transistors.
5. Implement the function *S = ABC + AB'C' + A'B'C + A'BC'*, which gives the sum of two inputs with a carry bit, using NMOS pass transistor logic. Design a DCVSL gate which implements the same function. Assume *A*, *B*, *C*, and their complements are available as inputs.
6. Suppose we wish to implement the two logic functions given by *F = A + B + C* and *G = A + B + C + D*. Assume both true and complementary signals are available.
   a. Implement these functions in dynamic CMOS as cascaded f stages so as to minimize the total transistor count.
   b. Design an *np*-CMOS implementation of the same logic functions. Does this design display any of the difficulties of part (a)?

Course Outcome 2 (CO2):

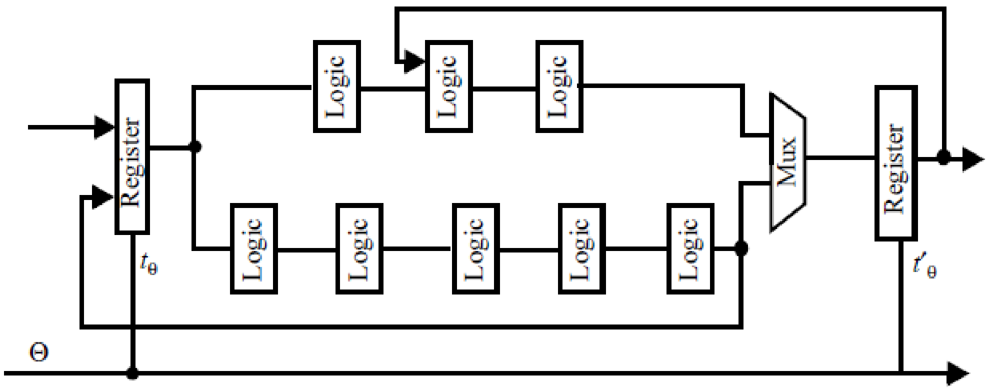
1. Determine the mode of operation (saturation, linear, or cutoff) and drain current I_D for each of the biasing configurations given below. Use the following transistor data: NMOS: *k'n* = 115μA/V2, *VT*0 = 0.43 V, λ = 0.06 V–1, PMOS: *k'p* = 30μA/V2, *VT*0 = –0.4 V, λ = -0.1 V–1. Assume (*W/L*) = 1.
   a. NMOS: *VGS* = 2.5 V, *VDS* = 2.5 V. PMOS: *VGS* = –0.5 V, *VDS* = –1.25 V.
   b. NMOS: *VGS* = 3.3 V, *VDS* = 2.2 V. PMOS: *VGS* = –2.5 V, *VDS* = –1.8 V.
   c. NMOS: *VGS* = 0.6 V, *VDS* = 0.1 V. PMOS: *VGS* = –2.5 V, *VDS* = –0.7 V.
2. An NMOS device is plugged into the test configuration shown below in Figure below. The input *Vin* =2V. The current source draws a constant current of 50 μA. *R* is a variable resistor that can assume values between 10kΩ and 30 kΩ. Transistor M1 experiences short channel effects and has following transistor parameters: *k*' = 110*10-6 V/A2, VT = 0.4 , and VDSAT = 0.6V. The transistor has a W/L = 2.5μ/0.25μ. For simplicity body effect and channel length modulation can be neglected. i.e λ=0, γ=0.
   a. When *R* =10kΩ find the operation region, VD and VS.
   b. When R= 30kΩ again determine the operation region VD, VS
   c. For the case of R = 10kΩ, would VS increase or decrease if λ ≠ 0. Explain qualitatively



3. The superscalar, superpipelined, out-of-order executing, highly parallel, fully x86 compatible JMRII microprocessor was fabricated in a 0.25 m technology and was able to operate at 100MHZ, consuming 10 watts using a 2.5 V power supply.
   a. Using fixed voltage scaling, what will the speed and power consumption of the same processor be if scaled to 0.1 μm technology?
   b. If the supply voltage on the 0.1 μm part were scaled to 1.0 V, what will the power consumption and speed be?
   c. What supply should be used to fix the power consumption at 10 watts? At what speed would the processor operate?
4. Figure below shows a clock-distribution network. Each segment of the clock network (between the nodes) is 5 mm long, 3 μm wide, and is implemented in polysilicon. At each of the terminal nodes (such as *R*) resides a load capacitance of 100 fF.



   a. Determine the average current of the clock driver, given a voltage swing on the clock lines of 5 V and a maximum delay of 5 nsec between clock source and destination node *R*. For this part, you may ignore the resistance and inductance of the network
   b. Unfortunately the resistance of the polysilicon cannot be ignored. Assume that each straight segment of the network can be modeled as a Π-network. Draw the equivalent circuit and annotate the values of resistors and capacitors.
   c. Determine the dominant time-constant of the clock response at node *R*.
5. For the circuit in Figure 0.1, assume a unit delay through the Register and Logic blocks (i.e., $t_R = t_L = 1$). Assume that the registers, which are positive edge-triggered, have a set-up time t_S of 1. The delay through the multiplexer t_M equals 2 t_R.
   a. Determine the minimum clock period. Disregard clock skew.
   b. Repeat part a, factoring in a nonzero clock skew: $\delta = t'_\theta - t_\theta = 1$.
   c. Repeat part a, factoring in a non-zero clock skew: $\delta = t'_\theta - t_\theta = 4$.
   d. Derive the maximum positive clock skew that can be tolerated before the circuit fails.
   e. Derive the maximum negative clock skew that can be tolerated before the circuit fails.



Course Outcome 3 (CO3):

6. A two-stage buffer is used to drive a metal wire of 1 cm. The first inverter is of minimum size with an input capacitance Ci=10 fF and an internal propagation delay tp0=50 ps and load dependent delay of 5ps/fF. The width of the metal wire is 3.6 μm. The sheet resistance of the metal is 0.08 Ω/ , the capacitance value is 0.03 fF/μm2 and the fringing field capacitance is 0.04fF/μm.
   a. What is the propagation delay of the metal wire?
   b. Compute the optimal size of the second inverter. What is the minimum delay through the buffer?
   c. If the input to the first inverter has 25% chance of making a 0-to-1 transition, and the whole chip is running at 20MHz with a 2.5 supply voltage, then what's the power consumed by the metal wire?
7. A standard CMOS inverter drives an aluminium wire on the first metal layer. Assume R_n=4kΩ, R_p=6kΩ. Also, assume that the output capacitance of the inverter is negligible in comparison with the wire capacitance. The wire is .5um wide, and the resistivity is 0.08 Ω/cm.
   a. What is the "critical length" of the wire?
   b. What is the equivalent capacitance of a wire of this length?
8. Consider an isolated 2mm long and 1μm wide M1 (Metal1) wire over a silicon substrate driven by an inverter that has zero resistance and parasitic output capacitance. How will the wire delay change for the following cases? Explain your reasoning in each case.
   a. If the wire width is doubled.
   b. If the wire length is halved.
   c. If the wire thickness is doubled.
   d. If thickness of the oxide between the M1 and the substrate is doubled.

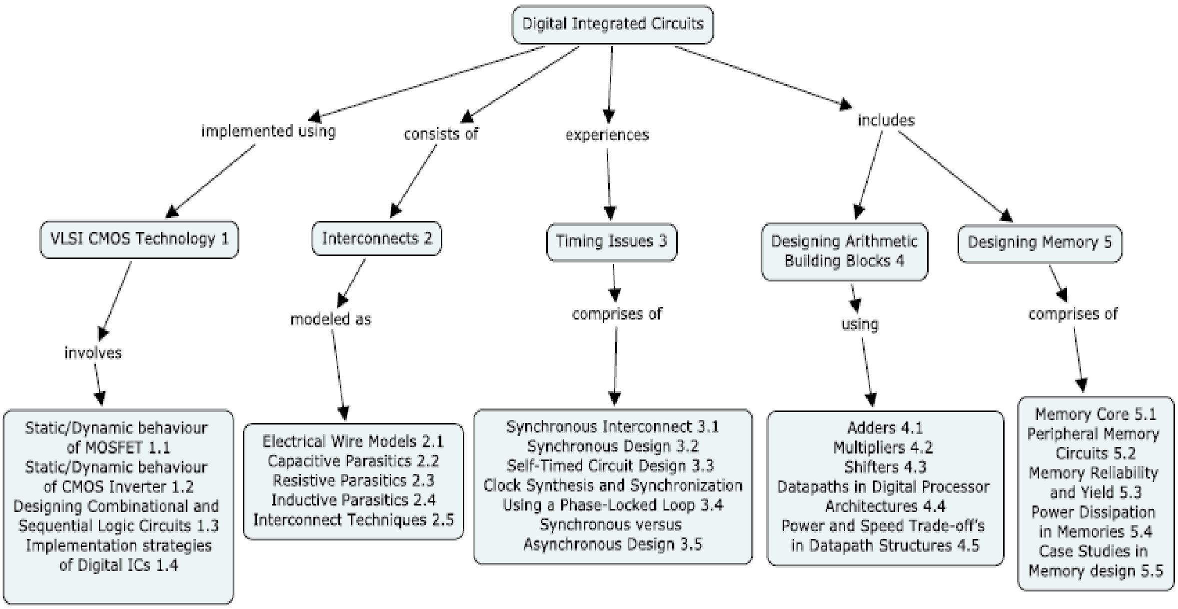
Course Outcome 4 (CO4):

1. Design a Complimentary Static CMOS Full Adder.
2. Design a 4x4b-bit CMOS Barrel Shifter.
3. Design 4-bit CMOS carry look-ahead adder.
4. Design 8-to-1 CMOS multiplexer using 2-to-1 CMOS multiplexer.

Course Outcome 5 (CO5):

1. Design a 8x8 MOS NOR ROM.
2. Design a 4x4 MOS NAND ROM.
3. Design a 8-to-1 column decoder for accessing memory.
4. Design a 4x4 CAM memory

Concept Map



Syllabus

VLSI CMOS Technology: Static/Dynamic behaviour of MOSFET, Static/Dynamic behaviour of CMOS Inverter, Designing Combinational and Sequential Logic Circuits**,** Implementation strategies of Digital ICs, **Interconnects:** Electrical Wire Models, Capacitive Parasitics, Resistive Parasitics, Inductive Parasitics, Advanced Interconnect Techniques. **Timing Issues in Digital Circuits:** Synchronous Interconnect, Synchronous Design, Self-Timed Circuit Design, Clock Synthesis and Synchronization Using a Phase-Locked Loop, Synchronous versus Asynchronous Design. **Designing Arithmetic Building Blocks:** Adders, Multipliers, Shifters, Datapaths in Digital Processor Architectures, Power and Speed Trade-off's in Datapath Structures. **Designing Memory:** Memory Core, Peripheral Memory Circuits, Memory Reliability and Yield, Power Dissipation in Memories, Case Studies in Memory design.

Reference Books

1. Jan M. Rabaey, Anantha P. Chandrakasan, Borivoje Nikolić, "Digital Integrated Circuits: A Design Perspective", Prentice Hall, Third Edition, 2008.
2. N. Weste and K. Eshraghian, "Principles of CMOS VLSI Design: A Systems Perspective", Second Edition, Addison-Wesley, 1993, Third Impression 2010.
3. Weste Neil, David Harris, "CMOS VLSI Design: A Circuits and Systems Perspective", Fourth Edition, Addison Wesley, 2010.
4. R. Jacob Baker, "CMOS Circuit Design, Layout, and Simulation", Wiley-IEEE, Revised Second Edition, 2008.
5. John P. Uyemura, "Introduction to VLSI Circuits and Systems". John Wiley & Sons, 2002.
6. John P. Uyemura, "CMOS Logic Circuit Design". Kluwer Academic Publishers, 2001.
7. John P. Uyemura, " Chip Design for Submicron VLSI: CMOS Layout and simulation". Thomson/Nelson, 2006.
8. Pucknell, "Basic VLSI Design", Prentice Hall, 1995.
9. Wayne Wolf, "Modern VLSI Design: System On Chip", Pearson Education, 2002.

Course Contents and Lecture Schedule

No.	Topic	No. of Lectures
1	**VLSI CMOS Technology**	
1.1	Static/Dynamic behaviour of MOSFET	1
1.2	Static/Dynamic behaviour of CMOS Inverter	1

1.3	Designing Combinational and Sequential Logic Circuits	2
1.4	Implementation strategies of Digital ICs	2
2	**Interconnects**	
2.1	Electrical Wire Models	1
2.2	Capacitive Parasitics	2
2.3	Resistive Parasitics	2
2.4	Inductive Parasitics	2
2.5	Advanced Interconnect Techniques	2
3	**Timing Issues**	
3.1	Synchronous Interconnect	1
3.2	Synchronous Design	2
3.4	Self-Timed Circuit Design	1
3.5	Clock Synthesis and Synchronization Using a Phase-Locked Loop	1
3.6	Synchronous versus Asynchronous Design	1
4	**Designing Arithmetic Building Blocks**	
4.1	Adders	2
4.2	Multipliers	2
4.3	Shifters	1
4.4	Datapaths in Digital Processor Architectures	1
4.5	Power and Speed Trade-off's in Datapath Structures	1
5	**Designing Memory**	
5.1	Memory Core	1
5.2	Peripheral Memory Circuits	2
5.3	Memory Reliability and Yield	1
5.4	Power Dissipation in Memories	2
5.5	Case Studies in Memory design	1

Course Designers:

1. Dr.S. Rajaram rajaram_siva@tce.edu
2. Mr. V. R. Venkatasubramani venthiru@tce.edu

14CN170	COMMUNICATION SYSTEMS LABORATORY

Category	L	T	P	Credit
PC	0	0	1	1

Preamble

This laboratory supplements the theory course (14CN120 Digital Communication Techniques) assist the students in obtaining a better understanding of the operation of different modules of digital communication systems and to provide experience in analyzing and test of digital communication systems using simulation software as well as lab instruments

Prerequisite

NIL

Course Outcomes

On successful completion of the course, a student will be able to

CO1	Generate standard discrete time signals, correlated and uncorrelated random processes	Apply
CO2	Simulate the source coding and channel coding techniques	Apply
CO3	Simulate the BER performance of Binary digital modulation techniques	Apply
CO4	Design, construct and test a scrambler and descrambler with given polynomial	Create
CO5	Implement a transceiver of given specification	Create

Mapping with Programme Outcomes

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

List of Experiments

1. Simulation of standard discrete time signals
2. Generation of Random Samples and correlated Random Samples
3. Source Coding Techniques
    a. Huffman Coding
    b. Lempel-Ziv Algorithm
4. Error Control Coding (Linear Block Code, Cyclic Code, Convolutional Code)
5. Generation and detection of binary digital modulation techniques
6. BER performance Analysis of Binary digital Modulation Techniques in AWGN Environment (Binary Phase Shift Keying, Amplitude Shift Keying, Frequency Shift Keying)
7. Scrambler and Descrambler
8. Generation of Minimum Shift Keying Signal
9. HDL Simulation of PN Sequence Generator
10. HDL Simulation of convolutional Coder

Course Designers:

1. Dr.S.J. Thiruvengadam sjtece@tce.edu
2. Dr.S.Rajaram rajaram_siva@tce.edu

14CN210	BASEBAND COMMUNICATION SYSTEM	Category	L	T	P	Credit
		PC	3	1	-	4

Preamble

The course 'Baseband Communication System' is offered as a core course in the second semester in continuation with the course on '14CN120 Digital Communication Techniques'. This course deals with transmission of digital signals over finite bandlimited channels and bandlimited wireless channels. The bandlimited channel creates ISI in addition to the AWGN. This can be mitigated either by properly designing pulse shapes in the transmitter or by equalizers in the receiver. The Wireless channel creates fading which can be mitigated using diversity techniques. This course will help the students to develop receiver algorithms for the various wireless communication standards.

Prerequisite

14CN120 Digital Communication Techniques

Course Outcomes

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

CO1. Describe the characteristics of Inter Symbol Interference and design pulse shape for transmission of digital signals through finite bandwidth channels for suppressing ISI.	Apply
CO2. Detect the transmitted data using techniques such as maximum likelihood sequence detector, zero forcing detector and MMSE detector in the presence of ISI.	Apply
CO3. Describe the design principles of equalizers such as linear equalizer, Decision Feedback Equalizer, MMSE equalizer and fractionally spaced equalizer and design the suitable equalizer for the given channel specifications.	Apply
CO4. Apply adaptive filtering concept for the design of equalizers suitable for time varying channels.	Apply
CO5. Describe the characteristics of fading and principles of different diversity techniques in mitigating fading and analyze the bit error rate of given digital modulation techniques in frequency flat and frequency selective fading environments.	Apply

Mapping with Programme Outcomes

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

S- Strong; M-Medium; L-Low

Assessment Pattern

	Bloom's category	Continuous Assessment Tests			End Semester Examinations
		1	2	3	
1	Remember	20	20	10	10
2	Understand	20	20	10	10
3	Apply	60	60	60	60
4	Analyze	0	0	20	20
5	Evaluate	0	0	0	0
6	Create	00	0	0	0

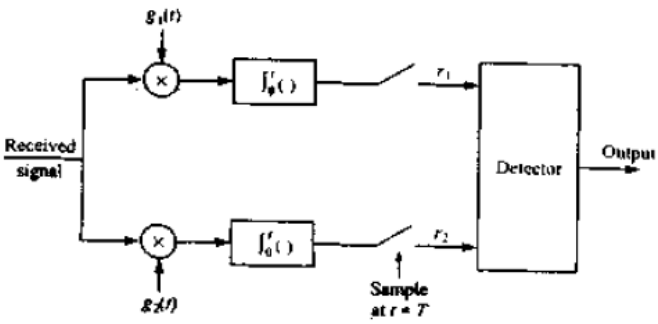
Course Level Assessment Questions

Course Outcome 1 (CO1):

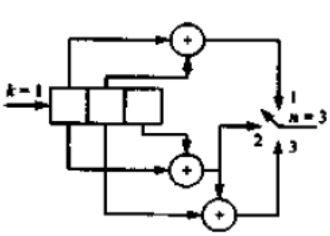
1. Calculate the bandwidth required to transmit data at the rate of 4000bps mapped with 16 QAM constellations filtered with RC pulses of roll off factor=0.5.
2. Binary PAM is used to transmit information over an un equalized channel. The noise free unequalised samples are given as $v_{in}(k) = \{0.2, 0.8, 0.2\}$. Determine the coefficient of three tap equalizer Which gives an output of $v_{eq}(k) = \{0,1,0\}$;Also find $v_{eq}(k), k = \pm 2, \pm 3$
3. For data rate of 9600bps data transmission with 4 PAM modulation over a channel with transfer function given by $f(W) = \dfrac{1}{\sqrt{1+\left(\dfrac{f}{W}\right)^2}}$, W=2400Hz. Obtain the transmit filter and receive filter frequency response. Assume the channel is compensated equally between transmitter and receiver.

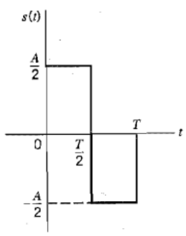
Course Outcome 2 (CO2):

1. Consider a two user, synchronous CDMA transmission system, where the received signal is $r(t) = \sqrt{E_1} b_1 g_1(t) + \sqrt{E_2} b_2 g_2(t) + n(t), \quad 0 \le t \le T$ and $b_1, b_2 \in \{-1,1\}$, $n(t)$ is zero mean Gaussian and white with power spectral density $N_o/2$. The demodulator is shown in figure.
   i. Determine the correlator outputs r_1 and r_2 at $t = T$.
   ii. Determine the variances of the noise components n_1 and n_2 in r_1 and r_2
   iii. Determine the joint pdf $p(r_1, r_2 | b_1 b_2)$



2. 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.



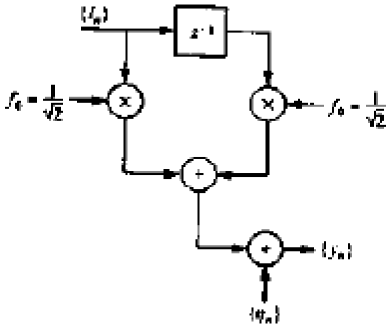


Course Outcome 3 (CO3):

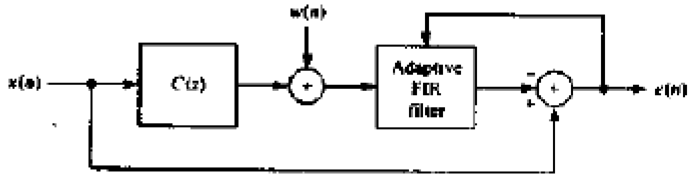
1. Binary PAM is used to transmit information over an unequalized linear filter channel. When $a=1$ is transmitted, the noise free output of the demodulator is $x_m = 0.3\delta(m+1)+0.9\delta(m)+0.3\delta(m-1)$. Design a three tap zero forcing equalizer so that the output is $q_m = \begin{cases} 1 & m=0 \\ 0 & m=\pm 1 \end{cases}$.
2. Determine the performance of the following types of equalizers
   a. Mean square error (MSE) criterion based infinite length Equalizer
   b. MSE based finite length equalizer
   c. Decision feedback equalizer
3. Consider a discrete time equivalent channel. The information sequence $\{I_k\}$ is binary $\{\pm 1\}$ and uncorrelated. The additive noise is white and real valued with variance 0.1. The received sequence is processed by a linear three tap equalizer on the basis of MSE criterion
   a. Determine the optimum coefficients of the equalizer
   b. Determine the minimum MSE and output SNR of the three tap equalizer.
   c. Suppose the channel is equalized by a DFE having a two tap feedforward filter and one tap feedback filter, on the basis of MSE criterion, determine the optimum coefficients and output SNR

Course Outcome 4 (CO4):

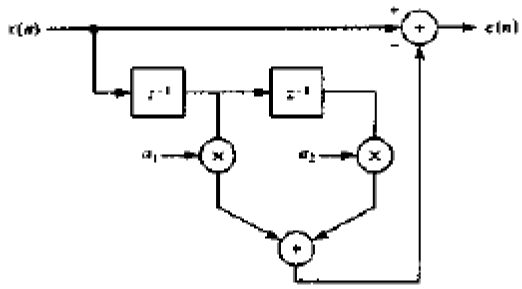
1. Consider a discrete time equivalent channel shown in figure1. The information sequence $\{I_k\}$ is binary $\{\pm 1\}$ and uncorrelated. The additive noise is white and real valued with variance 0.1. The received sequence is processed by a linear three tap



   equalizer on the basis of MSE criterion
   a. Determine the optimum coefficients of the equalizer
   b. Determine the minimum MSE and output SNR of the three tap equalizer.
   c. Suppose the channel is equalized by a DFE having a two tap feedforward filter and one tap feedback filter, on the basis of MSE criterion, determine the optimum coefficients and output SNR
2. Consider the adaptive FIR filter as shown in figure. The system $C(z)$ is characterized by the system function $C(z) = \frac{1}{1-0.9z^{-1}}$. Determine the optimum coefficients of the adaptive transversal FIR filter ($B(z) = b_0 + b_1 z^{-1}$) that minimize the mean square error. The additive noise is white with variance of 0.1.



3. Determine the coefficients a1 and a2 for the linear predictor shown in figure, given that the autocorrelation $\gamma_{xx}(m)$ of the input signal is $\gamma_{xx}(m) = b^{|m|}, 0 < b < 1$



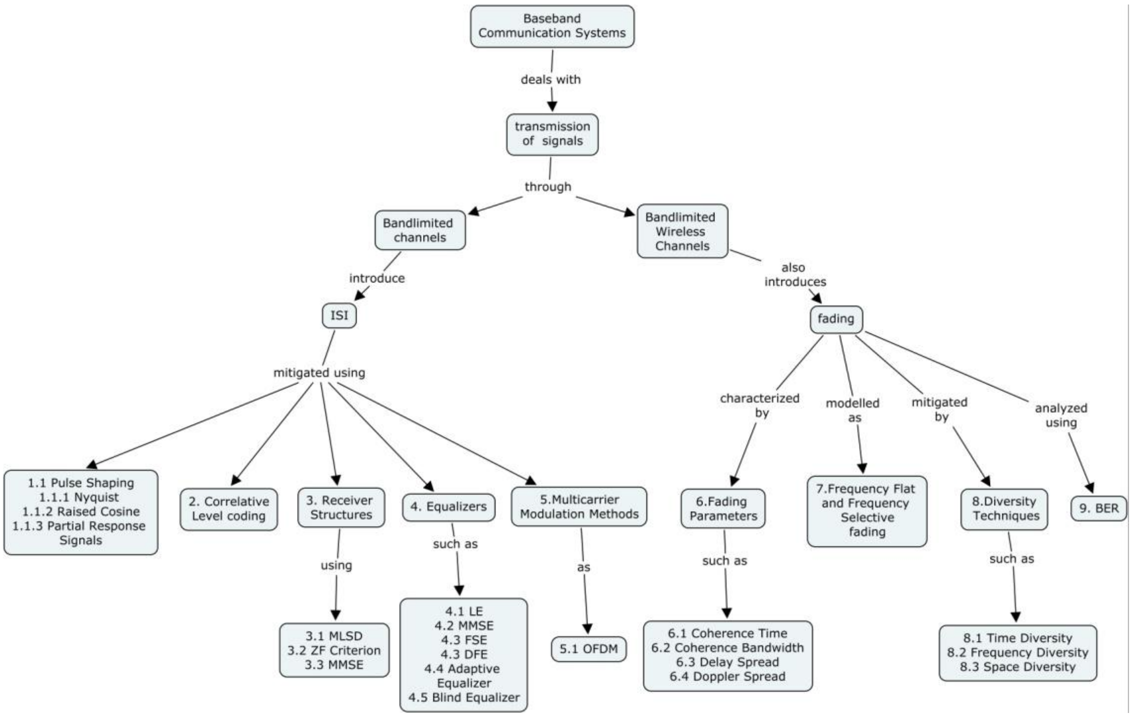
Course Outcome 5 (CO5):

1. Consider a digital communication system that uses two transmitting antennas and one receiving antenna. Let s_1 and s_2 are the symbols that are to be transmitted. The signal from the first antenna over two signal intervals is $(s_1, -s_2^*)$ and from the second antenna the transmitted signal is $(s_2, -s_1^*)$. Let (h_1, h_2) represent the complex valued channel path gains, which is assumed to be zero mean complex Gaussian with unit variance and statistically independent. (h_1, h_2) are assumed to be constant over the two signal intervals and known to the receiver. Let (n_1, n_2) represent the AWGN terms and uncorrelated.

    a. Show that the transmitted symbols s_1 and s_2 can be estimated from the received signal r_1, r_2 and achieve dual diversity reception
    b. If the symbols s_1 and s_2 are BPSK modulated, determine the probability of error.
2. Derive the expressions for BER for the following cases
    a. BPSK modulation with receive diversity of order L in slow, frequency non selective channel.
    b. BPSK modulation in slow, frequency selective channel.

3. In a fast FHSS, the information is transmitted via FSK, with noncoherent detection. Suppose that there are $N = 3$ hops/bit, with hard decision decoding of the signal in each hop. Determine the probability of error for this system in an AWGN channel with power spectral density of $N_o / 2$ and the total SNR over the three hops is 13dB

Concept Map



Syllabus

Signal Design for Band limited channels: Characterization of band limited channels, Design of transmit Pulse shapes, Nyquist Pulse, Raised Cosine Pulse, Partial Response Signals, **Correlative Level Coding, Receiver Structures:** Maximum Likelihood Sequence Detector, Zero Forcing Criterion, Minimum Mean Square Error, **Equalizers:** Linear Equalizer, MMSE, Fractionally spaced Equalizer, Decision Feedback Equalizer, Adaptive Equalizer, Blind Equalizer, **Multi carrier Modulation Methods:** Orthogonal Frequency Division Multiplexing (OFDM), **Fading Parameters:** Coherence Time, Coherence Bandwidth, Delay Spread, Doppler Spread, **Fading Models:** Frequency Flat fading, Frequency Selective fading, **Diversity Techniques:** Time Diversity, Frequency Diversity, Space Diversity, **Bit Error Rate Analysis:** BER Analysis for Frequency flat and Frequency selective fading channels

Reference Books

1. John G Proakis, Salehi, Massoud, “Digital Communications”,Academic Internet Publishers,Fifth Edition, 2009.
2. J.R.Barry,E.A Lee and D.G.Messerschmitt, “Digital Communications”, Springer,2004
3. David Tse and Pramod Viswanath, “Fundamentals of Wireless Communications”, Cambridge University Press, 2005 (First Asian Edition, 2006)
4. Bernard Sklar, “Digital Communications: Fundamentals and Applications”, Prentice Hall, Second Edition, 2001
5. Dennis Silage, “ Digital Communication Systems using MATLAB and SIMULINK”, Book Stand Publications, 2009

Course Contents and Lecture Schedule

S. No	Topic	No of lectures
1	Signal Design for Band limited channels: Characterization of band limited channels	2
2	Design of transmit Pulse shapes	2
3	Nyquist Pulse, Raised Cosine Pulse	2

4	Partial Response Signals	2
5	Correlative Level Coding	2
6	Receiver Structures: Maximum Likelihood Sequence Detector	2
7	Zero Forcing Criterion	2
8	Minimum Mean Square Error	2
9	Equalizers: Linear Equalizer	2
10	MMSE	2
11	Fractionally spaced Equalizer, Decision Feedback Equalizer	2
12	Adaptive Equalizer, Blind Equalizer	5
13	Multi carrier Modulation Methods: Orthogonal Frequency Division Multiplexing (OFDM)	2
14	Fading Parameters: Coherence Time, Coherence Bandwidth, Delay Spread, Doppler Spread	2
15	Fading Models: Frequency Flat fading, Frequency Selective fading	3
16	Diversity Techniques: Time Diversity, Frequency Diversity, Space Diversity	3
17	Bit Error Rate Analysis: BER Analysis for Frequency flat fading channels	4
18	BER Analysis for Frequency selective fading channels	4
	Total Number of Hours	45

Course Designers:

1. Dr. S.J. Thiruvengadam sjtece@tce.edu
2. Dr. M.N.Suresh mnsece@tce.edu

14CN220	OPTICAL COMMUNICATION AND NETWORKING	Category	L	T	P	Credit
		PC	3	1	-	4

Preamble

This course presents the state-of-the-art in the field of Optical communication networks which encompasses traditional networks operating on optical fiber as well as the next-generation networks such as wavelength division multiplexed and optical time division multiplexed networks. The course will enable the students to learn about key photonic devices that form the backbone of the optical communication network. The course will provide students with a fundamental understanding of optical communication network design, control, and management. Students will do design of analog and digital optical fiber link and WDM network design.

Prerequisite

NIL

Course Outcomes

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

CO1	Understand the behaviour of optical communication network components including optical transmitter, fibers, optical receiver, optical amplifier, add drop multiplexer and optical cross connects.	Understand
CO2	Analyze the performance of analog and digital optical communication system	Analyze
CO3	Solve the problems of wavelength assignment and routing in WDM networks	Apply
CO4	Perform protection in SONET/SDH network and optical layer protection	Create
CO5	Architect a optical communication network to meet a given set of specification	Create

Mapping with Programme Outcomes

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

S- Strong; M-Medium; L-Low

Assessment Pattern

	Bloom's category	Continuous Assessment Tests			End Semester Examinations
		1	2	3	
1	Remember	20	20	0	0
2	Understand	20	20	20	20
3	Apply	40	40	50	50
4	Analyze	20	20	0	0

5	Evaluate	0	0	0	0
6	Create	0	00	30	30

Course Level Assessment Questions

Course Outcome 1 (CO1) :

1. List the advantages of optical fiber communication?
2. Mention the reason for attenuation of light signal more near the wavelength of 1400nm?
3. Distinguish between LED and LASER.
4. Define quantum efficiency.
5. Define RWA problem.
6. How do you eliminate deadlock in packet switching network?
7. Distinguish first generation and second generation optical networks.
8. How does dispersion limit the performance of a fiber optic system?

Course Outcome 2 (CO2):

1. A 1.3μm light wave system uses a 50-km fiber link and requires at least 0.3 mW at the receiver. The fiber loss is 0.5 dB/km. Fiber is spliced every 5 km and has two connectors of 1-dB at both ends. Splice loss is only 0.2 dB each. Determine the minimum optical power that must be launched into the fiber.
2. Consider a piece of step-index optical fiber with a refractive index at the fiber core of 1.47 and a fractional refractive index change for the core and the cladding of 0.02. Determine the maximum fiber core diameter allowed if this fiber is designed to be single-mode over the wavelength range from 1310nm to 1550nm?
3. A 0.88 μm optical communication system transmits data over a 10 km single mode fibre by using 10 ns pulses. The dispersion parameter of the fibre is D = 80 ps/(km-nm). The LED has a spectral width Δλ of 51 nm. Determine the maximum bit rate possible.

Course Outcome 3 (CO3):

1. An optical transmission system transmits non-return-to-zero (NRZ) data at 2.488 Gbit/s on a single-mode fiber. The optical transmitter operates at 1550 nm and is carefully controlled that negligible optical power is transmitted at the “0” bits. The “0” bits and the “1” bits are assumed to be equally-probable. A PIN photo-detector is used to detect the optical signal. The quantum efficiency of the photo-detector is 0.8. Assuming the receiver circuit has an equivalent resistance of 1kΩ, the receiver bandwidth matches with the signal bandwidth, negligible dark and leakage current at the photo-detector, the operating temperature is $27^{o}C$ (Note that Bandwidth =1/(2×Bit Period) for NRZ)
   a. Compute the signal-to-noise ratio (SNR) with a received power of -20 dBm. (i) shot noise (ii) thermal-noise dominated. Which one, (i) or (ii), is a more practical and reasonable assumption? Explain.
   b. Find the minimum average optical power received at the detector in order to achieve an SNR by 20 dB by assuming the receiver is shot-noise dominated or thermal-noise dominated. Which one, (i) or (ii), is a more practical and reasonable assumption? Explain.

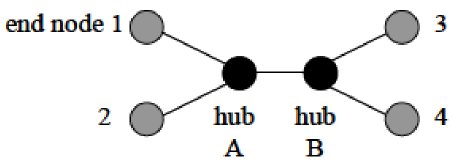
2. Analyze the attenuation -limited transmission distance of the following two systems operating at 100 Mb/s:

System one operating at 850 nm
(a) GaAlAs laser diode: fiber coupled power 0 dBm
(b) Silicon avalanche photodiode: -50 dBm sensitivity
(c) Graded index fiber: 3.5 dB/km attenuation at 850 nm

(d) 1 dB/connector connector loss
System two operating at 1300 nm
(a) InGaAsP LED: fiber coupled power -13 dBm
(b) InGaAs PIN photodiode: -38 dBm sensitivity
(c) Graded index fiber: 1.5 dB/km attenuation at 1300 nm
(d) 1 dB/connector connector loss
Allow 6 dB system margin in each case

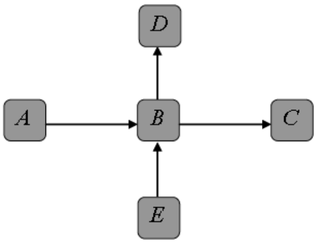
Course Outcome 4 (CO4):

1. A SONET link operating at ~40Gb/s carries as many as possible ATM streams at 149.760 Mb/s. How many voice channels multiplexed in DS-1 format can be accommodated in addition to the ATM streams? If 1 ATM is dropped, how many additional voice channels can be added?
2. 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.



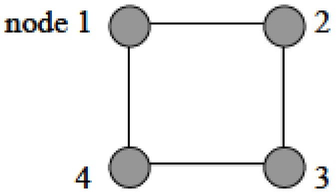
Consider the following s-d pairs each of which has 1 wavelength unit of traffic: 1-3, 1-4, 2-3, 2-4, 3-1, 3-2, 4-1, 4-2, 4-3. Specify the wavelength assignment (WA) that uses the minimum number of wavelengths.

3. Consider the switching node B in the network shown below. Each directed link is a single fiber. Assume that there are 3 s-d pairs: A-C, A-D, and E-C. Each s-d pair sends and receives traffic at 4 Gbps. In addition, assume that one wavelength channel can carry up to 10 Gbps.



Assume the use of electronic switching architecture at node B. Detemine the amount of traffic (in Gbps) that must be processed electronically at node B.

4. Consider a 4-node transparent optical network shown below. Assume that adjacent nodes are connected by two fibers, one for the transmission in each direction. In addition, assume that there are 2 wavelengths in each fiber.

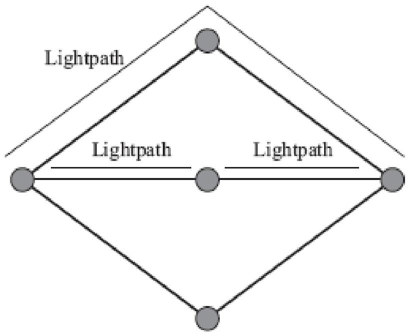


Assume that calls (i.e., lightpath demands) arrive in the following sequence

2-1, 2-4, 4-3, 1-3, 2-4, … where each value pair is the s-d pair for the call. Suppose that we use fixed routing with the paths 1-4-3, 2-1, 2-1-4, and 4-3 for s-d pairs 1-3, 2-1, 2-4, and 4-3 respectively. Evaluate the performance of following on-line WA schemes to each call (i.e., put on λ_1, put on λ_2 , or blocked)
(*a*) First-fit WA: Assign the first possible wavelength starting from the smallest wavelength index.
(*b*) Most-used WA: Assign the wavelength with the highest utilization (before the new call). The utilization of wavelength λi is the number of fibers on which wavelength λi is used.

Course Outcome 5 (CO5):

1. Consider the network shown in Figure, with three lightpaths to be supported. Each lightpath uses one unit of capacity on each link that it traverses. How to protect all the lightpaths in case of failure.



2. Compare the performance of UPSRs and BLSR/2s in cases where all the traffic is between a hub node and the other nodes. Assume the same ring speed in both cases. Is a BLSR/2 any more efficient than a UPSR in traffic-carrying capacity in this scenario?

Course Outcome 6 (CO6):

1. An engineer has the following components available:
   - GaAlAs laser diode, operating at 850 nm, fiber coupled power 0 dBm
   - Ten sections of cable each of which is 500 m long, has 4 dB/k m attenuation, has connectors at both ends
   - 2 dB/connector connector loss
   - A PIN photodiode receiver, -45 dBm sensitivity
   - An avalanche photodiode receiver, -56 dBm sensitivity

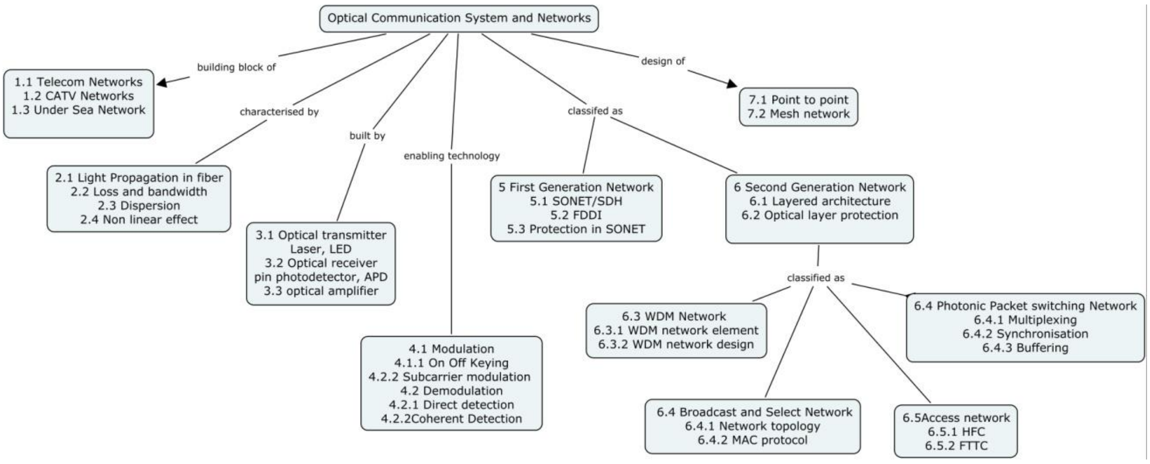
   Design a 5-km link operating at 20 Mb/s using suitable receiver, if 6-dB operating margin is required.
2. A 2.4 Gbit/s optical transmission system is to operate at a wavelength of 1550 nm over a distance of 72 km. Two different transmitter types are available, type 1 and 2, with specifications shown in Table 1:

Transmitter type	**Minimum output power**	**Worst case spectral width**
A	+2 dBm	0.6 nm
B	+1.2 dBm	0.5 nm

   A common receiver is used, which has a worst-case sensitivity of -24 dBm. Single mode fibre is to be used with a dispersion coefficient of 3.5 ps/km.nm and an attenuation 0.23 dB/km. The average distance between fusion splices is 800 m. The worst case connector loss is 0.36 dB, while the worst case fusion splice loss is 0.056

dB. Two connectors are used per system. Determine the dispersion penalty for each transmitter type. Design a system which will offer the highest power margin.

Concept Map



Syllabus

Overview: Motivation optical communication and network **-** application in Telecom Networks, CATV Networks, Under Sea Network **Transmission Characteristics:** light propagation in fiber, loss and bandwidth, dispersion, non linear effect **Optical Transmitter:** Light Emitting Diode – Laser, **Optical Receiver:** photo detector, Avalanche photodiode **Optical Amplifier:** EDFA,SOA **Enabling Technologies:** Modulation – Demodulation **Introduction to First generation Optical Network:** SONET/SDH –FDDI – protection **Second generation optical network:** layered architecture – protection **Broadcast and Select Network: - WDM networks**: Wavelength assignment and routing-WDM network design, **Access Network:** HFC- FTTC - **Photonic Packet switching network:** Interleaving - Synchronization, Header Processing - buffering **Fiber Optic Link Design:** Point to point – mesh network

Reference Books

1. Gerd Kaiser, "Optical fiber communications", 4th ed. McGraw Hill Int., 2008.
2. Rajiv Ramaswami Kumar N. Sivarajan, "Optical Networks", Harcourt Asia Limited, 2nd ed. 2004.
3. A.K.Ghatak and K.Thiagarajan, "Introduction to Fiber Optics", Cambridge university press, 1998.
4. Biswanath Mukherjee, " Optical WDM Network", Springer, 2006
5. J.Gower, "Optical communication systems", Prentice Hall of India, 2001.
6. John Senior, "Optical fiber communications-principles and practices", Prentice Hall of India, 1994.
7. Uyless Black, "Optical Networks" Pearson Education, 2002.
8. David Greenfield, "The Essential Guide to Optical Networks" Prentice Hall PTR 2001.

Course Contents and Lecture Schedule

S. No	Topics	No. of Lectures
1	Motivation for optical communication and network	1
1.1 1.2 1.3	Telecom Networks CATV Networks Under Sea Network	1
2	**Transmission Characteristics**	
2.1	Light Propagation in fiber	1
2.2	Loss and bandwidth	1
2.3	Dispersion	1
2.4	Non linear effect	1
3.1	**Optical Transmitter**	
3.1.1	Light Emitting Diode - structure, quantum efficiency and power	2
3.1.2	Laser – laser diode mode and threshold condition, rate equation, quantum efficiency and resonant frequency	2
3.2	**Optical Receivers**	
3.2.1	p-i-n photo detector	1
3.2.2	Avalanche photodiode	1
3.3	**Optical Amplifiers** EDFA – SOA	1
4.1	**Modulation**	
4.1.1	OOK modulation	1
4.1.2	Subcarrier modulation	1
4.2	**Demodulation**	
4.2.1	Direct Detection	1
4.2.2	Coherent Detection	2
5	**First Generation Optical Networks**	
5.1	SONET/SDH – multiplexing, physical layer, infra structure	2
5.2	FDDI	1
5.3	Protection in SONET/SDH	1
6	**Second Generation Optical Networks**	
6.1	Layered architecture	1
6.2	Optical layer protection	2
6.3	**WDM Networks**	
4.1.1	WDM network components	2
4.1.2	Wavelength Assignment and routing	2
6.4	**Broadcast and Select Network**	
6.4.1	Network topology	1
6.4.2	MAC protocol	2
6.5	**Access network**	
6.5.1	HFC	1
4.2.2	FTTC	2

6.6	**Photonic packet switching network**	
6.6.1	Interleaving	2
6.6.2	Synchronization- Header Processing	2
6.6.3	Buffering	2
7	**Fiber Optic Link Design**	
7.1	Point to point link	2
7.2	Mesh network design	2
	Total Number of Hours	45

Course Designers:

1. Dr. S.Ponmalar spmece@tce.edu

14CN230	ANTENNA TECHNOLOGIES AND DESIGN	Category	L	T	P	Credit
		PC	3	-	-	3

Preamble

Various antenna systems have been emerged recently for defense and commercial wireless applications. In order to meet the industrial design requirements, researchers have given much attention recently to the design constraints such as Size, Bandwidth, Power consumption, Power radiated and gain of the antenna. Hence various design and performance enhancement techniques have been introduced. Accurate characterization of planar structures have become a necessity as it is no longer economical or even feasible, to tune the planar structures once they are fabricated. This is facilitated through Electromagnetic Simulators such as ADS Momentum, CST Microwave Studio etc.One of the main competencies that a present day antenna engineer has to posses is the capability to design and develop antennas for various wireless applications that have good bandwidth, gain and radiation characteristics.

This subject is essential to understand the design methodology considering the constraints such as miniaturization, wide bandwidth and polarization. This course also presents various types of antenna and antenna array suitable for wireless systems such as Mobile handsets, base station, and satellite communication, the issues in respect of their design and development.

Prerequisite

NIL

Course Outcomes

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

CO1. Explain the behaviour of antenna in terms of its parameters	Remember
CO2. Understand the design issues in wireless device including handset, wearable devices and UWB communication Select an antenna for above mentioned wireless applications	Understand
CO3. Design and analyze antennas to meet the given specification using miniaturisation and bandwidth enhancement techniques	Create
CO4. Develop prototype of designed antenna	Create
CO5. Measure the parameters and radiation pattern of an antenna	Analyze

Mapping with Programme Outcomes

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

S- Strong; M-Medium; L-Low

Assessment Pattern

	Bloom's category	Continuous Assessment Tests			End Semester Examinations
		1	2	3	
1	Remember	40	20	20	20
2	Understand	40	20	20	20
3	Apply	20	20	20	20
4	Analyze	0	0	0	0
5	Evaluate	0	20	20	20
6	Create	0	20	30	30

Course Level Assessment Questions

Course Outcome 1 (CO1)

1. Define radiation resistance of an antenna.
2. What is meant by polarization of antenna?
3. Draw radiation pattern of a half wave dipole.
4. What is meant by pattern multiplication?
5. List some of the antennas used in handset.
6. Explain the radiation mechanism of PIFA antenna and their parameters.

Course Outcome 2 (CO2)

1. Why microstrip antennas are preferred for space applications?
2. Why monopole antennas are preferred for wireless communication?
3. What are surface waves in printed antennas?
4. What is the significance of substrate parameters?
5. How dual polarization can be achieved in microstrip antennas?
6. What are the effects of loading in an antenna?

Course Outcome 3(CO3)

1. Propose simulation steps to facilitate the design of patch antenna on a multilayer substrate having effective dielectric constant of 5.5.
2. Derive the field components of a square microstrip patch antenna.
3. Evaluate the performance of PC card antenna and INF antenna in a laptop prototype.
4. Explain how dual polarization is achieved with microstrip antenna.
5. Prepare a model chart for developing antenna for wearable devices considering different RF constraints.
6. Explain in detail how conventional planar antenna can be modified to provide wide bandwidth

Course Outcome 4(CO4)

1. A two element end-fire array in free space consists of 2 vertical side by side $\lambda/2$ elements with equal out of phase currents. At what angles in the horizontal plane is the field intensity is maximum: (a) when the spacing is $\lambda/2$?
2. What spacing of two in phase side by side $\lambda/2$ antenna produces maximum gain? What is the gain in dBi?
3. Given a set of wire antennas having same resonant frequency 2.5GHz, find the suitable candidate for TV reception?
4. Two X band rectangular horns, with aperture dimensions of 5.5cm and 7.5cm and each with a gain of 16.3dB at 10GHz are used as transmitting and receiving antennas. If the input power is 200Mw, and the antennas are polarization matched,

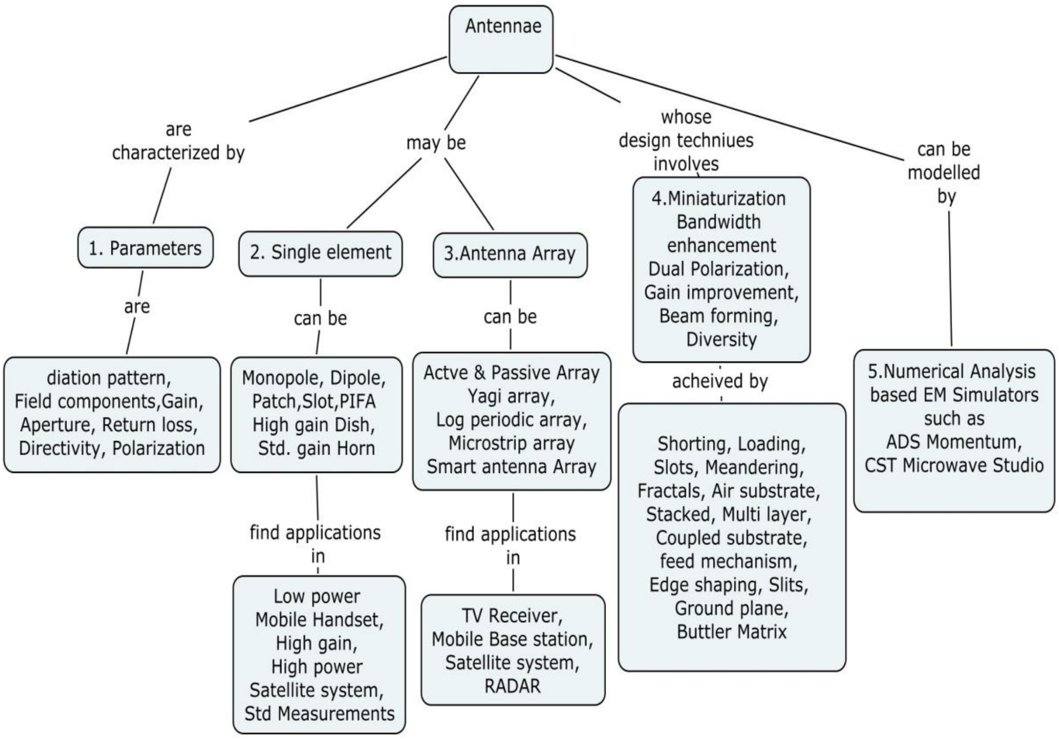
evaluate the amount of power received at a distance of 50m. Calculate the amount of power reduction if the propagation is disturbed to give VSWR of 1.1.

5. Compare the performance of two element in phase fed linear array of microstrip patches with the spacing d=λ/2 and d=λ/4 and thereby obtain the array condition for getting maximum radiation.
6. Given the specification, Frequency= 6GHz, Gain =20Db, Find the number of elements and spacing in the smart antenna array. Evaluate the resultant radiation for the phase shifts: (a) $\beta=0^\circ$ (b) $\beta=-90^\circ$ (c) $\beta=+90^\circ$ the and propose the phase condition for making the array as broadside array.

Course Outcome 5 (CO5)

1. Design a planar inverted F antenna operating in Cellular GSM lower band.
2. Suggest a suitable planar antenna system for the given specification:
   Center Frequency-5GHz, Dielectric constant–3.38, Thickness-1.52mm
   VSWR - 2:1, Bandwidth > 500MHz
3. Create a design methodology to generate dual band Minkowski Fractal antenna covering 2.4GHz and 5.8GHz.
4. Design a mini wireless antenna for Laptop computer applications.
5. Design a 4 element smart antenna operating at 2.4GHz application.
6. Design a dual polarized low cost antenna for cellular base station application to meet the specification: Center Frequency-5GHz, Thickness-1.6mm, VSWR-2:1,

Concept Map



Syllabus

Review of Antenna radiation mechanism & Parameters: Antenna parameters - Radiation mechanism, Radiation pattern, power density, radiation intensity, directivity, Gain, bandwidth, polarization, radiation efficiency, effective aperture, Return loss, Wireless applications. **Single antenna element:** - Monopole, Dipole, Patch, Slot, Field components derivation, Radiation characteristics. Microstrip Patch antennas, Printed dipole, slot, PIFA, Radiation Mechanisms, Feed mechanism, radiation field, Surface wave, Substrate selection and parameter, Microwave Antennas: Parabolic reflector, Horn antenna, High gain high power Dish antenna, Standard gain antenna, Feed mechanism, Multiple beam formation, Practical Design- High gain antenna for satellite applications, Simulations, Radiation pattern and antenna parameters, Ground plane effects. **Antenna Array:** Active Array**-**Two-element array concept - broadside, end-fire, Passive array-Yagi Uda antenna array, Frequency Independent antenna, Microstrip array, phased array. Smart antenna array- Benefits of Smart antennas, Types of Smart antenna, Fixed & switched beam antenna system, Analog & Digital Beamforming, Adaptive array system, Multiple antenna design, Combining techniques, Diversity. Smart antenna for Mobile stations, Smart antenna for space applications. **Antenna Performance Enhancement:** Miniaturization- Shorting and loading of antenna, Use of Slots, Meandering, Fractal techniques, Bandwidth Improvement- Multilayer substrate antenna, stacked resonator, Dual & Circular Polarization: Dual feed, Diagonal feed, Edge shaping of MSA, Circularly Polarized MSAs, MSA with Modified Corners. Multi beam formation-Use of Buttler matrix, Ground plane effects, **Numerical Simulation/Design customization using EM Simulators using EM Simulators:** Method of Moments (MoM), Finite Difference Time Domain method (FDTD) Simulation of Compact Microstrip antenna using ADS Momentum software and CST Microwave studio. EM simulation with ADS Momentum and CST Microwave studio, Antenna Prototype development of antenna for wireless application.

Reference Books

1. John D.Kraus, Ronald J.Marhefka “Antennas for all Applications” Fourth Edition, Tata McGraw- Hill, 2006.
2. Ahmed El-Zooghby, “Smart Antenna Engineering” Artech House, 2008
3. Grishkumar and K.P.Ray, “Broadband microstrip antennas” Artech House, 2003
4. Kin Lu Wong, “Planar Antennas for Wireless communication”, Wiley Interscience, 2003.
5. Zhi Ning Chen, Michael Yan Wah Chia, “ Antennas for Portable Devices” John Wiley & Sons Ltd, 2006.
6. J.C.Liberti, JR and Theodore Rappaport, “Smart Antennas for Wireless communication” Prentice Hall of India, 1999.

Course Contents and Lecture Schedule

No.	Topic	No. of Lectures
1	**Review of Antenna radiation mechanism & Parameters**	
1.1	Antenna fundamentals, Radiation mechanism	1
1.2	Antenna parameters- Radiation pattern, power density, radiation intensity,	2
1.3	directivity, Gain, polarization, radiation efficiency, effective aperture, Applications.	2
2	**Single antenna element:**	
2.1	Types of antennas, Monopole, Dipole, Radiation characteristics, radiation field, Feed mechanism	2
2.2	Microstrip Patch, Slot, Printed slot, Field components derivation, Surface wave, Substrate selection and parameter, Feed mechanism	1
2.3	Planar Inverted F Antenna (PIFA)	1
2.4	Microwave Antennas: Parabolic reflector, Horn antenna, High gain high power Dish antenna, Standard gain antenna, Multiple beam formation,	3
2.5	Practical Design- High gain antenna for satellite applications,	1

	Simulations, Radiation pattern and antenna parameters,	
2.6	phased array concept.	2
3	**Antenna Array**	
3.1	Active Array-Two-element array concept - broadside, end-fire,	2
3.2	Passive array-Yagi Uda antenna array,	1
3.3	Frequency Independent antenna,	1
3.4	Microstrip array, phased array	1
3.5	Smart antenna array- Benefits of Smart antennas, Types of Smart antenna, Fixed & switched beam antenna system,	2
3.6	Analog & Digital Beamforming, Adaptive array system,	2
3.7	Multiple antenna design, Combining techniques, Diversity.	2
3.8	Smart antenna for Mobile stations, Smart antenna for space applications.	2
4	**Antenna Performance Enhancement**	
4.1	Miniaturization- Shorting and loading of antenna	1
4.2	Use of Slots, Meandering	1
4.3	Fractal techniques	1
4.4	Bandwidth Improvement- Multilayer substrate antenna, stacked resonator	1
4.5	Dual & Circular Polarization: Dual feed, Diagonal feed	1
4.6	Edge shaping of MSA, Circularly Polarized MSAs, MSA with Modified Corners	1
4.7	Multi beam formation-Use of Buttler matrix	1
4.8	Ground plane effects	1
5	**Design customization using EM Simulators**	
5.1	Method of Moments (MoM)	1
5.2	Finite Difference Time Domain method (FDTD)	1
5.3	Understanding of ADS Momentum software	2
5.4	Understanding of CST Microwave studio.	2
5.5	Simulation of Microstrip antenna using ADS Momentum software and CST Microwave studio.	3
	Total Number of Hours	45

Course Designers:

1. Dr. B. Manimegalai naveenmegaa@tce.edu
2. Dr. V.Abhaikumar principal@tce.edu

14CN270	RF SYSTEMS LABORATORY	Category	L	T	P	Credit
		PC	0	0	1	1

Preamble

The unprecedented success of wireless communications created an unexpected demand for RF/Microwave communications engineers. This program aims to provide students with the technological skills needed in the design and engineering of modern Microwave systems and subsystems. This course focuses on the design and simulation of passive and active devices for microwave applications.

Prerequisite

14CN140 Microwave Circuits and Systems

Course Outcomes

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

CO1. Generate specifications for RF subsystems	Understand
CO2. Design and simulate passive RF subsystems	Apply
CO3. Design active RF subsystems	Apply
CO4. Simulate active RF subsystems	Apply
CO5. Fabricate and test prototype of RF subsystems.	Create

Mapping with Programme Outcomes

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

S- Strong; M-Medium; L-Low

List of Experiments

1. Simulation of Planar Transmission Lines and matching network
2. Simulation of Microwave Filters
3. Couplers and Power dividers
4. SPST and SPDT switches
5. Patch antenna
6. Low noise amplifier
7. Simulation of RF Transceiver
8. Test and measurement of RF transceiver at 2.4 GHz.

Course Designers:

1. Dr.S.Kanthamani skmece@tce.edu
2. Mr.K.Vasudevan kvasudevan@tce.edu

14CN310	MODELING AND SIMULATION OF COMMUNICATION SYSTEMS	Category	L	T	P	Credit
		PC	3	1	0	4

Preamble

The complexity of communication and signal processing systems has grown considerably to meet the requirements of the user's demands. The performance of the communication system can be evaluated using formula based calculations, waveform level simulation or through hardware prototyping and measurements. Except for some idealized and oversimplified cases, it is extremely difficult to evaluate the performance of the communication systems. Hardware prototypes are in general costly, time-consuming and non-flexible. In the simulation based approaches, systems can be modeled with almost any level of detail desired. Further, the mathematical, measured characteristics of devices and actual signals can be combined into analysis and design of communication systems. This aim of this course is to present the major aspects of modelling and simulation of communication systems.

Prerequisite

Nil

Course Outcomes

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

CO1. Present the basic concepts and properties of random variables, random processes and models and compute the response of the system that are used for simulating communication systems.	Understand
CO2. Model fading and multipath channels that are used in the performance analysis of GSM, UWB, Wi-Fi, Wi-Max and LTE communication systems and generate sampled values of random process that are used to model signals, noise, interference and time varying channels in communication systems.	Apply
CO3. Estimate the parameters such as average level, probability density function, power spectral density, delay and phase of the waveform.	Apply
CO4. Estimate the bit error rate using montocarle simulation and simplify and validate the simulation procedures using bounds and approximations.	Apply
CO5. Evaluate the performance of the communication system in terms of performance parameters such as outage probability, bit error rate for a given scenario using modeling and simulation.	Apply

Mapping with Programme Outcomes

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

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	20	10	10	10
Understand	20	10	10	10
Apply	60	60	60	60
Analyse	0	0	0	0
Evaluate	0	0	0	0
Create	0	20	20	20

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Draw the block diagram of communication system with hierarchical modeling
2. List the sources of error in simulation
3. List the properties of multivariate Gaussian distribution
4. State central limit theorem
5. Give the definition of Monte Carlo simulation
6. Define cyclo-stationary process

Course Outcome 2 (CO2):

1. Explain the method of generating correlated Gaussian sequences
2. Distinguish between small scale fading and large scale fading
3. The data $\{x(0), x(1), \cdots x(N-1)$ are observed, where x(n)'s are independent and identically distributed as zero mean Gaussian random variables with variance σ^2. The variance is estimated as $\hat{\sigma}^2 = \frac{1}{N}\sum_{n=0}^{N-1} x^2(n)$. Is this estimator unbiased?
4. Compare Chebyshev inequality and Chernoff bound in computing the tail probability.
5. What is impulsive noise?
6. Distinguish between frequency flat and frequency selective fading channels

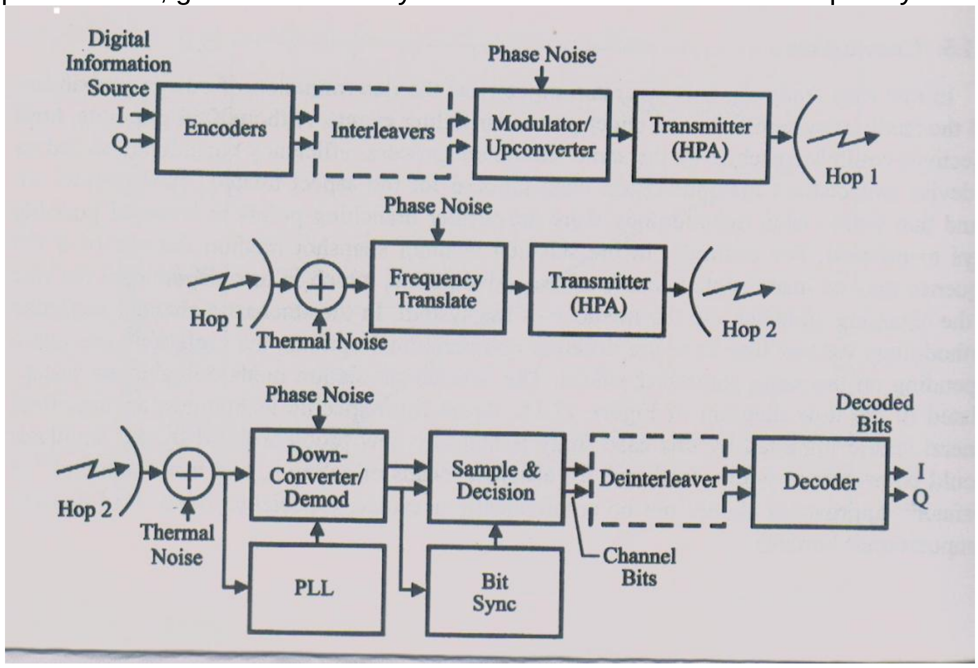
Course Outcome 3 (CO3):

1. Write a program to generate samples from a Gaussian distribution using the Box-Muller method
2. Determine the probability density function of the following transformations
   a. $y = -\log(x)$, where x is uniform in [0,1]
   b. $y = x^2$, where x is Gaussian (0,1)
3. Write a program to generate binary PN sequences for register lengths ranging from 6 to 16
4. The data $x(n) = r^n + w(n)$ for $n = 0,1,....N-1$ are observed, where w(n) is WGN with variance σ^2 and r is to be estimated. Find the CRLB for r. Does an estimator exists and if so find its variance?
5. The data $x(n) = A + w(n)$ for $n = 0,1,....N-1$ are observed, where w(n) is WGN with variance σ^2. Both A and σ^2 are unknown. Are the estimators $\hat{A} = \frac{1}{N-1}\sum_{n=0}^{N-1} x(n)$ and $\sigma^2 = \frac{1}{N}\sum_{n=0}^{N-1}\left(x(n) - A\right)^2$ unbiased?

6. Generate the eye diagram for a binary sequence when the received pulse corresponding to +1 is given by $g(t) = \begin{cases} 0 & t < 0 \\ 1 - e^{-t/T} & 0 \le t \le T \\ \left(1 - e^{-t/T}\right) e^{(t-T)/T} & t \ge T \end{cases}$ taking into account ISI generated over five pulse intervals.

Course Outcome 4 (CO4):

1. Given a digital satellite communication system shown in figure, what should be the interleaver depth to approach the coded performance of an independent error channel? In this system, the main factor which produces correlation among errors is phase noise, generated both by thermal noise and oscillator frequency instability.



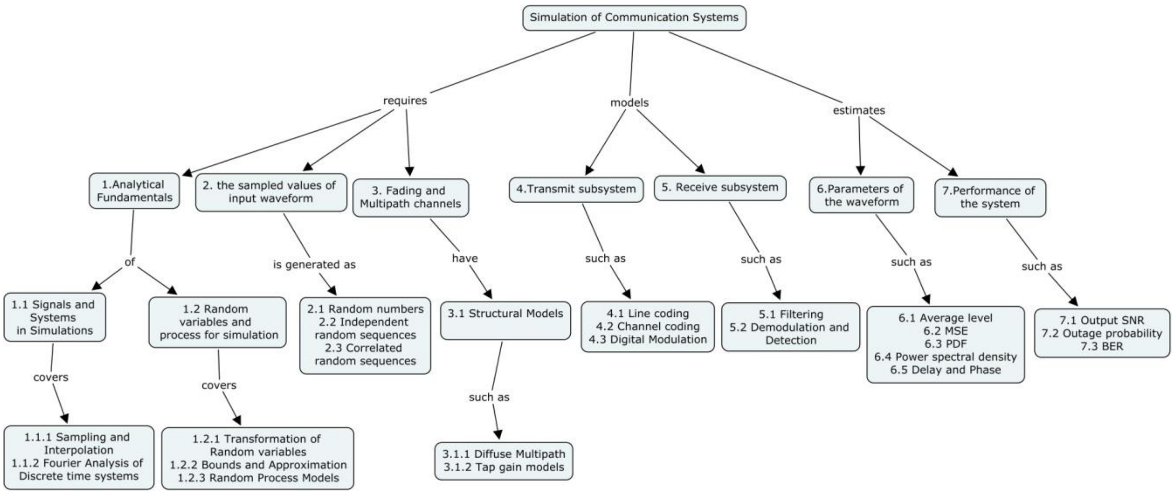
2. Simulate the IS-95 CDMA downlink system and analyze the BER performance.
3. Simulate the Physical downlink control format indicator channel in LTE downlink system assuming that the bandwidth is 10MHz. Analyze the error performance of it in the SISO and MISO transmit diversity schemes.
4. Simulate the Physical downlink hybrid ARQ channel (PHICH) in LTE downlink system assuming that the bandwidth is 10MHz and number of users is 8. Analyze the error performance of it in the SISO and MISO transmit diversity schemes.
5. Simulate the Physical uplink shared channel in LTE uplink system assuming that the bandwidth is 10MHz. Analyze the error performance of it.
6. Simulate a 90Mb/s 64-QAM digital radio system in a multipath fading environment in the 4GHz frequency band. State the assumptions clearly. Evaluate the BER and outage probability performance of the system

Course Outcome 5 (CO5):

1. Determine the probability of error of a binary PSK system in the presence of additive white Gaussian noise with zero mean and variance $\frac{N_0}{2}$. Develop a Monte Carlo simulation procedure to compute probability of error of PSK system.

2. Determine the probability of error of a binary FSK system in the presence of additive white Gaussian noise with zero mean and variance $\frac{N_0}{2}$. Develop a Monte Carlo simulation procedure to compute probability of error of FSK system.
3. Develop a simulation model to evaluate the performance of a 40Mb/s 16 QAM line of sight digital radio system in a multipath fading environment in the 2.4 GHZ band. The system outage probability is to be below 10^{-3}. State the assumptions clearly.

Concept Map



Syllabus

Introduction: Basic Concepts of Modeling of Communication Systems, **Analytic Fundamentals:** Signals and Systems; Sampling and interpolation, Fourier Analysis of Discrete Time Systems, Random Variables and Random Process for Simulation; Transformation of Random Variables, Bounds & Approximations, Random Process Models and Transformation of Random Process Models, **Sampled Value of the input waveform:** Random Number Generation: Uniform random numbers, random numbers from an arbitrary Probability Density Function, Gaussian Random Variables, Independent Random sequences, Correlated Random Sequences, **Modeling of Fading and Multipath Channels**: Structural Models for Multipath Fading Channel; Diffuse Multipath Channel Model, Statistical Tap-Gain Models, **Modeling of Transmitter Subsystems:** Line Coding, Channel Coding, Digital Quadrature Modulation, **Modeling of Receiver Subsystems:** Demodulation and Detection, Filtering and Synchronization, **Estimation of Parameters of Waveform:** Estimating the mean, mean square, PDF, power spectral density, Delay and Phase of a waveform, **Estimation of Performance of System:** Signal to Noise Ratio (SNR), Outage probability, Bit Error Rate (BER).

Reference Books

1. M.C.Jeruchim, P.Balaban and K.Sam Shanmugan, “Simulation of Communication Systems: Modeling, Methodology and Techniques”, Second Edition, Kluwer Academic Publishers, 2000.
2. Dennis Silage, “Digital Communication Systems using MATLAB and SIMULINK”, Book Stand Publications, 2009
3. John G Proakis, Salehi, Massoud, “Digital Communications”, Academic Internet Publishers, Fifth Edition, 2009.

Course Contents and Lecture Schedule

Module No.	Topic	No. of lectures
On	**Introduction:** Basic Concepts of Modeling of Communication Systems	2
1	**Analytic Fundamentals:**	
1.1	**Signals and Systems in Simulation**	
1.1.1	Sampling and interpolation	2
1.1.2	Fourier Analysis of Discrete Time Systems	2
1.2	**Random Variables and Random Process for Simulation**	
1.2.1	Transformation of Random Variables	2
1.2.2	Bounds and Approximations	2
1.2.3	Random Process Models	2
1.2.4	Transformation of Random Process Models	2
2	**Sampled Value of the input waveform**	
2.1	Random Number Generation: Uniform random numbers, random numbers from an arbitrary Probability Density Function, Gaussian Random Variables,	2
2.2	Independent Random sequences,	2
2.3	Correlated Random Sequences	2
3	**Modeling of Fading and Multipath Channels**:	
3.1	Structural Models for Multipath Fading Channel	1
3.1.1	Diffuse Multipath Channel Model	1
3.1.2	Statistical Tap-Gain Models	2
4	**Modeling of Transmitter Subsystems:**	
4.1	Line Coding	2
4.2	Channel Coding	2
4.3	Digital Quadrature Modulation	2
5	**Modeling of Receiver Subsystems:**	
5.1	Demodulation and Detection	2
5.2	Filtering	2
5.3	Synchronization	2
6	**Estimation of Parameters of Waveform:**	
6.1	Mean, mean square	1
6.2	Probability Density Function	1
6.3	power spectral density	2
6.4	Delay and Phase of a waveform	1
7	**Estimation of Performance of System:**	
7.1	Signal to Noise Ratio (SNR)	1
7.2	Outage probability	1
7.3	Bit Error Rate (BER)	2

Course Designers:

1. Dr.S.J. Thiruvengadam sjtece@tce.edu

14CNPA0	RADIO FREQUENCY INTEGRATED CIRCUITS	Category	L	T	P	Credit
		PE	3	1	-	4

Preamble

The rapid expansion of untethered (wireless) communications services - paging, RF identification (RFID), analog and digital cellular telephony, Personal Communications Services (PCS), etc. has led to an explosion in the development of Integrated circuit (IC) implementation of RF circuits for wireless communication applications. Students concentrating in wireless communications, microelectronics can benefit from such a course. The growing regional communications and electronics industry would also benefit from a RF integrated circuit curriculum. The course will focus on the Transceiver architectures for current wireless communications standards, active/passive device technologies for RFIC implementations, low noise amplifiers, mixers, frequency sources, power amplifiers and RFIC packaging. Case studies of modern RFIC chip sets for current wireless communications standards are examined. The course involves circuit design at the IC level, modern RF/microwave CAD software will be used in conjunction with the course.

Prerequisite

NIL

Course Outcomes

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

CO1. Understand the transceiver architectures relevant to current wireless communications standards and their relative advantages and disadvantages	Remember
CO2. Discuss passive and active device technologies relevant to RFICs	Understand
CO3. Calculate noise, linearity and dynamic range performance metrics for RF devices and circuits	Apply
CO4. Design IC implementations of RF blocks (such as LNA, mixers and oscillators) based on foundry models and design rules to meet for a wireless communication systems	Create
CO5. Utilization of RF/microwave CAD software	Understand

Mapping with Programme Outcomes

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

S- Strong; M-Medium; L-Low

Assessment Pattern

	Bloom's category	Continuous Assessment Tests			End Semester Examinations
		1	2	3	
1	Remember	20	20	10	10
2	Understand	20	20	10	10
3	Apply	40	40	60	60
4	Analyze	0	0	0	0
5	Evaluate	0	0	0	0
6	Create	20	20	20	20

Course Level Assessment Questions

Course Outcome 1 (CO1)

1. Differentiate low frequency analog design and radio frequency integrated circuit design.
2. Convert 2.5nW power into dBm.
3. Define noise figure
4. Correlate third order intersects point and 1dB compression point.
5. What is metal migration?
6. Define skin depth.

Course Outcome 2 (CO2)

1. Calculate the inductance per unit length for traces with a h/w of 0.5, 1, and 2.
2. Why packaging is essential?
3. Differentiate various packaging techniques.
4. Mention few guidelines for designing bipolar transistor?
5. Compare cadence software with other high frequency simulation tools.
6. What is meant by blocking?

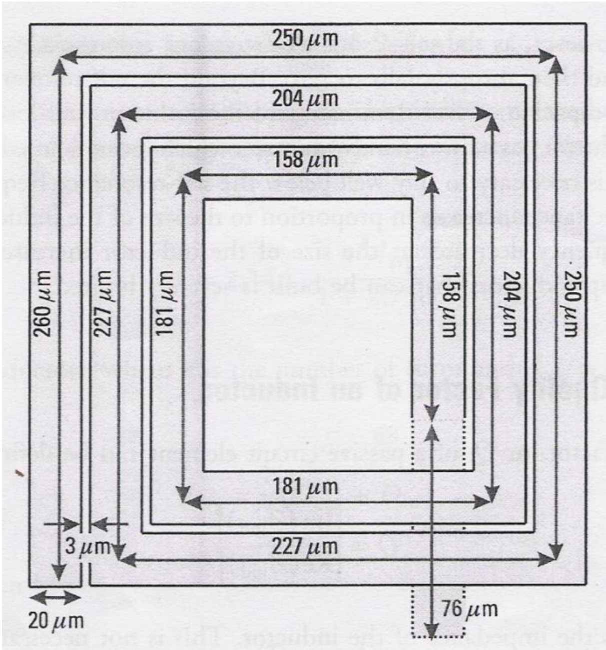
Course Outcome 3 (CO3)

7. A rectangular aluminum line has a width of 20 μm, a thickness of 3 μm, and a length of 100 μm. Compute the resistance of the line at dc and at 5 GHz assuming that all the current flows in an area one skin depth from the surface. Assume that aluminum has a resistively of 3 $\mu\Omega$ cm.
8. Calculate bottom plate capacitance and fringing capacitance for a 1 poly, 2 metal processes with distance to substrate and conductor thickness as given in the first two rows of Table. Calculate for metal widths of 1 μm and 50 μm.

	Poly	Metal 1	Metal 2
Height above substrate h (μm)	0.4	1.0	2.5
Conductor thickness t (μm)	0.4	0.4	0.5

9. Given a square inductor with the dimensions shown in figure. Determine a model for the structure including all model values. The inductor is made out of 3-μm-thick aluminum metal. The inductor is suspended over 5 μm of oxide above a substrate.

The underpass is 1-μm aluminum and is 3 μm above the substrate. Assume the vias are lossless.



Inductor with dimensions

Course Outcome 4 (CO4)

1. From the data in table for a typical 50-GHz bipolar process, calculate z_o, f_T and $f_{\max}$ for the 15x transistor. Use this to verify some of the approximations made in the above derivation for $f_{\max}$.

Example Transistors

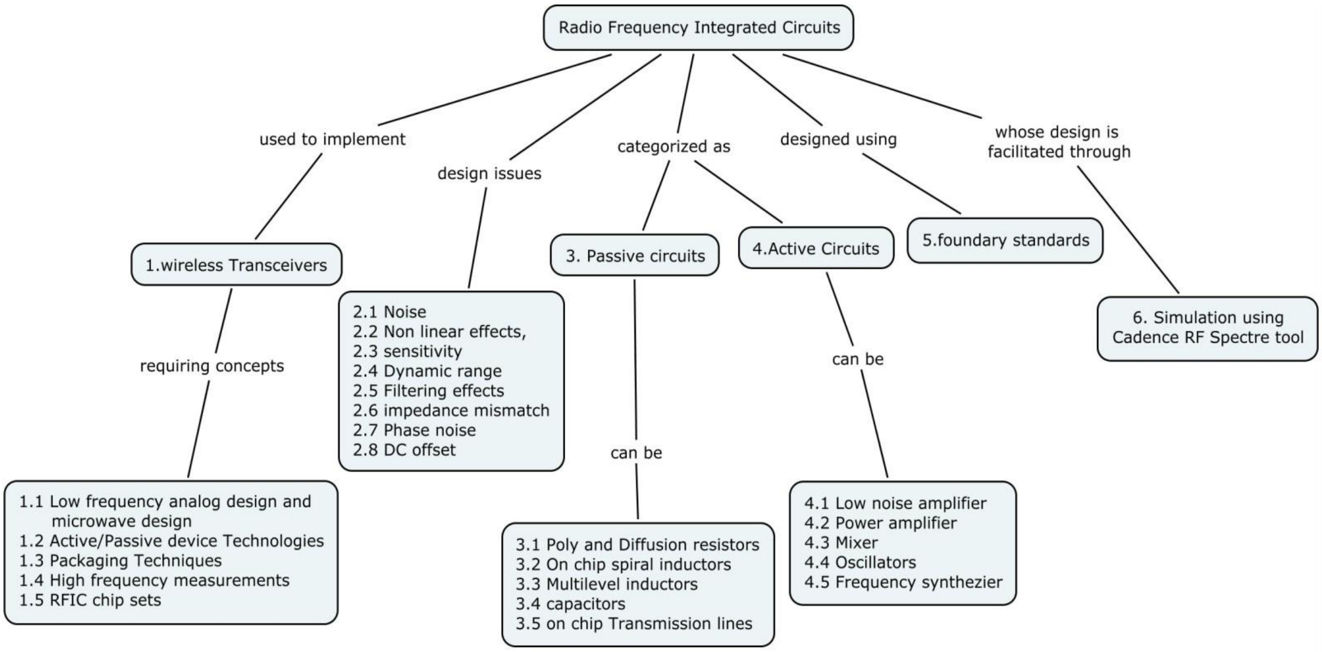
Parameter	Transistor Size		
	1x	4x	15x
I_{optf_T} (mA)	0.55	2.4	7.9
C_π (fF)	50	200	700
C_μ (fF)	2.72	6.96	23.2
r_b (Ω)	65	20.8	5.0

2. Derive the noise figure of the components connected in cascaded sections.
3. Consider a non-linear circuit with 7 and 8 MHz tones applied at the input. Determine all output frequency components, assuming distortion components up to the third order.

Course Outcome 5 (CO5)

1. Design a low-noise amplifier using spectre RF with Typical LNA Characteristics in Heterodyne Systems as NF=2 dB, IIP3= -10 dBm, Gain =15 dB, Input and Output Impedance =50ohms, Input and Output Return Loss= -15 dB, Reverse Isolation= 20 dB. Define Transducer Power Gain (GT), Operating Power Gain (GP),and Power Supply Rejection Ratio (PSRR). Draw the test bench setup circuit for LNA, what is your guess about the PSRR of this LNA?
2. Design a transmit mixer using spectra RF with IF is 40MHz and your LO is 5.4GHz. Draw the setup to obtain the PAC and Pnoise analysis.

Concept Map



Syllabus

Radio frequency Integrated Circuits: Transceiver architectures-Role of RFICs in Transceiver, Lower frequency design and RFIC design-design issues of RFICs in transceivers-Active/Passive device technologies for RFIC implementations-Modern RFIC chip sets for current wireless standards, Packaging techniques, High frequency measurement **RFIC design issues:** Noise, Linearity and distortion in RF circuits, dynamic range, Filtering issues, selectivity, and sensitivity and phase noise **Design of Passive circuit elements in IC technologies:** Sheet resistance, Parasitic effects(L and C),metal migration, Poly resistors, diffusion resistors, On chip spiral inductors, design of inductors, Lumped model of inductors, Multilevel inductors, capacitors, on chip transmission lines, **Design of active circuit in IC technologies:** Low noise amplifier, Power amplifier, mixers ,frequency synthesizers and Oscillators, **Foundry Process, Computer aided design of RFICs:** Introduction to Commercial packages, Introduction and usage of CADENCE, Spectre RF tool , Simulation of active and passive circuits using Cadence Spectre RF.

Reference Books

1. John M. W. Rogers, John W. M. Rogers, Calvin Plett, “Radio Frequency Integrated Circuit Design”, Second Edition, Artech house 2010.
2. Thomas H. Lee, “The Design of CMOS Radio-Frequency Integrated Circuits”, Second Edition, Cambridge University Press, 2004.
3. Behzad Razavi, “ Fundamentals of Microelectronics”, Prentice Hall, 2008
4. Robert Caverly, “CMOS RFIC Design Principles” Artech House, 2007.
5. Habil. MBA Frank Ellinger, “Radio frequency integrated circuits and technologies”, Springer-Varlag Berlin Heidelberg, 2007.

Course Contents and Lecture Schedule

Sl.No:	Topic	No. of Lectures
	Radio frequency Integrated Circuits	
	Introduction	
1	Transceiver architectures-Role of RFICs in Transceiver	1
1.1	Lower frequency design and RFIC design-issues	2
1.2	Active/Passive device technologies for RFIC implementations	1
1.3	Modern RFIC chip sets for current wireless standards	1
1.4	Packaging techniques	1
1.5	High frequency measurement	1
2	**RFIC design issues**	
2.1	Noise	3
2.1	Linearity	2
2.2	Distortion in RF circuits	1
2.3	Dynamic range	1
2.4	Filtering issues, selectivity, and sensitivity	1
2.5	Phase noise	
3	**Design of Passive circuit elements in IC technologies**	
3.1	**Introduction**	1
3.2	Sheet resistance, Poly resistors, diffusion resistors	2
3.3	On chip spiral inductors	2
3.4	Multilevel inductors	3
3.5	On chip capacitors	1
3.6	on chip transmission lines	1
4	**Design of active circuit in IC technologies**	
4.1	Low noise amplifier	4
4.2	Power amplifier	3
4.3	Mixers	3
4.4	Oscillator	2
4.5	Frequency Synthesizers	2
5.	**Foundry standards**	2
6	**Computer aided design of RFICs**	
5.1	Introduction to Commercial packages	1
5.2	Introduction and usage of CADENCE	1
5.3	Spectre RF tool	1
5.4	LNA design and simulation using Spectre RF	2
5.5	Mixer design and simulation using Spectre RF	2
5.6	Oscillator design	2
5.7	Frequency Synthesizer design and simulation	2
	Total Number of Hours	**46**

Course Designers:

1. Dr. S.Kanthamani skmece@tce.edu
2. Dr. S.Raju rajuabhai@tce.edu

14CNPB0	RADAR SIGNAL PROCESSING	Category	L	T	P	Credit
		PE	3	1	0	4

Preamble

The objective of this course is to provide in-depth coverage of fundamental topics in radar signal processing from a digital signal processing perspective. The techniques of linear systems, filtering, sampling, and Fourier analysis techniques and interpretations are used in this course to provide a unified approach in improving probability of detection and Signal to interference ratio.

Prerequisite

NIL

Course Outcomes

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

CO1. Explain the generic RADAR signal processor flow of operations.	Understand
CO2. Describe the signal models such as Amplitude model, clutter model, noise model, jamming model, frequency model, spatial model and Sampling concept in designing and analyzing RADAR signal processor.	Understand
CO3. Design RADAR waveforms, Matched filter, Moving target indication and Pulse Doppler processing for RADAR receivers	Apply
CO4. Describe and apply the detection rules/tests such as Neyman-Pearson principle, Likelihood ratio test for RADAR signal processing.	Apply
CO5. Design a CFAR detector to improve the detection performance of RADAR.	Create

Mapping with Programme Outcomes

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

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	20	20	10	10
Understand	20	20	10	10
Apply	60	60	80	80
Analyse	0	0	0	0
Evaluate	0	0	0	0
Create	0	0	0	0

Course Level Assessment Questions

Course Outcome 1 (CO1):

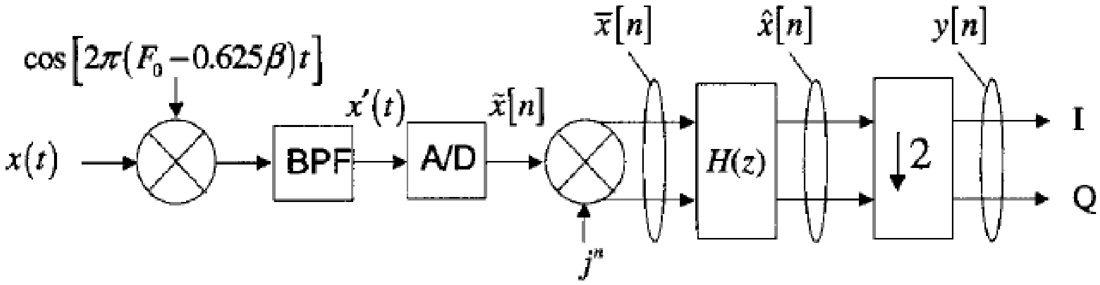
1. Mention the basic RADAR functions.
2. What is clutter?
3. Define ambiguity function.

Course Outcome 2 (CO2):

1. Define pulse to pulse decorrelation and scan to scan decorrelation.
2. State the conditions for an area scatterers is said to be 'beam limited' or 'pulse limited.
3. Define cross range resolution and range resolution

Course Outcome 3 (CO3):

1. Compute the maximum instantaneous SNR at the output of a linear filter whose impulse response is matched to the signal $x(t) = \exp\left(-t^2 / 2T\right)$.
2. Consider a linear FM waveform that sweeps from 9.5 to 10.5 GHz over a pulse duration of 20μsec.
   a. What is the time bandwidth product?
   b. Determine the Rayleigh resolution (in meters) of the matched filter output
   c. Determine the ambiguity function
3. Draw the spectrum corresponding to successive signals in digital I/Q system shown in figure



4. Consider an X-band (10 GHz) RADAR with a peak transmitted power of 1kW and a pencil beam antenna with a 1^0 beam width, and suppose an echo is received from a jumbo jet aircraft with an RCS of 100 m^2 at a range of 10 km. Determine the received power P_r.
5. Consider a simple pulse of duration τ secs $x(t) = \begin{cases} 1; & 0 \le t \le \tau \\ 0 & otherwise \end{cases}$ passed in to a matched filter with impulse response $h(t) = \begin{cases} \alpha; & T_{M-\tau} \le t \le T_M \\ 0; & otherwise \end{cases}$. Calculate the output of the matched filter $y(t)$. The average time between false alarms is specified as 30 minutes and the receiver bandwidth 0.4 MHz.
   - What is the probability of false alarm P_{fa}?
   - What is the threshold –to – noise power ratio?
6. Consider a supersonic aircraft traveling at Mach 2 (about 660 m/s) and the RADAR is operating in L-band. Find the Doppler frequency for the given target.
7. Find the NP test to distinguish between the hypotheses that a sample $x[0]$ is observed from the possible PDFs

$$H_0 : p(x[0]) = \frac{1}{2}\exp\left(-|x[0]|\right)$$

$$H_1 : p(x[0]) = \frac{1}{\sqrt{2\pi}}\exp\left(-\frac{1}{2}x^2[0]\right)$$

Show the decision regions.

8. Weather radar has a PRF of 2 kHz. Using a series of 50 samples of data from a particular range bin and look direction, we compute the following values of the autocorrelation function: $s_y[0]=50,\ s_y[1]=30\exp\left(j\pi/3\right)$. Use the pulse-pair processing (PPP) time domain method to compute the estimated mean frequency of the echo in Hz.

Course Outcome 4 (CO4):

1. Find the NP test to distinguish between the hypotheses that a sample $x[0]$ is observed from the possible PDFs

$$H_0 : p(x[0]) = \frac{1}{2}\exp\left(-|x[0]|\right)$$

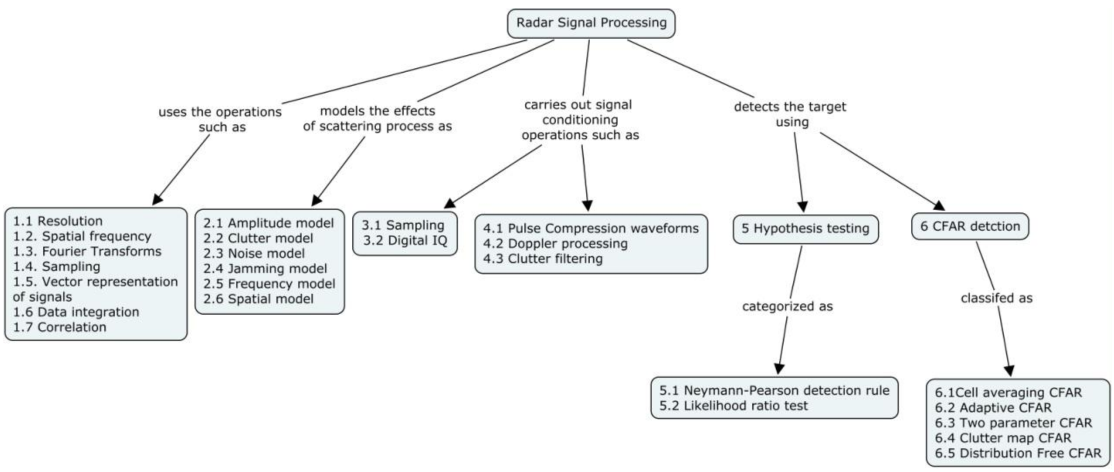
$$H_1 : p(x[0]) = \frac{1}{\sqrt{2\pi}}\exp\left(-\frac{1}{2}x^2[0]\right)$$

2. Determine the matched filter output for P3 codes of length 4 and 5.
3. Consider the detection problem $\begin{array}{ll} H_o : \mathbf{y}_i = \mathbf{w}_i & for\ i = 0,1...N-1 \\ H_1 : \mathbf{y}_i = m + \mathbf{w}_i & for\ i = 0,1...N-1 \end{array}$ where $\mathbf{w}_i$ are i.i.d Complex Gaussian random variables with zero mean and variance β^2, m is constant. Assume that the detection is based on coherent integration of N samples.
   a. Determine the coherent integration detection rule.
   b. Determine the expressions for P_{FA}

Course Outcome 5 (CO5):

1. Find the MAP decision rule for $\begin{array}{l} H_0 : x[0] \sim N(0,1) \\ H_1 : x[0] \sim N(0,2) \end{array}$ if $p(H_0)=1/2$ and also if $p(H_0)=3/4$. Display the decision regions in each case and explain.
2. Consider the data correspond to Gaussian I/Q noise with power 20 dB, a single non fluctuating target with a power of 35 dB present in range bin 50, if the desired Probability of false alarm is $P_{FA}=10^{-3}$, what is the ideal threshold? Now by using CA CFAR with leading and lagging windows of 10 cells each after 3 guard cells are used to estimate the interference power. Find the CA CFAR threshold?
3. Discuss the threshold settings in two parameters CFAR and distributed CFAR.

Concept Map



Syllabus

Introduction to RADAR systems: Elements of a pulsed RADAR, transmitter and waveform generator, antennas and receiver. **Phenomenology:** Resolution, spatial frequency, Fourier transform, sampling, vector representation of signals, data integration and correlation. **Signal models:** Amplitude model, clutter model, noise model, jamming model, frequency model, spatial model **Signal conditioning:** Sampling, Digital I/Q **Pulse Compression waveforms** phase modulated, frequency modulated, Clutter filtering, vector formulation of matched filter, Matched filters for clutter suppression, Doppler processing, pulse Doppler processing, pulse pair processing, **Hypothesis testing:** Radar detection: Neyman Pearson detection rule, likelihood ratio test, coherent detection: Gaussian case for coherent receivers, unknown parameters and threshold detection **CFAR detection:** Cell averaging CFAR, analysis of cell averaging CFAR concept, CA CFAR limitations, adaptive CFAR, two parameter CFAR, distribution free CFAR

Reference Books

1. Mark A.Richards, Fundamentals of Radar Signal Processing, Tata McGraw Hill Edition 2005.
2. Merrill I. Skolnik, Introduction to RADAR Systems, Tata McGraw Hill, Third Edition 2001.
3. Steven M.Kay, “ Fundamentals of Statistical Signal Processing”, Vol II Detection Theory, Prentice Hall Inc, 1998.

Course Contents and Lecture Schedule

Module No.	Topic	No. of Lectures
1	**Phenomenology**	
1.1	Resolution,	1
1.2	spatial frequency	1
1.3	Fourier transform	1
1.4	Sampling	1
1.5	vector representation of signals	1
1.6	Data integration and correlation	1
2	**Signal models**	
2.1	Amplitude model	2
2.2	Clutter model	2
2.3	Noise model	1
2.4	Jamming model	1
2.5	Frequency model,	1
2.6	Spatial model	1
3	**Signal conditioning**	
3.1	Sampling	2
3.2	Digital I/Q	2
4	**Pulse Compression**	
4.1	Phase Modulated	2
4.2	Frequency Modulated	2
4.3	Clutter filtering	2
4.3.1	Vector formulation of matched filter	1
4.3.2	Matched filters for clutter suppression	1
4.4	Doppler processing	1
4.4.1	Pulse Doppler processing	1
4.4.2	Pulse pair processing	1
5	**Hypothesis testing**	

Module No.	Topic	No. of Lectures
5.1	Radar Detection	1
5.1.1	Neyman-Pearson detection rule	2
5.1.2	Likelihood ratio test	2
5.2	Coherent Detection	1
5.2.1	Gaussian case for coherent receivers	1
5.2.2	Unknown parameters and threshold detection	1
6	**CFAR detection**	
6.1	Cell averaging CFAR	1
6.1.1	Analysis of cell averaging CFAR	2
6.1.2	CA CFAR limitations	1
6.2	Adaptive CFAR	1
6.3	Two parameter CFAR	1
6.4	Clutter map CFAR	1
6.5	Distribution free CFAR	1

Course Designers:

1. Dr.S.J. Thiruvengadam sjtece@tce.edu
2. Mr. P.G.S.Velmurugan pgsvels@tce.edu

14CNPC0	MULTIMEDIA COMMUNICATION SYSTEMS	Category	L	T	P	Credit
		PE	3	1	0	4

Preamble

Multimedia has become an indispensable part of modern computer technology. In this course, students will be introduced to all aspects of multimedia representations, communication, compression, retrieval and applications. This course will introduce issues in effectively representing, processing and retrieving multimedia data such as sound and music, graphics, image and video. The students will gain knowledge in those areas by studying about current media types of audio, image and video, and how they are used to create multimedia content, compress and distribute them via networked system to variety of end clients. They will also gain the knowledge about the established multimedia ISO standards such as – JPEG 2000, JPEG LS,MPEG2, MPEG4, MPEG7 and MPEG 21.

Prerequisite

Nil

Course Outcomes

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

CO1. Understand data representations for multimedia applications such as image data, audio and video data.	Apply
CO2. Understand video File formats and compression.	Apply
CO3. Examine the ideas behind MPEG standards such as MPEG 1, MPEG 2, MPEG 4 and MPEG 7.	Analyze
CO4. Examine how to support multimedia applications with appropriate operating system, file system, and architectural features.	Analyze

Mapping with Programme Outcomes

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

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	20	20	20	20
Understand	40	40	20	20
Apply	40	40	60	60
Analyse	0	0	0	0
Evaluate	0	0	0	0
Create	0	0	0	0

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Define SMIL.
2. Define sound.

3. State the relationship between STP and LTP.
4. Define signal to quantization noise ratio.
5. Compare JPEG and JPEG 2000.
6. List the MPEG audio layers.
7. Define motion compensation.
8. Define open protocols and systems.
9. Define the bit rates over ATM?

Course Outcome 2 (CO2):

1. Explain multimedia authoring tools with neat sketch.
2. What are the ways to effectively present Multimedia?
3. Discuss about the different color models for video.
4. Explain about the structure and hardware aspects of Musical Instrument Digital Interface (MIDI)
5. Explain the concept of dithering to print images
6. Discuss about MPEG 4 video coding with neat sketch?
7. Explain the following terms: a) ATM b) ISDN
8. Explain different multiplexing technologies with neat sketch.

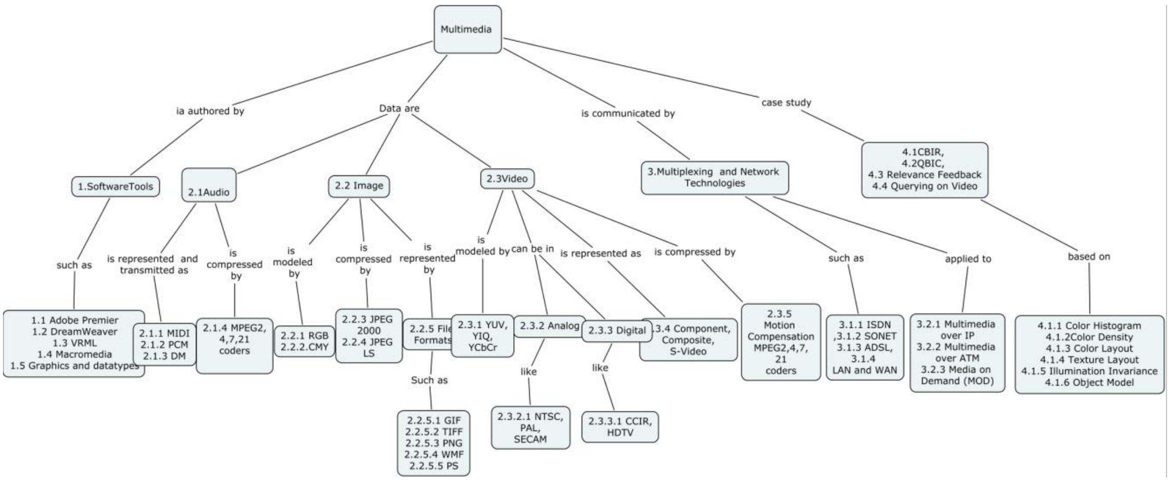
Course Outcome 3 (CO3):

1. Suppose we have a 5 bit grayscale image. What size of ordered dithered matrix do we need to display the image on a 1 bit printer?
2. Can a single MIDI message produce more than one note sounding?
3. Is it possible for more than one note to sound at once on a particular instrument? If so, how is it done in MIDI?

Course Outcome 4 (CO4):

1. How can we retrieve the images? Explain C-BIRD using a case study?
2. How Relevance feedback is used in CBIR system.
3. How does MPEG -4 perform VOP- based motion compensation?

Concept Map



Syllabus

Introduction to Multimedia- Multimedia and Hypermedia- World Wide Web- Multimedia Software Tools-Multimedia Authoring and Tools- Editing and Authoring Tools, Adobe Premier-DreamWeaver VRML, Macromedia Graphics and Image data Representations- - **Multimedia Data , Audio, Image and Video- Audio**- MIDI- Musical Instrument Digital Interface-Basic Audio Compression Techniques, PCM,DM- MPEG Audio Compression MPEG 2,4,7 and 21- **Image**- Image model-RGB, CMY -Image Compression Standards JPEG Standard, JPEG 2000 Standard- Image File formats- GIF, TIFF,PNG,WMF,PS, JPEG, EXIF, Graphics and Animation Files, PDF, BMP, PPM **Video** – Color models in video- YUV,YIQ,YCbCr,- Types – Component, Composite, S-Video- Analog video – NTSC, PAL, SECAM- Digital video – Chromo subsampling, CCIR, HDTV-Video Compression Techniques- Basic Video Compression Techniques- Video compression based on motion compensation- MPEG Video Coding I: MPEG 1 and MPEG 2- MPEG Video Coding II: MPEG 4, 7 and 21- **Multimedia Communication-** Computer and Multimedia Networks- Multiplexing Technologies ISDN, SONET, ADSL- LAN and WAN- Multimedia Network Communications and Applications- Quality of Multimedia Data Transmission- Multimedia over IP- Multimedia over ATM networks- Media on Demand (MOD)- **Multimedia Retrieval:** Content- Based Retrieval in Digital Libraries- C-BIRD- Color Histogram, Color Density, Color Layout- Texture Layout- Search by Illumination Invariance-Search by Object Model- QBIC, Blob world, Metaseek, Mars, viper- Relevance Feedback- Querying on Videos

Reference Books

1. Ze-Nian Li, and Mark S. Drew, “Fundamentals of Multimedia”, Pearson Prentice Hall, October 2003.
2. K. Rammohanarao, Z. S. Bolzkovic, D. A. Milanovic, “Multimedia Communication Systems”, 1st edition, Prentice Hall, May 2002.
3. Yao Wang, Joern Ostermann, and Ya-Qin Zhang, “Video Processing and Communications”, Prentice Hall, 2002.
4. Michael Rabinovich and Oliver Spatscheck, “Web Caching and Replication”, Addison-Wesley, 2002.
5. Fred Halsall, Multimedia Communications: Applications, Networks, Protocols and Standards, Addison-Wesley, 2001.

Course Contents and Lecture Schedule

Module No.	Topic	No. of Lectures
I	**Introduction to Multimedia** Multimedia and Hypermedia- World Wide Web	1
1	Multimedia Software Tools	
1.1	Multimedia Authoring and Tools	1
1.2	Editing and Authoring Tools, Adobe Premier, DreamWeaver,	1
1.3	VRML	1
1.4	Macromedia	1
1.5	Graphics and Image data types	1
2.1	**Multimedia Data ,** Audio, Image and Video**- Audio**	
2.1.1	MIDI- Musical Instrument Digital Interface	1
2.1.2	Basic Audio Compression Techniques- PCM,	1
2.1.3	DM	1
2.1.4	MPEG Audio Compression MPEG 2,4,7 and 21	1
2.2	**Image**- Image model	
2.2.1	RGB,	1
2.2.2	CMY	1

Module No.	Topic	No. of Lectures
2.2.3	Image Compression Standards JPEG 2000 Standard,	1
2.2.4	JPEG – LS Standard	1
2.2.5	Image File formats-	
2.2.5.1-2.2.5.10	GIF, TIFF,PNG,WMF,PS, JPEG, EXIF, Graphics and Animation Files, PDF, BMP, PPM	2
2.3	**Video** – Color models in video	1
2.3.1	YUV, YIQ, YCbCr	1
2.3.2	Analog video	1
2.3.2.1	– NTSC, PAL, SECAM	1
2.3.3	Digital video –	1
2.3.3.1	Chromo subsampling, CCIR, HDTV	1
2.3.4	Types – Component, Composite, S-Video	1
2.3.5	Basic Video Compression Techniques- Video compression based on motion compensation- MPEG Video Coding I:MPEG 1 and MPEG 2, MPEG 4, 7 and 21	2
3	**Multimedia Communication**	1
3.1	Multiplexing Technologies	1
3.1.1	ISDN,	1
3.1.2	SONET,	1
3.1.3	ADSL	1
3.1.4	LAN and WAN	1
3.2	Multimedia Network Communications and Applications	1
3.2.1	Multimedia over IP	1
3.2.2	Multimedia over ATM networks	1
3.2.3	Media on Demand (MOD)	1
4	**Multimedia Retrieval:** Retrieving Images-Content- Based Retrieval in Digital Libraries	1
4.1	C-BIRD	1
4.1.1	Color Histogram, Color Density, Color Layout	1
4.1.2	Texture Layout	1
4.1.3	Search by Illumination Invariance	1
4.1.4	Search by Object Model	1
4.2	QBIC, Blob world, Metaseek, Mars, viper	1
4.3	Relevance Feedback	1
4.4	Querying on Videos	1

Course Designers:

1. Dr.S.Md.Mansoor Roomi smmroomi@tce.edu
2. Dr.B.Yogameena ymece@tce.edu

14CNPD0	ANALOG CMOS CIRCUIT DESIGN	Category	L	T	P	Credit
		PE	3	1	-	4

Preamble

The course aims at understanding the engineering and design principles of Analog CMOS technology for application in analog integrated circuits and subsystems.

Prerequisite

NIL

Course Outcomes

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

CO1. Analysis of large and small signal model of MOSFETs	Analysis
CO2. Design of Analog CMOS Subcircuits including MOS Switch, Current sinks and Sources, Current Mirrors.	Create
CO3. Design of CMOS Single Stage Amplifiers including Differential Amplifiers, Cascode Amplifiers and Inverters	Create
CO4. Design of CMOS Operational Amplifiers considering Power Supply rejection ratio and noise.	Analysis
CO5. Design of CMOS Analog circuits including open loop comparator and Digital- Analog Converters.	Synthesis

Mapping with Programme Outcomes

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

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's category	Continuous Assessment Tests			Terminal Examinations
	1	2	3	
Remember	20	10	0	0
Understand	30	30	20	20
Apply	30	40	50	50
Analyze	0	0	0	0
Evaluate	0	0	0	0
Create	20	20	30	30

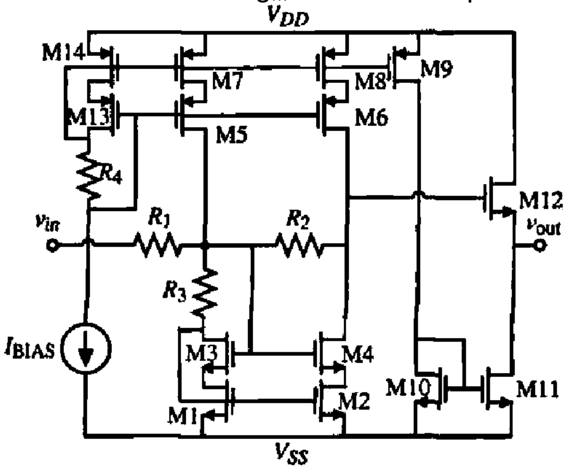
Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Find the values of g_m,g_{mbs} and g_{ds} for the both n-channel and p-channel device if the dc value of the magnitude of the drain current is 50µA and the magnitude of the dc value of the source-bulk voltage is 2V.Assume that the W/L ration is 1µm/1µm.
2. Develop an expression for the small-signal transconductance of an MOS device operating in weak inversion using the large-signal expression.
3. Calculate the V_{on} for an NMOS transistor in weak inversion assuming that f_s and f_n can be approximated unity.
4. Find the small signal voltage gain and the -3dB frequency in hertz for the active load inverter, the current source inverter and the push pull inverter if W1=2µm, L1= µm, W2=1 µm, L2=1 µm and the dc current is 50 µA. Assume that C_{gd1}=4pF, C_{bd1}=10pF, C_{gd2}= 4pF, C_{bd2}=10fF, C_{gs2}=5pF and C_L=1pF.
5. Find the complete small signal model for an n-channel transistor with the drain current at 4V, gate at 4V, Source at 2V, and bulk at0V.

Course Outcome 2 (CO2):

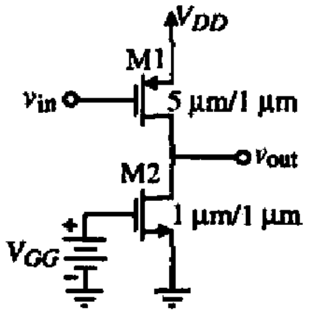
9. If the mobility of an electron is 500cm^2/(V-s) and the mobility of the hole is 200cm^2/(V-s). Compare the performance of an n-channel with a p-channel transistor. In particular, consider the value of the transconductance parameter and speed of the MOS transistor.
10. Using small signal analysis, design the output impedance of a MOS cascode current mirror. Include in your analysis the voltage –dependent current source that models the body effect.
11. Design Analog CMOS subcircuits including MOS Switch, MOS Diode/Active Resistor, Current Sinks and Sources, Current Mirrors, Bandgap Reference, Current and Voltage References.
12. Design the current boosting mirror to achieve 100µA output when M2 is saturated. Assume that i_1=10 µA and W1/L1=10. Find W2/L2 and the value of V_{DS2} where i_2 =10 µA.
13. In the following figure replace R_1 with a differential amplifier using a current mirror load. Design the differential transconductance g_m so that it is equal to $1/R_1$.



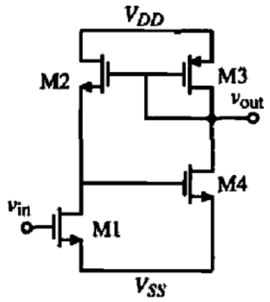
Course Outcome 3 (CO3):

1. CMOS amplifier is shown in figure. Assume M1 and M2 operate in the saturation region.
   (a) What value of V_{GG} gives 100 µA through M1 and M2?
   (b) What is the dc value of V_{IN}?
   (c) What is the small signal voltage gain, V_{out}/V_{in}, for this amplifier?

(d) What is the -3dB frequency in hertz of this amplifier if Cgd1=Cgd2=5fF, Cbd1=Cbd2=30fF and C_L=500fF?



2. An MOS output stage is shown in figure. Draw a small signal model and calculate the ac voltage gain at low frequency. Assume that bulk effects can be neglected.



3. The specification for a cascade amplifier are V_{DD}=5V, P_{diss}=1mW, A_v=-50V/V, V_{out}(max)= 4V and V_{out}(min)=1.5V.The slew rate with a 10pF load should be 10V/µs or greater.
4. Develop the expression for V_{IC}(max) and V_{IC}(min) for the p-channel input differential amplifier.

Course Outcome 4 (CO4):

1. Assume the S/H of diode bridge track and hold circuits has each of D_5 and D_6 replaced by two series diodes. Show the voltages at all nodes for the cases of sampling a 1 V input and a -1 V input for before as well as after track mode.

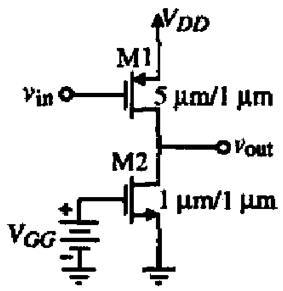
2. A CMOS amplifier is shown in figure. Assume M1 and M2 operate in the saturation region.

   (a) What value of V_{GG} gives 100 µA through M1 and M2?

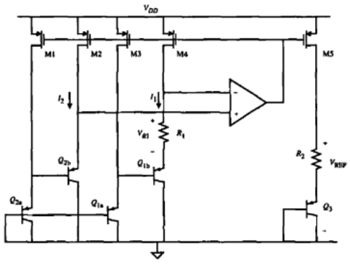
   (b) What is the dc value of V_{IN}?

   (c) What is the small signal voltage gain, V_{out}/V_{in}, for this amplifier?

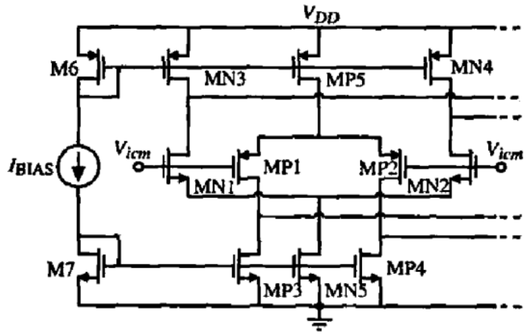
   (d) What is the -3dB frequency in hertz of this amplifier if Cgd1=Cgd2=5fF, Cbd1=Cbd2=30fF and C_L=500fF?



3. An improved bandgap reference generator is illustrated in figure below. Assume that the device M1 through M5 are identical in W/L. Further assume that the area ratio for the bipolar transistor is 10:1. Design the components to achieve an output reference output reference voltage of 1.262V. Assume that the amplifier is ideal. What advantage, if any , is there in stacking the bipolar transistor.



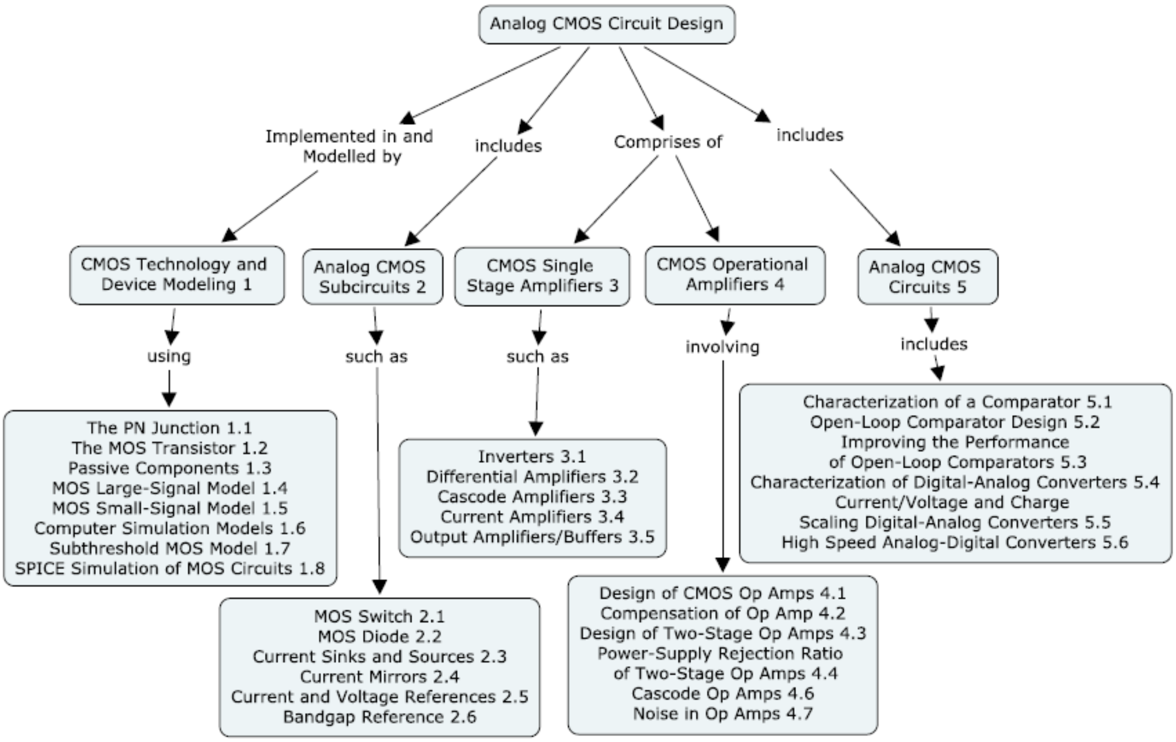
4. Find the value of V_{onn} and V_{onp} of the following figure. If the W and L values of all transistors are 10 µm and 1 µm, respectively, and the bias current in MN5 and MP5 are 100 µA each.



Course Outcome 5 (CO5):

1. Assume for a 0.8 µm technology that A_0= 20, n = 3, V_{eff}=0.5 V, and $\mu_{n=0.05}$ M^2/V. What is the maximum clocking frequency of the comparator?.In the following figure replace R_1 with a differential amplifier using a current mirror load. Design the differential transconductance g_m so that it is equal to $1/R_1$.
2. Assume that the first resistor string of a 10 bit, multiple-R-string, D/A converter must match to 0.1 percent, and that the first string realizes the top 4 bits. What is the matching requirement of the second resistor string, which realizes the lower 6 bits?
3. An 8 bit D/A converter has V_{ref} = 5 V. What is the output voltage when B_{in}=10100100? Also find V_{LSB}.
4. Design a comparator given the following requirements: P_{diss}<2mW, V_{dd}=3V, V_{ss}=0V, C_{load}= 3pF, t_{prop}<1µs, ICMR-1.5-2.5 V, A_0>2200 and output voltage swing within 1.5V.

Concept Map



Syllabus

CMOS Technology and Device Modeling: The PN Junction, The MOS Transistor, Passive Components, MOS Large-Signal Model, MOS Small-Signal Model, Computer Simulation Models, Subthreshold MOS Model, SPICE Simulation of MOS Circuits. **Analog CMOS Subcircuits:** MOS Switch, MOS Diode, Current Sinks and Sources, Current Mirrors, Current and Voltage References, Bandgap Reference. **CMOS Single Stage Amplifiers:** Inverters, Differential Amplifiers, Cascode Amplifiers, Current Amplifiers, Output Amplifiers/Buffers. **CMOS Operational Amplifiers:** Design of CMOS Op Amps, Compensation of Op Amp, Design of Two-Stage Op Amps, Power-Supply Rejection Ratio of Two-Stage Op Amps, Cascode Op Amps, Noise in Op Amps. **Analog CMOS Circuits:** Characterization of a Comparator, Open-Loop Comparator Design, Improving the Performance of Open-Loop Comparators, Characterization of Digital-Analog Converters, Current/Voltage and Charge Scaling Digital-Analog Converters, High Speed Analog-Digital Converters.

Reference Books

1. Phillip E.Allen, Douglas R.Holberg, “CMOS Analog Circuit Design”, Third edition, Oxford University Press, 2011.
2. Behzad Razavi, “Design of Analog CMOS Integrated Circuits”, Tata McGraw Hill, 2002.
3. David Johns, Ken Martin,” Analog Integrated Circuit Design”, Second Edition, Wiley, 2011.
4. P. R. Gray, P. J. Hurst, S. H. Lewis, R. G. Meyer “Analysis and Design of Analog Integrated Circuits”, Fourth Edition, Wiley-India, 2008.
5. Willey M.C. Sansen, “Analog design essentials”, Springer, 2006.
6. Franco Maloberti, “Analog design for CMOS VLSI systems”, Springer, 2001.
7. Kenneth Laker, Willy Sansen “Design of Analog Integrated Circuits and Systems”, McGraw-Hill, 1994.

Course Contents and Lecture Schedule

No.	Topic	No. of Lectures
1	**CMOS Technology and Device Modeling**	
1.1	The PN Junction	1
1.2	The MOS Transistor	1
1.3	Passive Components	1
1.4	MOS Large-Signal Model	1
1.5	MOS Small-Signal Model	1
1.6	Computer Simulation Models	1
1.7	Subthreshold MOS Model	1
1.8	SPICE Simulation of MOS Circuits	2
2	**Analog CMOS Subcircuits**	
2.1	MOS Switch	1
2.2	MOS Diode	1
2.3	Current Sinks and Sources	2
2.4	Current Mirrors	2
2.5	Current and Voltage References	1
2.6	Bandgap Reference	1
3	**CMOS Single Stage Amplifiers**	
3.1	Inverters	1
3.2	Differential Amplifiers	2
3.4	Cascode Amplifiers	1
3.5	Current Amplifiers	1
3.6	Output Amplifiers/Buffers	1
4	**CMOS Operational Amplifiers**	
4.1	Design of CMOS Op Amps	2
4.2	Compensation of Op Amp	1
4.3	Design of Two-Stage Op Amps	2
4.4	Power-Supply Rejection Ratio of Two-Stage Op Amps	1
4.5	Cascode Op Amps	1
4.6	Noise in Op Amps	1
5	**Analog CMOS Circuits**	
5.1	Characterization of a Comparator	1
5.2	Open-Loop Comparator Design	2
5.3	Improving the Performance of Open-Loop Comparators	1
5.4	Characterization of Digital-Analog Converters	1
5.5	Current/Voltage and Charge Scaling Digital-Analog Converters	2
5.6	High Speed Analog-Digital Converters	1
	Total Hours	45

Course Designers:

1. Dr.N.B.Balamurugan nbbalamurugan@tce.edu
2. Mr.V. R. Venkatasubramani venthiru@tce.edu

14CNPE0	REAL TIME EMBEDDED SYSTEMS	Category	L	T	P	Credit
		PE	3	1	0	4

Preamble

The goal of this course is to familiarize students with the technologies and issues involved in Real-Time and hardware-resource constrained systems. Design engineers are often called upon to make decisions about general purpose computing solutions vs. specialized hardware solutions, this course will give students the tools to intelligently make the necessary tradeoffs and understand the business consequences of their choices in Real Time Embedded System Design. ARM processors are embedded in products ranging from mobile phones to automotive braking systems. The course begins by a brief note on the ARM processor design philosophy and discussing how and why it differs from the traditional RISC philosophy and also introduces a simple embedded system based on the ARM processor. It teaches proven techniques and rules for writing C code that will compile efficiently on the ARM architecture, and it helps determine which code should be optimized. It covers the theory and practice of handling exceptions and interrupts on the ARM processor through a set of detailed examples. Real-time Embedded systems are created for a special application. In general, real-time embedded systems are required to have multitasking, prioritized process threads and sufficient number of interrupt levers. They are often required in small embedded operating systems that are packaged as part of micro-devices. The kernel programs can be considered to meet the requirements of a real-time embedded system.

Prerequisite

NIL

Course Outcomes

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

CO1. Apply the idea of Real Time Embedded System in Engineering and science.	Apply
CO2. Design and analyze the Real time embedded system for engineering applications.	Apply
CO3. Identify, formulate and solve Real Time System for specific Engineering applications.	Analyze
CO4. Design, Apply and analyze the performance parameters of ARM based Hardware for the solution of Real Time Embedded System.	Analyze
CO5. Test and validate the performance of the embedded hardware and software.	Create

Mapping with Programme Outcomes

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

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	20	20	10	10
Understand	40	40	40	40
Apply	40	40	20	20
Analyse	0	0	20	20
Evaluate	0	0	0	0
Create	0	0	10	10

Course Level Assessment Questions

Course Outcome 1 (CO1):
1. What is an AMBA and HBA Bus?
2. What is a pipeline structure in ARM processor?
3. What is a register file in ARM processor?
4. Define the term IPC.
5. What do you meant by Real Time system?
6. What is a Thread?

Course Outcome 2 (CO2):
1. Differentiate between CISC and RISC?
2. How does pipeline in a processor work?
3. State the advantage of Pipeline structure.
4. Distinguish traditional computing system and Real time embedded system.
5. How does ARM handle the interrupts?
6. Write the importance of RTOS for an embedded system.
7. Compare and explain various Loop execution (optimized) in ARM processors.
8. Explain the Flushing and Cleaning methods of Cache Memory.
9. Explain the function of memory management.

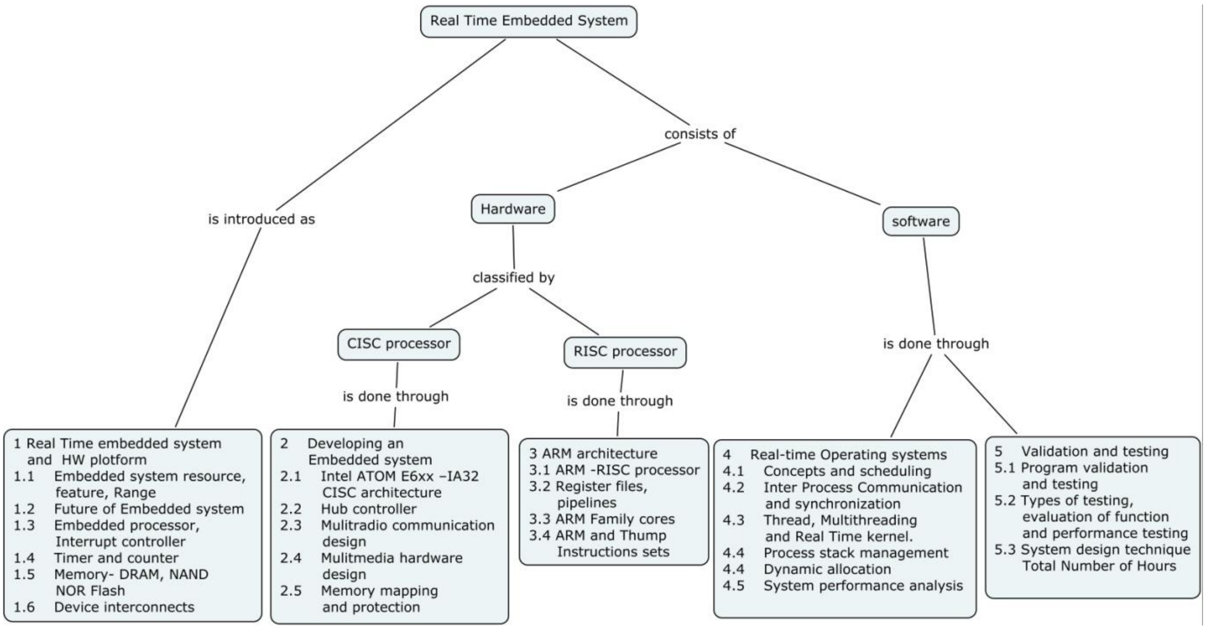
Course Outcome 3 (CO3):
1. Develop an assembly level program for computing Fibonacci function with less memory usage.
2. Develop a C program for ARM processor for accessing an IO using polling method and interrupt driven method.
3. Write an assembly level program for transferring a file from one space to another space using memory management unit.
4. Develop an assembly code to run floating point primitive for IEEE754 format and in ARM7 Processor.

Course Outcome 4 (CO4):
1. Develop a pseudo level c code for providing a semaphore to access a specific hardware resource in a two concurrent process of a multitasking system.
2. Develop a pseudo level c code for providing a pipe for two tasks running in multitasking.
3. Design an embedded system which can react for opening and closing the door, upon correct key stroke entry in a security system.
4. Design a digital clock and wake timer using ARM processor with appropriate interrupt handling.
5. Design an embedded system to mange multiple task in real time.

Course Outcome 5 (CO5):

1. Design an Embedded system for a data acquisition system with multi tasking in real time.
2. Design an Embedded system for a vending machine using polled loop kernel method.
3. Design an Embedded system for an Electronic instruments using interrupt driven kernel method.

Concept Map



Syllabus

Real time embedded system and HW plot form: Modern Embedded system resources, features, range and future. Intel CISC Processor, peripherals, memory and device interconnects. **Developing an embedded system:** CISC**–**Atom processor. Intel Hub controller, mulitiradio and multimedia hardware design. **ARM Processor:** RISC architecture, registers and instructions sets. **Real-time systems:** Concepts and scheduling, IPC, synchronization, Threads overview, Multithreading models, Real Time kernel and memory management: Process stack management, Dynamic allocation, and System performance analysis. **Validation and testing:** Program validation and testing, Types of testing, Evaluation of function and performance testing, System design technique.

Reference Books

1. "Peter Barry Patrick Crowley" Modern Embedded Computing Designing Connected, Pervasive, Media-Rich Systems, Elsevier 2012
2. Andrew N. Sloss Dominic Symes Chris Wright "ARM System Developer's Guide Designing and Optimizing System Software" Elseivier inc 2007.
3. Philip A. Laplante, "Real time systems Analysis and Design – An Engineer's Handbook", IEEE computer society press PHI, 4th Ed. 2007.
4. Karl Hamcher, Zvonko Vranesic, Safwat Zaky, "Computer Organization", fifth ed. McGraw Hill -2002.

Course Contents and Lecture Schedule

Module No.	Topic	No. of Lectures
1	Real Time embedded system and HW plotform	**10**
1.1	Embedded system resource, feature, Range	1
1.2	Future of Embedded system	1
1.3	Embedded processor, Interrupt controller	2
1.4	Timer and counter	2
1.5	Memory- DRAM, NAND NOR Flash	2
1.6	Device interconnects	2
2	**Developing an Embedded system**	**8**
2.1	Intel ATOM E6xx –IA32 CISC architecture	1
2.2	Hub controller	1
2.3	Mulitradio communication design	1
2.4	Mulitmedia hardware design	1
2.5	Memory mapping and protection	2
2.6	MMU and Process. Memory Hierarchy	2
3	**ARM-RISC Architecture**	**10**
3.2	ARM architecture-RISC	2
3.2	Register files, pipelines	2
3.3	ARM Family cores	2
3.4	ARM and Thump Instructions sets	4
4	**Real-time Operating systems**	**10**
4.1	Concepts and scheduling	1
4.2	Inter Process Communication and synchronization	2
4.3	Thread, Multithreading and Real Time kernel.	2
4.4	Process stack management	2
4.4	Dynamic allocation	2
4.5	System performance analysis	1
5	**Validation and testing**	**6**
5.1	Program validation and testing	2
5.2	Types of testing, evaluation of function and performance testing	2
5.3	System design technique	2
	Total Number of Hours	**44**

Course Designers:

1. Dr.K. Hariharan khh@tce.edu
2. Dr.L.R. Karl Marx lrkarlmarx@tce.edu

14CNPF0	ESTIMATION AND DETECTION ALGORITHMS	Category	L	T	P	Credit
		PE	3	1	-	4

Preamble

The course “14CNPF0: Estimation and Detection Algorithms” is offered as elective subject in continuation with the course on “14CN120: Digital Communication Technique”. This course aims at developing Estimation and Detection Algorithms for scalar and vector parameters of a system in noise. Further, it also aims at developing algorithms for detecting the desired signals from the noisy received signal.

Prerequisite

14CN120 Digital Communication Techniques

Course Outcomes

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

CO1. Formulate the estimation problem and determine the CRLD for the given estimation problem.	Understand
CO2. Design an estimator based on maximum likelihood, maximum a posteriori, least square and minimum mean square error methods.	Apply
CO3. Formulate the detection problem	Understand
CO4. Detect known signal in Gaussian noise using matched filter and generalized matched filter.	Apply
CO5. Detect Random signal in Gaussian noise using estimator correlator and design detectors for array processing applications.	Apply

Mapping with Programme Outcomes

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

S- Strong; M-Medium; L-Low

Assessment Pattern

	Bloom’s category	Continuous Assessment Tests			End Semester Examinations
		1	2	3	
1	Remember	20	20	10	10
2	Understand	20	20	10	10
3	Apply	60	60	80	80
4	Analyze	0	0	0	0
5	Evaluate	0	0	0	0
6	Create	0	0	0	0

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. In Bayesian estimator, if the cost function is absolute error, the estimator is defined to be the median of the posterior PDF. Justify
2. Can an optimal estimator be obtained from CRLB? Explain
3. Compare the estimation performance of ML, MAP and MMSE based estimators. When an estimator is said to be unbiased?

Course Outcome 2 (CO2):

1. The data $x(n) = Ar^n + w(n)$ for $n = 0,1,....N-1$ are observed, where w(n) is WGN with variance σ^2 and $r > 0$ is known.
   a. Find the CRLB for A.
   b. Show that an efficient estimator exists and find its variance.
2. Consider the observations $x(n) = A + w(n) \quad n = 0,1\cdots N-1$, where A is real number and w(n) is WGN with variance σ^2. Let the estimator $\hat{A} = \frac{1}{N}\sum_{n=0}^{N-1} x(n)$. Prove that the PDF $\hat{A}$ is $N(A, \sigma^2 / N)$
3. MAP Estimator:
   a. Assume that the conditional PDF $p(x[n] \mid \theta) = \theta \exp(-\theta x(n)) \quad x[n] > 0$ where the x[n]'s are independent and identically distributed and the prior PDF is $p(\theta) = \lambda \exp\{-\lambda\theta\} \quad \theta > 0$. Determine MAP estimator for θ.
   b. The data $x(n) = A + w(n)$ for $n = 0,1,....N-1$ are observed, where A is unknown and the noise variance σ^2 is also unknown. The conditional PDF $p(\mathbf{x} / A, \sigma^2) = \frac{1}{\left(2\pi\sigma^2\right)^{\frac{N}{2}}} \exp\left(-\frac{1}{2\sigma^2}\sum_{n=0}^{N-1}\left(x(n) - A\right)^2\right)$. The prior PDF for σ^2 is
   $$p(\theta) = \frac{\lambda \exp\left(-\frac{\lambda}{\sigma^2}\right)}{\sigma^4} \quad \sigma^2 > 0$$

Course Outcome 3 (CO3):

1. Detection performance is monotonic with deflection coefficient. Justify this statement.
2. For the DC level in WGN detection problem assume that we wish to have $P_{FA} = 10^{-4}$ and $P_D = 0.99$. If the SNR is $10\log_{10} A^2/\sigma^2 = -30$ dB, determine the necessary number of samples N.
3. Explain the function of 'Clairvoyant Detector'?

Course Outcome 4 (CO4):

1. A radar signal $s[n] = A\cos 2 f_0 n$ for $n = 0,1...N-1$ is received embedded in WGN with variance $\sigma^2 = 1$. A detector is to be designed that maintains $P_{FA} = 10^{-8}$. If $f_0 = 0.25$ and $N = 25$, find the probability of detection versus A.
2. Consider the detection of $s[n] = A\cos 2 f_0 n$ for $n = 0,1...N-1$ in the presence of WGN with variance σ^2. Define the input SNR as the average power of a signal sample to the noise power. This is approximately $\eta_{in} = \left(A^2/2\right)/\sigma^2$. Find the output SNR of a matched and hence the PG. Next determine the frequency response of the matched filter and

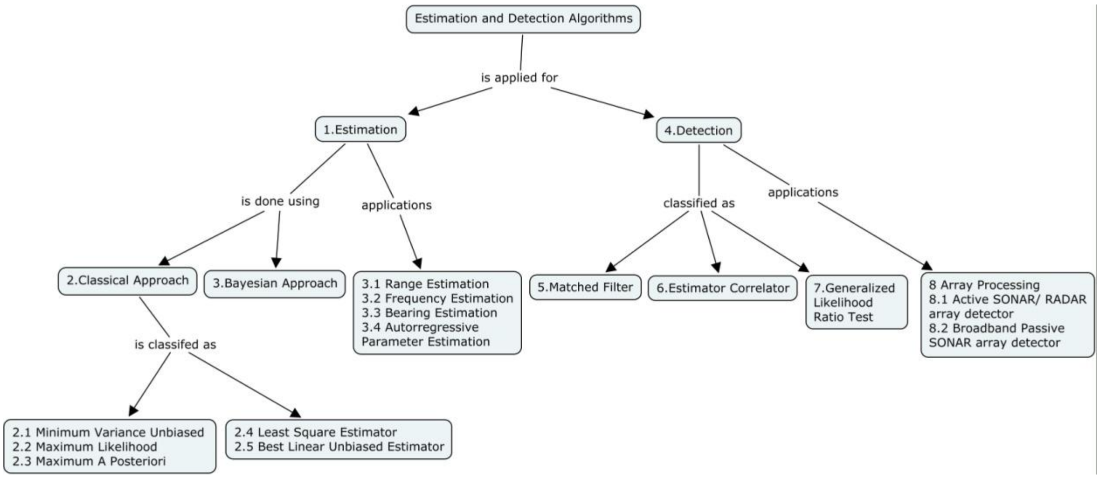
plot its magnitude as N increases. Explain why the matched filter improves the detectability of a sinusoid. Assume that $0 < f_0 < 1/2$ and N is large.

3. In a Pulse Amplitude Modulation (PAM) communication system we transmit one of M levels so that $s_i[n] = A_i, n = 0,1...N-1$, for $i = 0,1...M-1$. If P_e is to be minimized and each signal is equally likely to be transmitted, find the optimal receiver for WGN of variance σ^2.

Course Outcome 5 (CO5):

1. The output of an array of sensors is observed. There are M=2 sensors and N=3 samples with $\{1,2,3\}$ being observed at the output of the first sensor and $\{4,5,6\}$ being observed at the output of the second sensor. Find $\tilde{\mathbf{x}}[n]$, $\tilde{\mathbf{x}}_m$.
2. A sinusoidal random process is observed at the output of an array as $\tilde{x}_m[n] = \bar{A}\exp\left[j\left(2\pi\left(f_0 m + f_1 n\right) + \phi\right)\right]$ where $\bar{A}$ is deterministic and ϕ is a random variable with $\phi \sim u[0,2\pi]$. Show that the cross-correlation between sensors m and m' is $r_{mm'}[k] = |\bar{A}|^2 \exp\left[j2\pi\left(f_0(m'-m) + f_1(k)\right)\right]$.
3. For a complex Gaussian random signal with mean zero and known covariance matrix $\mathbf{C}_{\tilde{s}} = \sigma_{\tilde{s}}^2\mathbf{I}$ embedded in CWGN with known variance σ^2, find the NP detection statistic. Explain your results.

Concept Map



Syllabus

Estimation: Mathematical Estimation problem, Assessing Estimator Performance, **Estimation Algorithms-Classical Approach:** Minimum Variance Unbiased Estimation, CRLB, Maximum Likelihood Estimation, Expectation Maximization Algorithms, Maximum a Posteriori Estimator, Least Square Estimator, Best Linear Unbiased Estimation **Estimation Algorithms-Bayesian Estimator, Signal Processing Examples:** Range Estimation, Frequency, Estimation, Bearing Estimation, Autoregressive Parameter Estimation **Detection Algorithms:** Classical Approach-Neyman Pearson Theorem, Bayesian Approach-Minimization of Bayes Risk ,Receiver Operating Characteristics, **Matched Filter:** Generalized Matched Filter, Multiple Signal, Estimator Correlator, Generalized Likelihood Ratio Test: Composite Hypothesis Testing, Multiple Hypothesis Testing Detector for Array Processing , Detectors for Array Processing Applications, Active SONAR/RADAR array detector and Broadband Passive Array detector.

Reference Books

1. Steven M.Kay, " Fundamentals of Statistical Signal Processing", Vol I Estimation Theory, Prentice Hall Inc, 1998
2. Steven M.Kay, " Fundamentals of Statistical Signal Processing", Vol II Detection Theory, Prentice Hall Inc, 1998,
3. Monson H.Hayes, " Statistical Digital Signal Processing and Modeling", John Wiley, 1996
4. Sophocles. J. Orfanidis: "Optimum Signal Processing An Introduction", Collier Macmillan, 2nd edition 1998
5. John G. Proakis, Vinay K.Ingle, Stephen M.Kogon: "Statistical and adaptive signal Processing: spectral estimation, signal modeling, adaptive filtering, and array processing", McGraw-Hill, 2000.

Course Contents and Lecture Schedule

No.	Topic	No. of Lectures
1	**Estimation**	
1.1	Mathematical Estimation Problems	1
1.2	Assessing Estimator Performance	1
2	**Estimation Algorithms- Classical Approach**	
2.1	Minimum Variance Unbiased Estimation	2
2.2	Maximum Likelihood Estimation	2
2.3	Maximum A Posteriori Estimation	2
2.4	Least Square Estimation	2
2.5	Best Linear Unbiased Estimation	2
3	**Estimation Algorithms- Bayesian Approach**	3
3.1	**Signal Processing Examples**	
3.1.1	Range Estimation	1
3.1.2	Frequency Estimation	1
3.1.3	Bearing Estimation	1
3.1.4	Autoregressive Parameter Estimation	1
4	**Detection Algorithms**	2
4.1	Classical Approach -Neyman Pearson Theorem	2
4.2	Bayesian Approach-Minimization of Bayes Risk	2
4.3	Receiver Operating Characteristics	1
4.3	Examples	2
5	**Matched Filter**	3
5.1	Generalized Matched Filter	2
5.2	Multiple Signal Detection	2
5.3	Examples	2
6.	**Estimator Correlator**	3
6.1	Examples	3
7	**Generalized Likelihood Ratio Test**	2
7.1	Composite Hypothesis Testing	2
7.2	Multiple Hypothesis Testing	2
7.3	Examples	2
8	**Detectors for Array Processing Applications**	2
8.1	Active SONAR/RADAR array detector	2
8.2	Broadband Passive SONAR array detector	2

Course Designers:

1. Dr. S.J. Thiruvengadam sjtece@tce.edu

14CNPG0	SATELLITE REMOTE SENSING AND DATA ANALYSIS	Category	L	T	P	Credit
		PE	3	1	-	4

Preamble

This course deals with the acquisition and processing of satellite images to analyze and extract information from them, using signal and image processing operations.

Prerequisite

NIL

Course Outcomes

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

CO1. Determine the quality of the image using noise model statistics and improve the quality of a distorted image by geo-referencing	Apply
CO2. Analyze the performance of supervised and unsupervised training for different sensor data	Analyze
CO3. Characterize the influence of feature extraction, in terms of accuracy on classified images	Apply
CO4. Determine the performance of different feature extraction methods	Analyze
CO5. Remove the data redundancies by suitable compression techniques to transmit the satellite image efficiently	Apply

Course Outcomes

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

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

S- Strong; M-Medium; L-Low

Assessment Pattern

	Bloom's category	Continuous Assessment Tests			End Semester Examinations
		1	2	3	
1	Remember	20	20	20	20
2	Understand	30	20	20	20
3	Apply	50	40	40	40
4	Analyze	0	20	20	20
5	Evaluate	0	0	0	0
6	Create	0	0	0	0

Course Level Assessment Questions

Course Outcome (CO1)

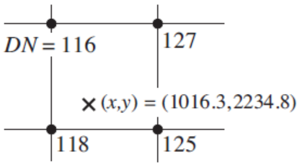
6. What is atmospheric window?
7. Define: spectral reflectance of earth surface features.
8. What is meant by geometric correction?
9. Write the law's 2D masks to ridges and waves.
10. What is meant by Scale space fusion?
11. Explain the terms; Fractal dimension, Lacunarity.
12. What are different types of Vegetation Indexes?

Course Outcome (CO2)

1. Prove the rotation invariance property of Fourier transform.
2. Explain how wetness and dryness are analyzed using tasseled cap transformation?
3. The cross-correlation coefficient is commonly used to register image patches. Which environmental and calibration factors in remote-sensing imagery are removed by this normalization?
4. Differentiate supervised and unsupervised classification.
5. Which spectral bands are used in multi spectral ratio to analyse vegetation.
6. How wavelets are used for Image Compression?

Course Outcomes (CO3/ CO4 /CO5)

1. Given the *DN* values of four neighboring pixels, find the *DN* of the resampled pixel at X using bilinear resampling:



2. The following table shows the histogram of a poor contrast grey scale Image:

Grey level i	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
n_i	15	0	0	0	0	70	110	45	70	35	0	0	0	0	0	15

Modify the same image as a high contrast one.

3. The following table gives the number of pixels at each of the grey levels in an image with those grey values only:

0	1	2	3	4	5	6	7
3244	3899	4559	2573	1428	530	101	50

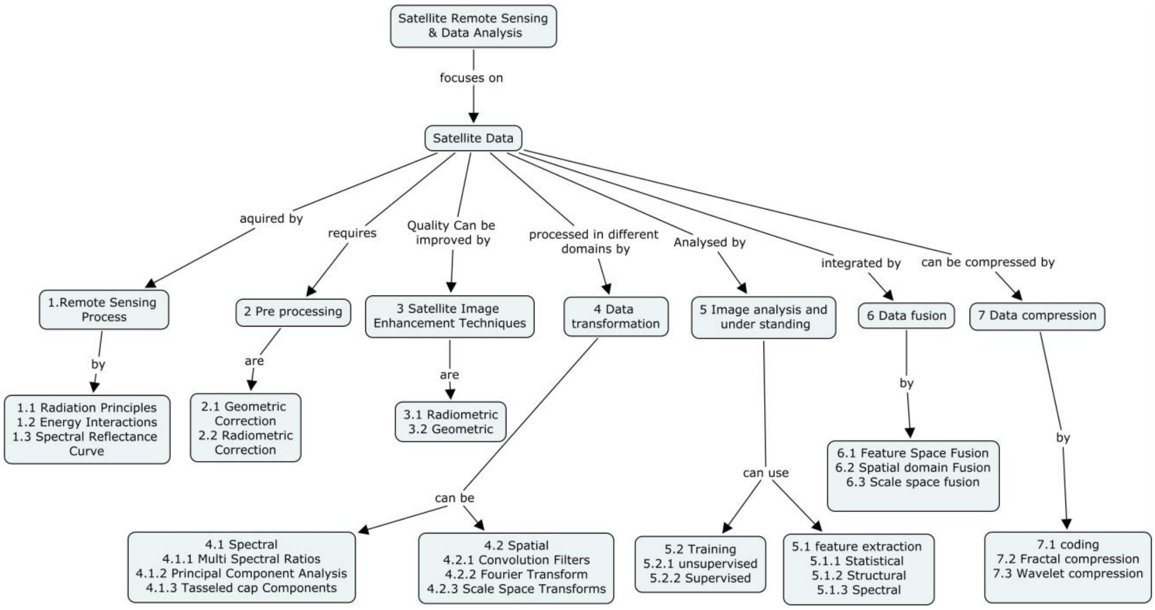
Draw the histogram corresponding to these grey levels, and then perform histogram equalization and draw the resulting histogram.

4. Determine the Fourier transform of a 5 X 5 image f(x,y) with constant matrix f(x,y)=1.

5.Classify the following image into 3 classes using K- means clustering.

12	6	5	13	14	14	16	15
11	10	8	5	8	11	14	14
9	8	3	4	7	12	18	19
10	7	4	2	10	12	13	17
16	9	13	13	16	19	19	17
12	10	14	15	18	18	16	14
11	8	10	12	14	13	14	15
8	6	3	7	9	11	12	12

Concept Map



Syllabus

Remote Sensing Process: Definition, Remote sensing process, Radiation principles, Spectral reflectance curve, EMR interactions with-atmosphere-earth surface features.
Satellite Data: Satellite Image Characteristics, Resolution types, **Preprocessing-** Geometric Correction, Radiometric Correction, **Satellite Image Enhancement:** Radiometric Enhancement- Histogram Based Enhancements, Density Slicing, Stretching, Geometric Enhancement- Neighborhood Operations, Template Operators, **Data Transformation**: Spectral Transforms - Multispectral Ratios - Vegetation Indexes, Principal Components, Tasseled-Cap Components, Color-Space Transforms, Spatial Transforms – Convolution, Fourier Transform, Scale Space Transforms, **Image Analysis And Understanding:** Feature Extraction- Statistical, Structural, Spectral, Training –Supervised, Unsupervised, Hybrid Training, **Data Fusion**: Feature Space fusion, Spatial domain fusion, Scale space fusion, **Data Compression:** Compression by coding, Fractal Compression, Wavelet Compression.

Reference Books

1. Thomas M.Lillesand, Ralph W.Kiefer, "Remote Sensing and Image Interpretation", Fifth Edition, 2004.
2. Robert A. Schowengerdt, Remote Sensing Models & Methods For Image Processing, III Edition, 2004.
1. J. A. Richards "Remote Sensing Digital Image Analysis: An Introduction", Second Revised Edition, 1993.
2. John R. Jensen, "Remote Sensing Of The Environment – An Earth Resource Perspective", Pearson Education Series, 2003.
3. Rafael C.Gonzalez, Richard E.Woods, "Digital Image Processing" (3rd Edition), Prentice Hall, 2007.

Course Contents and Lecture Schedule

No.	Topic	No. of Lectures
1.	**Remote sensing**	
1.1	Remote sensing process, Radiation principles	1
1.2	Spectral reflectance curve	1
1.3	EMR interactions with-atmosphere-earth surface features	2
2.	**Satellite Data**	

No.	Topic	No. of Lectures
2.1	Satellite Image Characteristics	1
2.2	Geometric Correction	1
2.3	Radiometric Correction	1
3.	**Satellite Image Enhancement**	
3.1	Radiometric Enhancement	1
3.1.1	Histogram Based Enhancements, Density slicing	1
3.1.2	Stretching	1
3.2	Geometric Enhancement	1
3.2.1	Neighborhood Operations, Template operators	1
4.	**Data Transformation**	
4.1	Spectral Transforms	1
4.1.1	Multispectral Ratios	1
4.1.2	Vegetation Indexes	1
4.1.3	Principal Components	1
4.1.4	Tasseled-Cap Components	1
4.2	Spatial Transforms	1
4.2.1	Convolution	2
4.2.2	Fourier Transform	1
4.2.3	Scale Space Transforms	1
5.	**Image Analysis And Understanding**	
5.1	Feature Extraction	1
5.1.1	Statistical	2
5.1.2	Structural	1
5.1.3	Spectral	2
5.2	Training	2
5.2.1	Supervised	2
5.2.2	Unsupervised	2
5.2.3	Hybrid Training	1
6.	**Data Fusion**	
6.1	Feature Space fusion	1
6.2	Spatial domain fusion	1
6.3	Scale space fusion	2
7.	**Data Compression**	
7.1	Compression by coding	1
7.2	Fractal Compression	1
7.3	Wavelet Compression	2

Course Designers:

1. Dr.R.A.Alagu Raja alaguraja@tce.edu
2. Dr. B.Sathya Bama sbece@tce.edu

14CNPH0	WIRELESS NETWORK SECURITY

Category	L	T	P	Credit
PE	3	1	0	4

Preamble

This course presents the security of wireless communication systems and design of information and electronic warfare model relative to security. The network security model includes intrusion protection and detection, host based security technologies and techniques, securing LAN, VPN and issues involve in collecting and analyzing secure data from multiple sources.

Prerequisite

Nil

Course Outcomes

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

CO1. Understand why wireless is different from its wired counterpart.	Understand
CO2. Design a secure process and practice the information security model	Design
CO3. Assess wireless security model and to setup a secure wireless system.	Evaluate
CO4. Apply security in point to point and end to end in wireless applications	Apply

Mapping with Programme Outcomes

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

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	30	30	20	20
Understand	30	30	20	20
Apply	20	20	40	40
Analyse	20	20	20	20
Evaluate	0	0	0	0
Create	0	0	0	0

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Why the wireless devices are less secured than their wired counterparts.
2. Mention the factors that should be included to recognize the secure mobile devices
3. Define the term man in Middle attack? Give an example
4. List some ways to prevent the spread of computer viruses
5. State the fundamental idea behind SAW filters
6. Bring out the role of NAT in firewalls

Course Outcome 2 (CO2):

8. In what ways the temporal attack is different from content attack
9. Enlist the taxonomy of communication systems related to the various models of communication devices
10. State the importance of elliptic curve encryption algorithm
11. Using vigenere scheme with 27 characters in which the 27th character is the space but with a one time key. The encrypted message is 20 5 21 3.If the encryption key is 5 which decrypts the message.
12. Write the principle behind Host based security
13. Mention the principal requirements for providing E2E security in wireless applications. Give suitable examples

Course Outcome 3 (CO3):

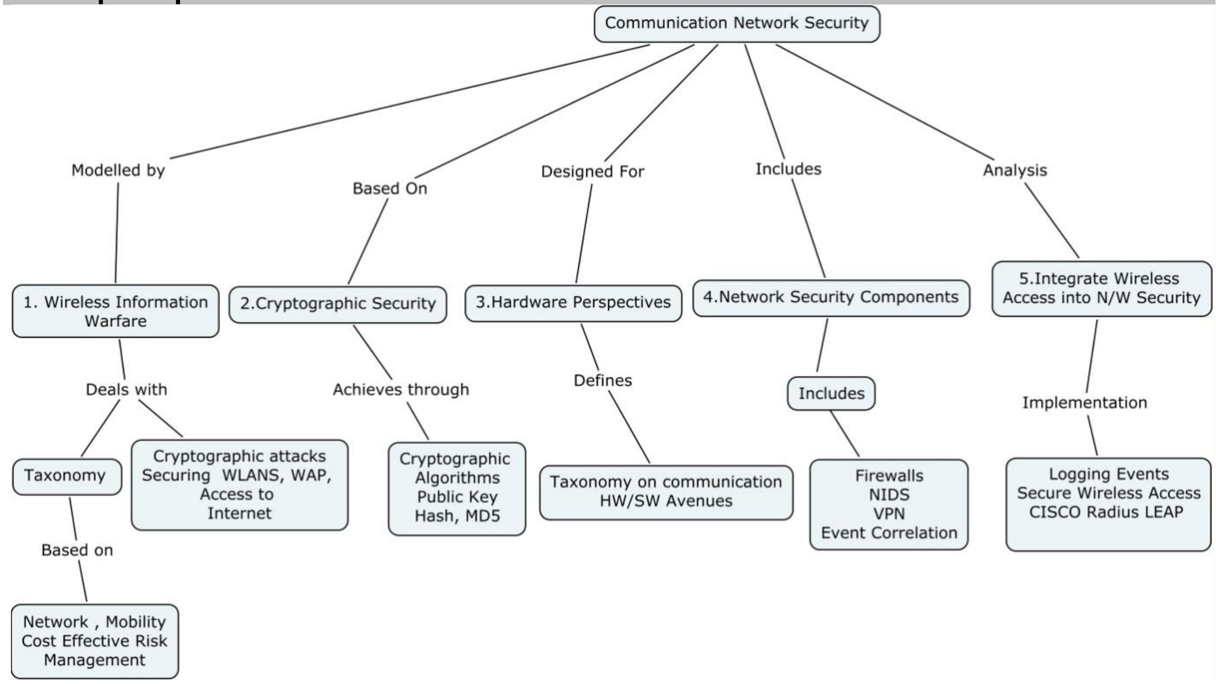
1. Perform encryption and decryption using RSA algorithm for the following
   p=3, q=11, e=7 and message m=5.
2. Consider Diffie- Hellman algorithm with a common prime q=11, primitive root a=2.
   a) If user A has public key Y_A=9, what is A's private key.
   b) If user B has public key Y_B=3, what is B's private key.

Encrypt the message "meet me at the usual place" using the Hill cipher with the key $\begin{pmatrix} 9 & 4 \\ 5 & 7 \end{pmatrix}$ show your calculations and results

Course Outcome 4 (CO4):

1. Summarize the method which can be used to extend the resources of a private network across an un-trusted network
2. How will you check file integrity in order to detect modifications to host operating systems
3. Show how the most devasting attacks in a wireless system that involve the cryptographic security and also discuss its key management with a typical example.

Concept Map



Syllabus

Wireless Information warfare: Protecting privacy and means of communication, taxonomies of wireless communication based on network architecture mobility, model for cost effective risk management, cryptographic attacks, key management, securing wireless LANS, Electromagnetic capture threats, wireless threat analysis, securing wireless LAN countermeasures. **Wireless LAN transmission media:** WAP security architecture, BLUETOOTH, wireless access to internet. **Cryptographic Security:** Classical crypt analysis, digital cryptography**,** DES modern cipher breaking, non-keyed message digest, public key cryptography, Diffie – Hellman and Elliptic curve cryptography, comparison of public key crypto systems. **Network Security Components:** Network security model, network intrusion protection and detection, Host based security, virtual private networking, event correlation, wireless security components, secure configuration , secure authentication, encryption, wireless device placement. **Integrating Wireless Access into the network security process:** Logging wireless events, policy issues, accessing wireless network security, change control and device administration, wireless security models, Cisco implementation with LEAP,, WLAN authentication and key management with radius, wireless access with IP security, secure wireless public access, secure wireless point to point connectivity. **Hardware perspective for end to end security in wireless application:** Taxonomy of communication systems, protocol sensitive communication security , evolution towards wireless, hardware and software avenues, encryptor structures in wireless-interception and vulnerability of wireless systems, communication ESMs and interception receivers, SAW technology.

Reference Books

1. Randall K. Nichols, Panos C. Lekkas, “Wireless Security Models, Threats and solutions”. McGrawHill, 2005.
2. Brian Carter, Russel Shumway, “Wireless Security End to End”, CISSPI, 2005.
3. Merrit Maxim, David Pollino, “Wireless Security”, RSA Press, 2005.
4. Cyrus Peikari, Seth Fogie, , “Maximum Wireless Security ”, SAMS, 2005.

Course Contents and Lecture Schedule

Module No.	Topics	No. of Lectures
1	**Wireless Information warfare**	
1.1	Protecting privacy and means of communication	1
1.2	taxonomies of wireless communication based on network architecture mobility	1
1.3	model for cost effective risk management using decision theory	1
!.4	cryptographic attacks, securing wireless LANS, Electromagnetic capture threats, wireless threat analysis, securing wireless LAN countermeasures.	3
!.5	**Wireless LAN transmission media**	
!.5.1	WAP security architecture, BLUETOOTH, wireless access to internet.	3
2	**Cryptographic Security:**	
2.1	Classical crypt analysis, digital cryptography**,**	2
2.2	DES modern cipher breaking	2
2.3	non-keyed message digest, public key cryptography	2

2.4	Diffie – Hellman and Elliptic curve cryptography	2
2.5	Comparison of public key crypto systems.	1
3	**Network Security Components:**	
3.1	Network security model	1
3.2	network intrusion protection and detection	1
3.3	Host based security,	1
3.4	virtual private networking, event correlation,	1
3.5	Wireless security components, secure configuration, secure authentication, encryption, wireless device placement.	1
4	**Integrating Wireless Access into the network security process:**	
4.1	Logging wireless events, policy issues	1
4.2	Accessing wireless network security	1
4.3	Change control and device administration	
4.4	Wireless security models, Cisco implementation with LEAP,	1
4.5	WLAN authentication and key management with radius,	2
4.6	Wireless access with IP security, secure wireless public access, secure wireless point to point connectivity.	3
5	**Hardware perspective for end to end security in wireless application:**	
5.1	Taxonomy of communication systems	1
5.2	protocol sensitive communication security	1
5.3	evolution towards wireless, hardware and software avenues	2
5.4	encryptor structures in wireless- interception and vulnerability of wireless systems	2
5.5	Communication ESMs and interception receivers, SAW technology.	2

Course Designers:

1. Dr.R.Sukanesh sukanesh@tce.edu
2. Dr.M.Suganthi msuganthi@tce.edu
3. Dr.T.Aruna taece@tce.edu

14CNPI0	MIMO OFDM SYSTEMS	Category	L	T	P	Credit
		PE	3	1	0	4

Preamble

High data rate wireless systems with very small symbol periods usually face unacceptable Inter-symbol interference (ISI) originated from multipath propagation and inherent delay spread. Orthogonal frequency division multiplexing (OFDM) is a multicarrier based technique for mitigating ISI to improve capacity in the wireless system with spectral efficiency. On the other hand, MIMO systems have rising attention of the wireless academic community and industry because their promise to increase the capacity and performance with acceptable bit error rate (BER) proportionally with the number of antennas. MIMO OFDM is an attractive air interface solution for next generation wireless local area networks and wireless metropolitan area networks and fourth generation mobile cellular wireless systems.

Prerequisite

Nil

Course Outcomes

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

CO1. Describe the concepts of MIMO OFDM Wireless communication systems.	Understand
CO2. Determine the capacity and bit error rate of MIMO OFDM system for a given power delay profile of the MIMO channel.	Apply
CO3. Obtain Impulse response coefficients from power delay profile of the SISO,SIMO,MISO and MIMO channels and estimate the channel impulse response using least square, MMSE and Robust MMSE estimation algorithms.	Apply
CO4. Estimate and correct the timing and frequency offset in the signal received in the MIMO OFDM receivers.	Apply
CO5. Analyze the performance of MIMO OFDM physical channel in Wi-Max/LTE wireless standards.	Apply

Mapping with Programme Outcomes

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

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	20	10	10	10
Understand	20	10	10	10
Apply	60	80	80	80
Analyse	0	0	0	0
Evaluate	0	0	0	0
Create	0	0	0	0

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Define Doppler spread.
2. Draw the block diagram of OFDM communication system.
3. Define spatial multiplexing.
4. Define null steering and optimal beamforming.
5. What are the gains available in MIMO systems?
6. Write the motivation behind using MIMO OFDM systems?
7. Distinguish between flat fading and frequency selective fading.
8. How complexity of MIMO OFDM spatial multiplexing receivers is reduced?

Course Outcome 2 (CO2):

1. In which systems, channel reciprocity becomes useful information.
2. Determine the channel capacity of SISO and SIMO systems.
3. Determine the channel capacity of MIMO system when CSI is known to the transmitter side and when CSI is not available at transmitter side.
4. Compare the detection performance of ZF and MMSE signal detection techniques in MIMO system.
5. Assume that two-branch diversity with BPSK modulation is used to transmit digital data. The received signals through the two diversity branches are given by, $y_i = \sqrt{\rho} h_i x + n_i \quad i = 1,2$ where y_i is the received signal, x is the transmitted signal (where $x = \pm$ with equal probability), and n_i is a zero mean (white) Gaussian noise with variance 1/2. Assume that the joint probability mass function of h_1 and h_2 is given by,

$$p_{h_1,h_2}(h_1,h_2) = \begin{cases} 0.1 & \text{if } h_1 = h_2 = 1, \\ 0.1 & \text{if } h_1 = 1, h_2 = 2, \\ 0.1 & \text{if } h_1 = 2, h_2 = 1, \\ 0.7 & \text{if } h_1 = 2, h_2 = 2 \end{cases}$$

   a. What is the probability of bit error if maximal ratio combining is used at the receiver?
   b. What is the probability of bit error if selection combining is used?

Course Outcome 3 (CO3):

1. Write a program to simulate SCM channel model.
2. Distinguish between block type and comb type pilot structures used for channel estimation.
3. A scattering function for a fading channel is given by S(τ, λ) = 1 if 0 ≤ τ ≤50 μs and |λ| < 5 Hz, and it is zero otherwise.
   c. Determine the mulltipath intensity profile of the channel. What is its Doppler power spectrum?.
   d. What are the multipath delay spread, Doppler spread, coherence time and coherence bandwidth of the channel?

e. Can we design a digital communication system such that this channel can be viewed as a slow frequency flat fading channel? If so, what should the symbol period be selected as?

4. Consider a deterministic MIMO channel (with AWGN) described by

$$H = \begin{bmatrix} j & 1-j & 1 & -0.5 \\ -0.3 & 0.4+0.1j & 1-j & j \\ 0.2j & 0 & -0.5+0.5j & 1 \\ 1 & -j & 1 & 1 \\ -j & 0.6+0.5j & 2 & -1 \end{bmatrix}$$

Using the singular value decomposition, determine the equivalent representation with parallel channels.

5. Consider a fixed physical environment and a corresponding flat fading MIMO channel. Now suppose, we double the transmit power constraint and the bandwidth. Argue that the capacity of the MIMO channel with receiver CSI exactly doubles. This scaling is consistent with that in the single antenna AWGN channel.

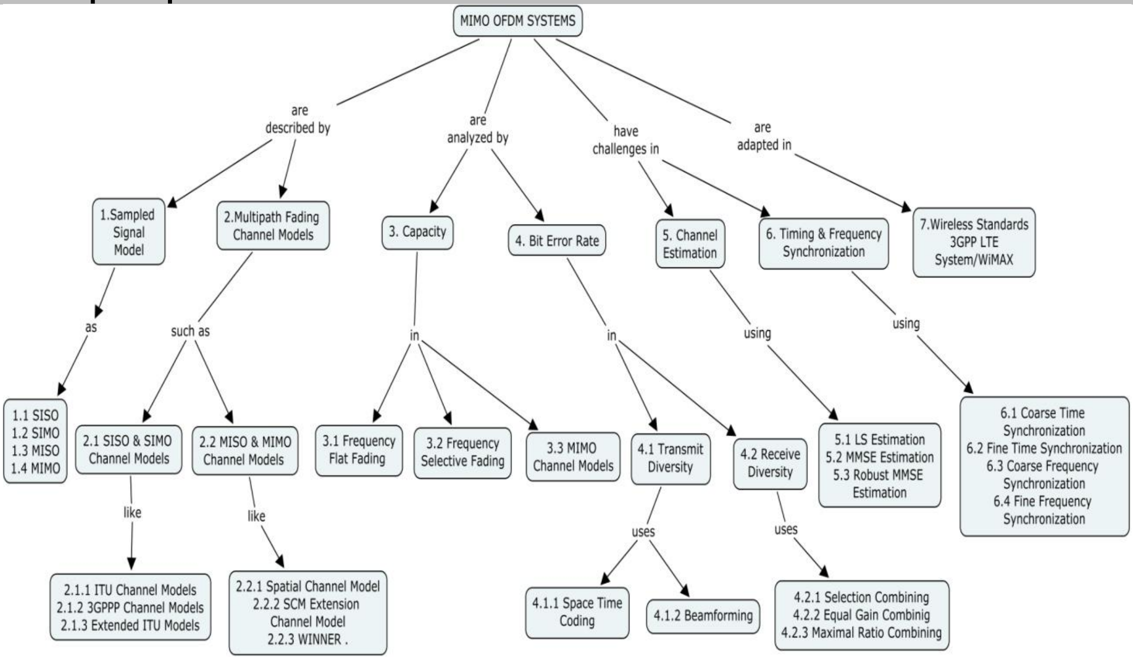
Course Outcome 4 (CO4):

1. Define inter symbol interference.
2. Analyze the effects of symbol time offset(STO) in OFDM systems.
3. Analyze the effects of integer frequency offset and fractional frequency in OFDM systems.
4. Discuss the synchronization technique using cyclic prefix in OFDM systems.
5. Compare the time domain and frequency domain synchronization techniques used in OFDM systems.

Course Outcome 5 (CO5):

1. Compare the frame structure of WiMAX and LTE standards.
2. Discuss the overview of basic system architecture configuration of LTE.
3. Design a MIMO-OFDM system that achieves an overall rate of 3 Mbps over a bandwidth of 200 kHz. Assume that Nt = 2, multipath spread Tm = 1 ms and Doppler spread BD = 10 Hz. Specify the OFDM symbol duration, the number of subcarriers, the length of cyclic prefix, and the modulation scheme used.

Concept Map



Syllabus

Sampled Signal Model: Signal model for SISO, SIMO , MISO and MIMO **Multipath Fading Channel Models**: ITU Channel Models, 3GPPP Channel Models , Extended ITU Models, Spatial Channel Model , SCM Extension Channel Model, WINNER Channel Model **Capacity Analysis:** Capacity in Frequency Flat Fading channel , Capacity in Frequency Selective Fading Channel **Bit Error Rate Analysis:** BER Analysis for Space Time Coding, Transmit Beamforming , Receiver Selection Combining, Receiver Equal Combining, Receiver Maximal Ratio Combining **Channel Estimation :** LS Estimation, MMSE Estimation, Robust MMSE Estimation **Timing & Frequency Synchronization :** Coarse Time Synchronization, Fine Time Synchronization, Coarse Frequency Synchronization, Fine Frequency Synchronization **Wireless Standards:** 3GPP LTE System, WiMAX

Reference Books

1. A. Paulraj, R. Nabar and D Gore, “Introduction to Space-Time Wireless Communications”, Cambridge University Press, 2003.
2. D.Tse and P. Viswanath, “Fundamentals of Wireless Communications”, Cambridge University Press, 2005 (First Asian Edition, 2006)
3. Y.S.Cho, J.Kim, Won Young Yang, Chung G. Kang, “ MIMO OFDM Wireless Communications with MATLAB” John Wiley & sons(Asia) private Ltd, 2010
4. L. Hanzo, Y.A. Li Wang, M. Jiang “MIMO-OFDM for LTE, Wi-Fi and WiMAX ”, John Wiley & Sons Ltd, 2011
5. T.M. Duman, A. Ghrayeb “Coding for MIMO Communication Systems” John Wiley & Sons Ltd, 2007,
6. E. Biglieri, R. Calderbank, A. Constantinides, A. Goldsmith, A. Paulraj, “MIMO Wireless communications” Cambridge University press, 2007
7. Erik. G. Larsson, “ Space Time Block Coding for Wireless Communications”, Cambridge University Press, 2003

Course Contents and Lecture Schedule

Module No.	Topic	No of lectures
1.	**Sampled Signal Model:** Signal model for SISO, SIMO	2
2.	Signal model for MISO, MIMO	2
3.	**Multipath Fading Channel Models**: SISO & SIMO Channel Models - ITU Channel Models	2
4.	3GPPP Channel Models, Extended ITU Models	2
5.	MISO & MIMO Channel Models **–** Spatial Channel Model, SCM Extension Channel Model	2
6.	WINNER Channel Model	1
7.	**Capacity Analysis:** Capacity in Frequency Flat Fading channel	3
8.	Capacity in Frequency Selective Fading channel	3
9.	**Bit Error Rate Analysis:** BER Analysis for Space Time Coding, Transmit Beamforming	4
10.	Receiver Selection Combining, Receiver Equal Combining	3
11.	Receiver Maximal Ratio Combining	2
12.	**Channel Estimation :** LS Estimation	2
13.	MMSE Estimation	3
14.	Robust MMSE Estimation	2
15.	**Timing & Frequency Synchronization :** Coarse Time	4

	Synchronization, Fine Time Synchronization	
16.	Coarse Frequency Synchronization, Fine Frequency Synchronization	4
17.	**Wireless Standards:** 3GPP LTE System	2
18.	WiMAX	2
	Total	45

Course Designers:

1. Dr.S.J. Thiruvengadam sjtece@tce.edu
2. Mrs.K.Rajeswari rajeswari@tce.edu

14CNPJ0	PHYSICAL LAYER LTE SYSTEMS	Category	L	T	P	Credit
		PE	3	1	0	4

Preamble

The course on the physical layer Long Term Evolution (LTE) systems is offered as an elective course in continuation with the course on ‘WT21 Space Time Wireless Communications”. LTE is a standard for wireless communication of high-speed data for mobile phones and data terminals. The goal of LTE was to increase the capacity and speed of wireless data networks using new digital signal processing techniques and modulations that were developed around the turn of the millennium. While the first mobile communications standards focused primarily on voice communication, the emphasis now has returned to the provision of systems optimized for data. This trend began with the 3rd Generation Wideband Code Division Multiple Access (WCDMA) system designed in the Third Generation Partnership Project (3GPP), and is now reaching fulfilment in its successor, known as LTE. LTE is the first cellular communication system optimized from the outset to support packet-switched data services, within which packetised voice communications are just one part. The objective of this course is to present the techniques for the design of physical layer LTE systems and determine its performance.

Prerequisite

Nil

Course Outcomes

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

CO1. Describe the FDD and TDD frame formats, physical signals and channels of downlink and uplink LTE systems.	Understand
CO2. Carry out the cell search using synchronization signals in LTE downlink and determine the channel frequency response using reference signals in downlink and uplink of LTE systems.	Apply
CO3. Characterize the modulation schemes such as OFDM,OFDMA and SC-FDMA schemes and describe the single user and multi user modulation techniques in LTE downlink and uplink systems.	Apply
CO4. Determine the bit error rate and outage probability performances of LTE downlink and uplink channels.	Apply
CO5. Characterize the downlink and uplink physical layer design in LTE.	Apply

Mapping with Programme Outcomes

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

S- Strong; M-Medium; L-Low

Assessment Pattern

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

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. List the physical control channels in LTE downlink systems
2. List out the features of downlink LTE System.
3. Define cyclic delay diversity.
4. Distinguish between physical signals and physical channels in LTE systems.
5. Draw the block diagram of LTE downlink channel processing
6. Draw the block diagram of LTE uplink channel processing

Course Outcome 2 (CO2):

a. Name the signals transmitted on each downlink component carrier for cell search and define their structure.
b. Describe the basic cell-search procedure used in LTE.
c. Obtain the shift register implementation of scrambling sequence generator using the polynomial $g(x)=1+x+x^3$
d. Explain how reference signals used for channel estimation are generated in LTE.

Course Outcome 3 (CO3):

1. Distinguish between OFDM and SC-FDMA
2. What is DFT spread OFDM system? How does it relate to SC-FDMA?
3. Distinguish between single user and multiuser MIMO techniques.
4. List the modulation schemes used for PUSCH.
5. Compute and compare the autocorrelation amplitudes for PN sequence and Zadoff-Chu sequence at a zero time lag.
6. Compute the autocorrelation profile of Zadoff-Chu sequence assuming that the frequency offset is 7.5 kHz and the root indexes are 25, 29 and 34.

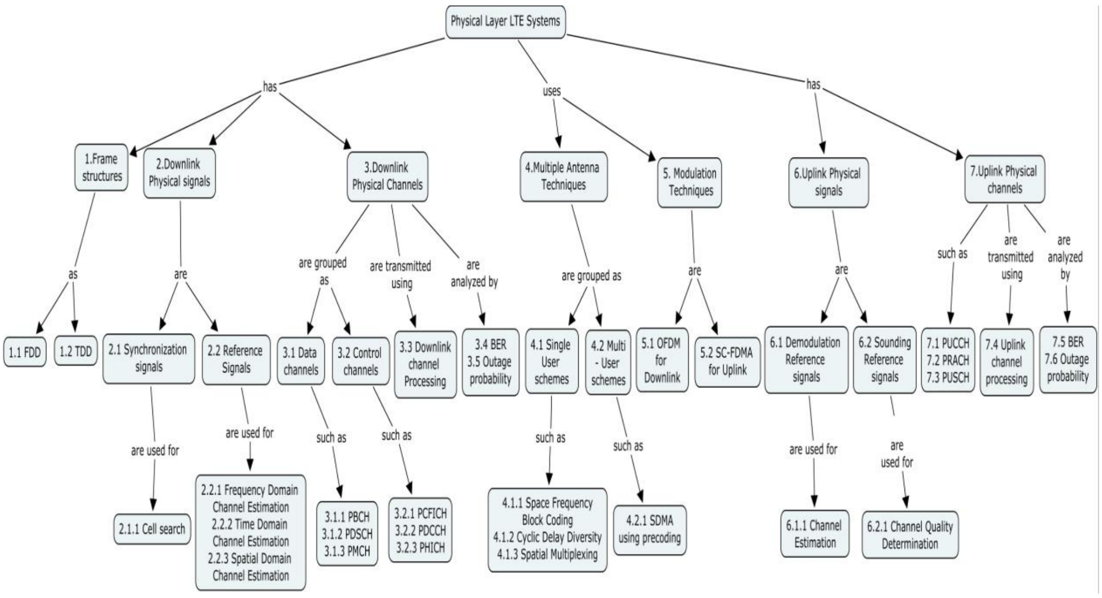
Course Outcome 4 (CO4):

1. Compute PRACH sub-carrier spacing for $800\mu s$ interval.
2. Determine the pairwise probability of PCFICH channel assuming that CFI can take values between 1 and 4.
3. Construct convolutional encoder used in LTE with m=6,n=3,k=1 and rate 1/3 for the generator polynomials $g_o=\{1011011\}, g_1=\{1111001\}, g_2=\{1110101\}$
4. Determine the bit error rate performance of LTE downlink PUSCH channel.
5. Determine the bit error rate performance of LTE uplink PUSCH channel.

Course Outcome 5 (CO5)

1. Design a transceiver for Physical Control Format Indicator Channel (PCFICH).
2. Design a transceiver for Physical Hybrid ARQ Indicator Channel (PHICH).
3. Design a transceiver for Physical Downlink Control Channel (PDCCH).

Concept Map



Syllabus

Frame structure: Frequency Division Duplexing, Time Division Duplexing **Downlink Physical signals:** Synchronization signals, Cell Search, Reference signals: Frequency Domain, Time domain and Spatial Domain channel estimations, **Downlink Physical channels:** Data channels-PBCH,PDSCH,PMCH, Control channels: PCFICH, PDCCH, PHICH, Downlink channel processing, BER and Outage probability, **Multiple Antenna Techniques:** Single user systems: Space Frequency Block coding, Cyclic Delay Diversity, Spatial Multiplexing, Multi user systems: Space Division Multiple Access(SDMA) using precoding, **Modulation Techniques:** OFDM for downlink, SC-FDMA for uplink, **Uplink Physical signals:** Demodulation Reference signals, channel Estimation, Sounding Reference signals, Channel Quality Determination, **Uplink Physical channels:** PUCCH,PRACH, PUSCH, Uplink channel processing, BER and Outage probability

Reference Books

1. 3GPP TS 36.211: "Evolved Universal Terrestrial Radio Access (E-UTRA); Physical channels and modulation", 2011
2. 3GPP TS 36.212: "Evolved Universal Terrestrial Radio Access (E-UTRA); Multiplexing and channel coding". 2011
3. 3GPP TS 36.213: "Evolved Universal Terrestrial Radio Access (E-UTRA); Physical layer procedures". 2011
4. Stefania Sesia, Issam Toufik, Matthew Baker, “LTE-The UMTS Long Term Evolution From theory to practice, John Wiley & Sons Ltd., 2009.
5. David Tse and Pramod Viswanath, “Fundamentals of Wireless Communications”, Cambridge University Press, 2005 (First Asian Edition, 2006)
6. Andrea Goldsmith, “ Wireless Communications”, Cambridge University Press, 2005
7. A.Paulraj, R. Nabar and D Gore, “Introduction to Space-Time Wireless Communications”, Cambridge University Press, 2003.

Course Contents and Lecture Schedule

Module No.	Topic	No. of Lectures
1	**Frame structure**	
1.1	Frequency Division Duplexing	1
1.2	Time Division Duplexing	1
2	**Downlink Physical signals:**	
2.1	Synchronization signals	1
2.1.1	Cell Search	2
2.2	Reference signals	1
2.2.1	Frequency Domain channel estimation	2
2.2.2	Time domain channel estimation	1
2.2.3	Spatial domain channel estimation	1
3	**Downlink Physical channels**	
3.1	Data channels	1
3.1.1	PBCH – Physical Broadcast Channel	1
3.1.2	PDSCH – Physical Downlink Shared Channel	1
3.1.3	PMCH – Physical Multicast Channel	1
3.2	Control channels	1
3.2.1	PCFICH – Physical Control Format Indicator Channel	1
3.2.2	PDCCH – Physical Downlink Control Channel	1
3.2.3	PHICH – Physical Hybrid ARQ Channel	1
3.3	Downlink channel processing	1
3.4	BER Analysis of Downlink physical Channels	2
3.5	Outage probability Analysis of Downlink Physical Channels	2
4	**Multiple Antenna Techniques:**	
4.1	Single user systems:	1
4.1.1	Space Frequency Block coding	2
4.1.2	Cyclic Delay Diversity	1
4.1.3	Spatial Multiplexing	1
4.2	Multi user systems:	1
4.2.1	Space Division Multiple Access(SDMA) using precoding	2
5	Modulation Techniques	
5.1	OFDM	2
5.2	SC-FDMA	2
6	**Uplink Physical signals**	
6.1	Demodulation Reference signals	1
6.1.1	channel Estimation	1
6.2	Sounding Reference signals	1
6.2.1	Channel Quality Determination	1
7	**Uplink Physical channels:**	
7.1	PUCCH – Physical Uplink Control Channel	2
7.2	PRACH – Physical Random Access Channel	1
7.3	PUSCH – Physical Uplink Shared Channel	1
7.4	Uplink channel processing	1
7.5	BER Analysis of Uplink physical Channels	2
7.6	Outage probability Analysis of Uplink Physical Channels	2
	Total	48

Course Designers:

1. Dr.S.J. Thiruvengadam sjtece@tce.edu
2. Dr.G. Ananthi gananthi@tce.edu

14CNPK0	RF MEMS

Category	L	T	P	Credit
PE	3	1	0	4

Preamble

The all pervasive use of wireless systems requires modules with ever increasing functionality, compactness and reduced power consumption. The performance of current RF (Radio Frequency) systems can be enhanced by replacing critical components by their micromechanical counterparts, MEMS (Micro Electro Mechanical Systems). This is a strong drive for developing RF MEMS units. The course will start by giving an overview of typical features of RF and wireless systems and describe central steps in MEMS micro machining. The functionality, modeling and implementation issues of central RF MEMS components are described. This comprises transmission lines, phase shifters, switches, capacitances, and inductors implemented by micromechanics. Special weight is laid on mechanical vibrating resonators and their use as filters. Also discusses conceptually the need for micromachining of antennas. The course concludes by giving a short overview of packaging and the usage of the MEMSCAD tools such as Intellisuite and Coventoreware.

Prerequisite

Nil

Course Outcomes

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

CO1. Understand the Concept of miniaturization and the need of MEMS in various applications	Remember
CO2. Understand the concepts of various actuation mechanisms of MEMS	Understand
CO3. Know the fundamental and technological possibilities and constraints when designing and implementing RF MEMS subsystems.	Apply
CO4. Understand Micro fabrication techniques	Undersatnd
CO5. Utilization of RF MEMS CAD software	Apply

Mapping with Programme Outcomes

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

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	20	20	20	20
Understand	20	20	20	20
Apply	60	60	50	50
Analyse	0	0	10	10
Evaluate	0	0	0	0
Create	0	0	0	0

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Compare Semiconductor and MEMS Switches.
2. Mention some MEMS softwares.
3. What is the role of magnetic core in the design of inductors?
4. How dielectric tunable capacitors are realized?
5. Define elasticity law.

Course Outcome 2 (CO2):

1. Tabulate the direct analogy of electrical and mechanical domains.
2. Why micromachining is essential for transmission lines?
3. Write down the applications of MEMS phase shifters.
4. Mention any two micromachining technique to improve antenna performance.
5. Classify MEMS packages.

Course Outcome 3 (CO3):

7. Design a RF MEMS shunt switch with an equivalent circuit approach operating at a frequency of 40 GHz.
8. Determine the Fragg frequency and the phase shift per unit length of a DMTL phase shifter at a frequency of 10 GHZ.

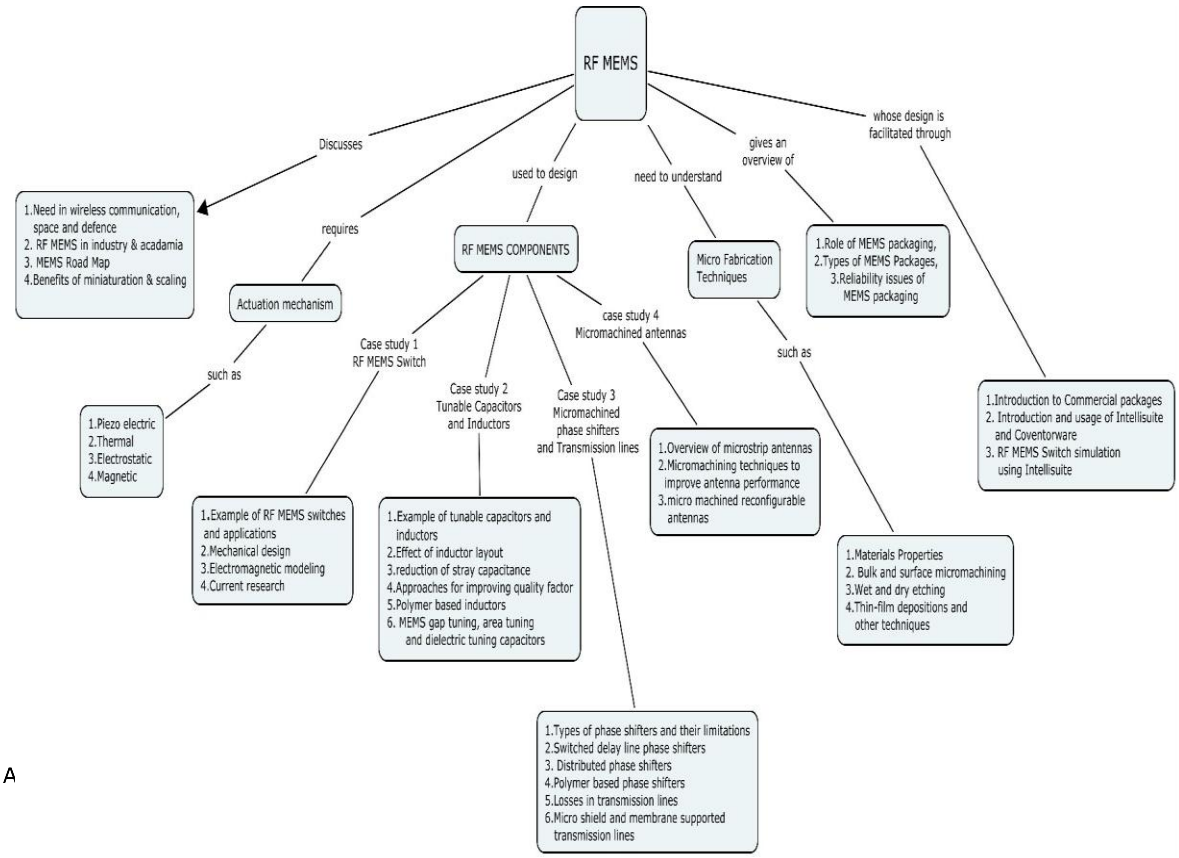
Course Outcome 4 (CO4):

1. Compare and contrast MEMS fabrication process flow with Conventional Integrated circuit process flow.
2. Tabulate and compare the performance parameters of a RF switch with MEMS Switches.

Course Outcome 5 (CO5):

1. 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.

Concept Map



Syllabus

RF MEMS: Introduction to RF MEMS: Application in wireless communications, space and defense applications, Benefits of Miniaturization and Scaling, RF MEMS in industry and academia, **Actuation Mechanisms in MEMS**: Piezoelectric, Electrostatic, Thermal, Magnetic, **RF MEMS Components: *Case study 1*:MEMS Switch,** Example of RF MEMS switches and applications, Mechanical design, Electromagnetic modeling (Capacitance, Loss, Isolation), Current research ***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 and Transmission lines:** Types of phase shifters and their limitations, MEMS phase shifters: Switched delay line phase shifters, Distributed phase shifters, Polymer based phase shifters, Losses in transmission lines , Micro shield and membrane supported transmission lines ***Case study 4:*** **Micromachined antennas:** Overview of microstrip antennas, Micromachining techniques to improve antenna performance, micro machined reconfigurable antennas, **Micro fabrication Techniques:** Materials Properties, Bulk and surface micromachining, Wet and dry etching Thin-film depositions (LPCVD, Sputtering, Evaporation), other techniques (LIGA, Electroplating),**Packaging of RF MEMS :** Role of MEMS packaging, Types of MEMS Packages, Reliability issues of MEMS packaging. **Computer aided design of MEMS:** Introduction to Commercial packages, Introduction and usage of Intellisuite and Coventorware, RF MEMS Switch simulation using Intellisuite.

Reference Books

1. Vijay K Varadhan, K.J.Vinoy, “RF MEMS and their Applications”, John Wiley & Sons, 2003.
2. G.K.Anantha Suresh, K.J.Vinoy, K.N.Bhatt, V.K.Aatre, “Micro and Smart systems”, John Wiley & Sons, 2010.

Course Contents and Lecture Schedule

Module No.	Topic	No. of Lectures
	RF MEMS	
1	**Introduction to RF MEMS**:	
1.1	Application in wireless communications, space and defense applications	1
1.2	Benefits of Miniaturization and Scaling, MEMS road map	1
1.3	RF MEMS in industry and academia	1
2	**Actuation Mechanisms in MEMS**	1
2.1	Piezoelectric, Electrostatic	1
2.2	Thermal, Magnetic	1
3	**RF MEMS Components**	
3.1	***Case study 1*: RF MEMS Switches**	
3.1.1	Example of RF MEMS switches and applications	1
3.1.2	Mechanical design	1
3.1.3	Electromagnetic modeling (Capacitance, Loss, Isolation)	3
3.1.4	Current research in MEMS switches	1
3.2	***Case study 2*: Tunable Capacitors and Inductors**	
3.2.1	Example of tunable capacitors and inductors and their	2

	applications in circuits	
3.2.2	Effect of inductor layout, reduction of stray capacitance of planar inductor	1
3.2.3	Approaches for improving quality factor, Polymer based inductors	2
3.2.4	MEMS gap tuning, area tuning and dielectric tuning capacitors	2
3.3	***Case study 3*: Micromachined phase shifters and Transmission lines**	2
3.3.1	Micro shield and membrane supported transmission lines	1
3.3.2	Types of phase shifters and their limitations	1
3.3.3	MEMS phase shifters: Switched delay line phase shifters, Distributed phase shifters, Polymer based phase shifters	3
3.3.4	Losses in transmission lines	1
3.3.5	Micro shield and membrane supported transmission lines	1
3.4	***Case study 4:* Micromachined Antennas**	
3.4.1	Overview of microstrip antennas	1
3.4.2	Micromachining techniques to improve antenna performance	1
3.4.3	Micro machined reconfigurable antennas	1
4	**Micro fabrication Techniques:** Materials Properties, Bulk and surface micromachining	1
4.1	Wet and dry etching Thin-film depositions (LPCVD, Sputtering, Evaporation), other techniques (LIGA, Electroplating)	1
5	**Packaging of RF MEMS:** Role of MEMS packaging	1
5.1	Types of MEMS Packages	2
5.2	Reliability issues of MEMS packaging	1
6	**Computer aided design of MEMS:** Introduction to Commercial packages, Introduction and usage of Intellisuite and Coventorware	3
	RF MEMS Switch simulation using Intellisuite.	3
	Total	46

Course Designers:

4. Dr.S.Kanthamani skmece@tce.edu

14CNPL0	VIDEO SURVEILLANCE SYSTEMS

Category	L	T	P	Credit
PE	3	1	0	4

Preamble

The purpose of this course is to provide an insight to the fundamental theory and techniques for efficient representation, processing of video signals and the applications of digital video. This course covers essential topics including motion analysis and video tracking. This provides a formal problem formulation for video tracking and typical challenges that make video tracking difficult. Also it discusses current and emerging applications of video tracking. Also covers video processing applications on such diverse topics as video surveillance, face tracking and recognition from video, motion tracking in medical videos, and using video to assist speech recognition.

Prerequisite

Nil

Course Outcomes

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

CO1. Apply motion segmentation and video tracking	Apply
CO2. Apply video tracking algorithms for intelligent surveillance and medical applications	Apply
CO3. Analyze different background subtraction techniques for different scenario	Analyze
CO4. Examine the ideas behind intelligent surveillance and medical applications	Apply
CO5. Analyze to choose right sensor for the right job	Analyze

Mapping with Programme Outcomes

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

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	20	20	20	20
Understand	40	40	20	20
Apply	40	40	40	40
Analyse	0	0	20	20
Evaluate	0	0	0	0
Create	0	0	0	0

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Define auto focus.
2. List the world wide video standards.
3. Define motion compensation.
4. List the main components of video tracking.
5. Define shutter speed.

Course Outcome 2 (CO2):

1. Compare CCD vs CMOS Sensors, Interlaced vs Progressive scan.
2. Discuss about the different color models for video.
3. How cameras are functioning?
4. Compare different type of sensors such as indoor vs outdoor, Thermal vs infrared.
5. How video tracker overcomes the challenges when it track multiple targets?

Course Outcome 3 (CO3):

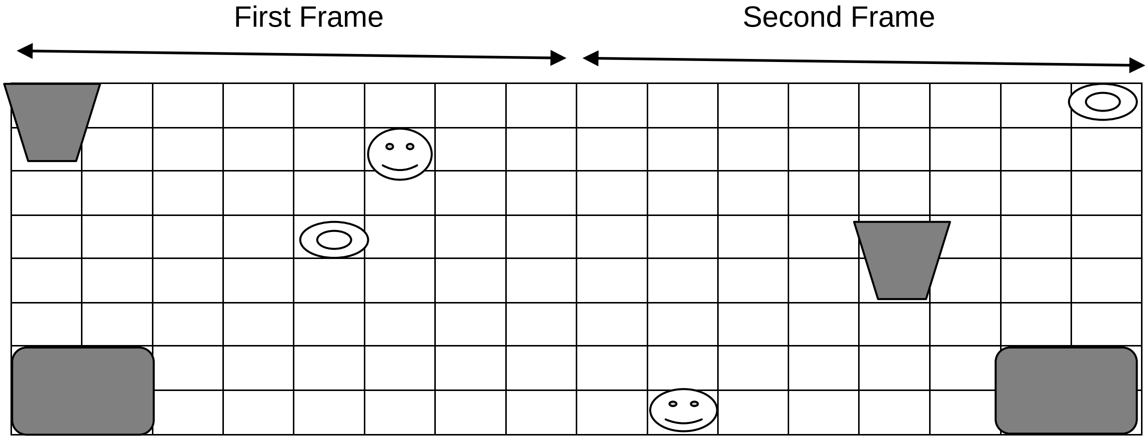
1. For the following colors in the RGB coordinate, determine their values in the YIQ and YUV coordinates, respectively.
    a. (1,1,1); (b) (0,1,0); (c) (1,1,0); (d) (0, 1,1).
2. How is video tracker applied to medical applications?
3. State different approaches for background subtraction
4. Design and analyze the suitable algorithm for multiple target tracking.
5. Color or feature affects the background subtraction results. Analyze it.

Course Outcome 4 (CO4):

1. Discuss image differencing and background subtraction algorithms for foreground segmentation.

2. Apply the suitable algorithm for tracking unmanned vehicle.
3. Analyze the video surveillance hardware for different applications.
4. Describe the components of knight multi camera surveillance system.
5. i) Sketch the Exhaustive search block based motion estimation and deformable block based motion estimation. With EBMA, does the computational requirement depend the block size? Reason it. Also, how Deformable block matching algorithm is used to describe affine and bilinear models.

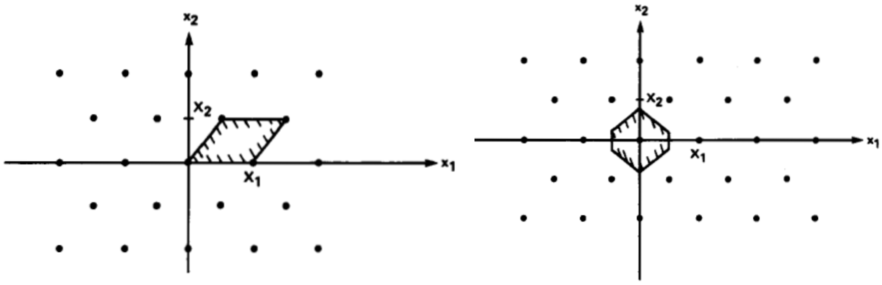
    ii) For the following frames, obtain the motion vector for the motion compensated prediction. Obtain the motion vector for the following four objects. Consider First 8X8 as Frame I and second 8X8 as Frame II.



Course Outcome 5 (CO5):

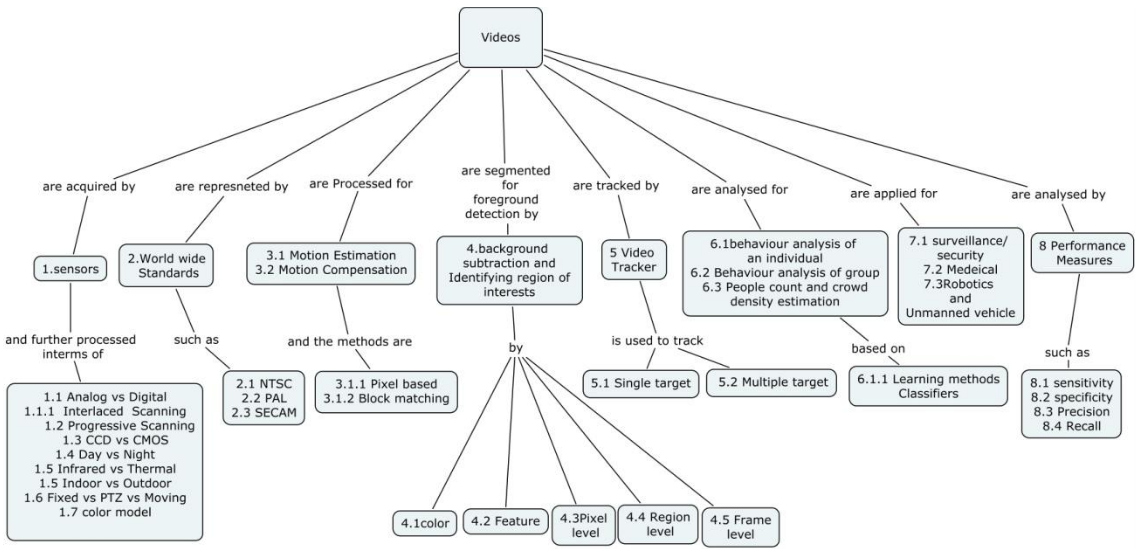
1. Design a video tracker for single target tracking and multiple target tracking. How will you overcome the challenges of a tracker?

2. How Mubarak shah's background subtraction algorithm gives solutions for global illumination changes, initialization of background model with moving objects present in the scene and repositioning of static background objects?
3. Demonstrate blob based people count and crowd density estimation is better than pixel based method? Illustrate the blob selection using shape, size and location?
4. Illustrate the video surveillance issues are formulated for medical and robotics applications?
5. Obtain the basis vectors and sampling density for the following.



Illustrate how voronoi unit cell is determined by drawing equidistant lines. With neat sketch discuss sampling and reconstruction system, spatio temporal sampling structures, multi dimensional sampled signals, frequency domain analysis and applications of sampling.

Concept Map



Syllabus

Digital video overview –Analog vs Digital, Analog to Digital, World wide Video Standards (NTSC, PAL, SECAM), Interlaced and Progressive Scan, Resolution, Color models in video- YUV,YIQ,YCbCr, Motion Analysis- Motion estimation (Pixel based and block matching based), motion compensation- **Digital Video Hardware:** How cameras work, Refraction, optics, F- Stop, Shutter speed, Depth of field, Digital image sensors- CCD vs CMOS, Manual, auto focus, power requirements, Day and night cameras, Infra red and thermal technologies, Indoor/ Outdoor cameras, Fixed/PTZ/ Moving cameras, CCTV **Motion Segmentation-** Background subtraction**,** Identifying region of interest in image sequences, Challenges, background subtraction using color or feature, Pixel level processing, Region level Processing. Frame level processing **Video Tracking-** Design of Video Tracker-Challenges- Main Components- Single Target Tracking- Multiple Target Tracking- Interactive vs automated target tracking- **Behaviour Analysis of individuals** Learning based behavior analysis- SVM learning- Behaviour analysis of human groups- People count and crowd density estimation **Applications** –surveillance- Architecture of Automated video surveillance system- Components of knight multi camera surveillance system medical applications – Robotics and unmanned vehicles **-** Performance Measures- Sensitivity, Specificity, Precision, Recall- Confusion Matrix

Reference Books

1. Essential Guide to Video Processing by Al Bovik, Academic Press, 2009
2. Digital Video Surveillance and security by Anthony C Caputo, Elsevier Inc, 2010
3. Video Tracking – Theory and Practice by Emilio Maggio, Andrea Cavallaro, John Wiley and Sons pvt Ltd, 2011
4. Automated Multi camera Video Surveillance Algorithms and Practice, Omar Javed, Mubarak Shah, Springer, 2008
5. Intelligent Surveillance Systems by Huihuan Qian, Xinyu Wu, Yangsheng Xu, Springer, 2011

Course Contents and Lecture Schedule

Module No.	Topic	No. of Lectures
1	**Digital video overview** –Analog vs Digital,	1
1.1	Analog to Digital, Interlaced and Progressive Scan, Resolution	1
1.1.1	Color models in video- YUV,YIQ,YCbCr,	1
1.2	**Digital Video Hardware,** How cameras work	1
1.3	Refraction, optics, F- Stop, Shutter speed, Depth of field	2
1.4	Digital image sensors- CCD vs CMOS,	1
1.5	Manual, auto focus, power requirements	1
1.6	Day and night cameras , Infra red and thermal technologies	1
1.7	Indoor/ Outdoor cameras, Fixed/PTZ/ Moving cameras, CCTV	1
2	World wide Video Standards, (NTSC, PAL, SECAM)	1
3	Motion Analysis- Motion estimation (Pixel based, Block matching based), motion compensation	1
4.	**Motion Segmentation-** Background subtraction	1
4.1	Identifying region of interest in image sequences	1
4.2	Challenges	1
4.3	background subtraction using color or feature	1
4.4	Pixel level processing	1
4.5	Region level Processing	1
4.6	Frame level processing	1
5	**Video Tracking-** Design of Video Tracker	1
5.1	Challenges- Main Components	1
5.2	Single Target Tracking	1
5.3	Multiple Target Tracking	1
6	Behaviour Analysis of individuals	2
6.1	Learning based behavior analysis	2
6.2	SVM learning	2
6.3	Behaviour analysis of human groups	2
6.4	People count and crowd density estimation	2

Module No.	Topic	No. of Lectures
7	**Applications**	1
7.1	Surveillance and security	1
7.2	Architecture of Automated video surveillance system	2
7.2.1	Components of knight multi camera surveillance system	2
7.3	medical applications	1
7.4	Robotics and unmanned vehicles	2
8	Performance Measures	1
8.1	Sensitivity, Specificity, Precision, Recall	2
8.2	Confusion Matrix	1
	Total	46

Course Designers:

1. Dr.B. Yogameena, ymece@tce.edu

14CNPM0	NETWORK MANAGEMENT

Category	L	T	P	Credit
PE	3	1	0	4

Preamble

Network Management is the discipline which studies the theoretical, practical and managerial aspects of managing communication networks. The course will enable the students to familiarize the various aspects of network management: Need for management of complex networks; monitoring using tools; manager/agent model of remote management; the Internet management protocols - SMI, MIBs, SNMP, MIB design case studies; TMN architecture, design and Implementation of NMS tools and platforms.

Prerequisite

NIL

Course Outcomes

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

CO1	Classify and analyze the different types of network management	Create/Analyze
CO2	Analyze the operation of the different version of SNMP protocol	Analyze
CO3	Implement the SNMP protocol through Remote Monitoring(RMON)	Create
CO4	Manage the broadband network such as ATM and ADSL technologies	Evaluate
CO5	Configure different network management applications	Design

Mapping with Programme Outcomes

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

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	30	20	0	0
Understand	40	40	40	40
Apply	30	40	30	30
Analyse	0	0	30	30
Evaluate	0	0	0	0
Create	0	0	0	0

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. What are the standards used for the various layers in an Ethernet based network that is managed by the Internet management protocol?
2. Describe the ordered list in ASN.1 syntax.

3. Define the terms MIB and SMI.
4. Describe the function of network mask.
5. Mention the MIBs for TCP and UDP.
6. Identify the OBJECT TYPE for the address of the neighboring gateway from your local gateway.

Course Outcome 2 (CO2):
1. Identify the top challenges in managing the network.
2. Why do you require an NMS?
3. Distinguish the database of the network management system wit its MIB. How do you implement each in a network management system?
4. Encode IP address 10.20.30.40 in TLV format.
5. Explain how you would determine whether a device is acting as a host or as a router using an SNMP command.
6. How would you use one of the standard MIB objects to determine which of the stations?

Course Outcome 3 (CO3):
1. You are given a class B IP address of 145.45.x.y for your network node. As a network engineer, you are asked to configure your network for 126 subnets.
    - How would you configure your address for subnets and hosts?
    - What is the maximum number of hosts that each subnet can accommodate?
2. Design Ethernet LAN using 10/100 Mbps switched Ethernet hub to handle the following the situations: No. of clients = 16 operating at 10Mbps, No. of server = 1, 50% of the traffic is directed to the server

    Draw the configuration and indicate the transmission modes on the ports.
3. Write the object DESCRIPTOR and syntax of the following SNMP managed entities: IP address, A row in the interface table, The MAC address of the interface card.
4. FDDI is heavily used as a backbone network in a corporate complex.
    - Draw a MIB tree for FDDI MIB. Limit your tree to the top five groups.
    - Develop a three-column table presenting entity, OID, and brief descriptions of the groups and the tables under each group.
5. Draw the message sequence diagram for the hub. Assume that a separate get-request message is sent for each data value.

Course Outcome 4 (CO4):
1. An NMS connected to an Ethernet LAN is monitoring a network of 10000 nodes comprising routers, hubs, and workstations. It sends an SNMP query to each station once a minute and receives a response when the stations are up. Assume that an average frame size is 1000 bytes long for get-request and response messages.
    - What is the traffic load on the LAN that has the NMS?

    If the Ethernet LAN operates at a maximum efficiency of 40% throughput, what is the overhead due to network monitoring?
2. As a network engineer in an NOC, how will you use the basic monitoring tools to validate the problems (if you do not have network monitoring system)
    - Customer says that periodically the messages he receives are missing some characters.
    - A customer in Atlanta complains that when she tries to log into the system in New York, she gets disconnected with a timeout. However, her colleague in her New York office reports that she is able to access the system.
3. The engineering department of 12 persons in a small corporation is on a regular 10Base-T Ethernet LAN hub with 16 ports. The busy group started complaining because of the slow network performance. The network was operating at 50% utilization, whereas 30% utilization is acceptable. How will you resolve the problem technically?
4. Consider a network of multi vendor components (hubs, routers, etc.,). The network is

managed by a general purpose NMS.

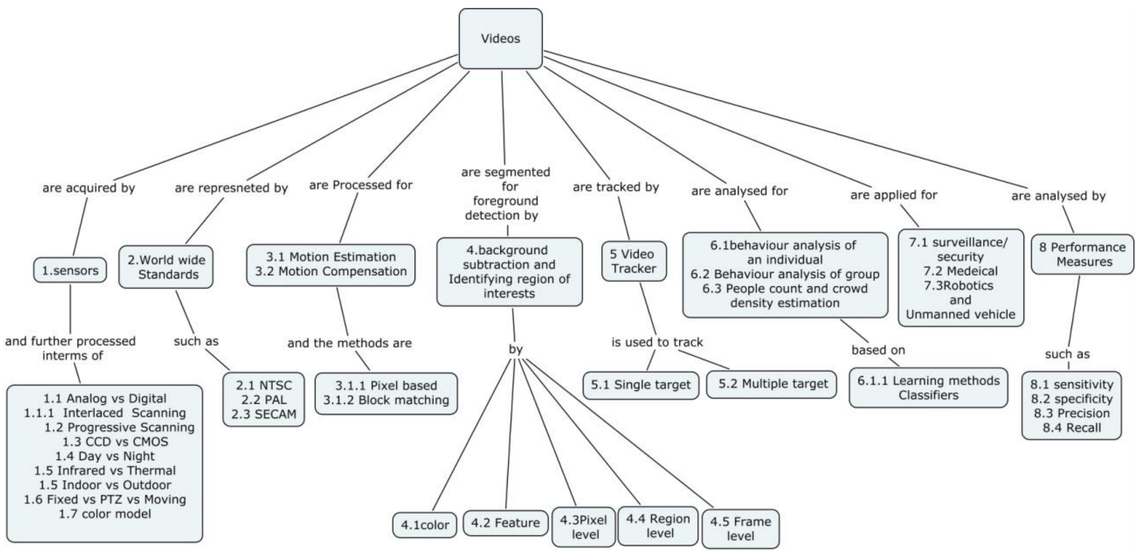
- Draw a two-tier management network that performs configuration and fault management.
- Explain the rational for your configuration.
- Compare the requirements if configuration is a three-tier configuration.

Course Outcome 5 (CO5):

1. If you add anew vendor's components with its own NMS to an existing network managed by a different NMS. Identify the sets of functions that you need to do to fulfill your task.
2. Two identical token rings with the same number of stations operate at different efficiencies. One operates at a higher efficiency than the other. You suspect that this difference is due to the different frame sizes of the data frames in the two rings.
    - Why would you suspect the frame size?
    - How would you use RMON to prove your suspicion?
    - How would you measure the types and distribution of frames in a token ring LAN?

3. Communication between two ATM switches is broken in a private ATM network. You are troubleshooting the problem from a network management station. What M interfaces would you use?

Concept Map



Syllabus

Syllabus: Data Communication and Network Management Overview – Analogy of Telephone Network Management, Data and Telecommunication Network, Case histories of networking and management, Network Management – Goals, organization and functions **SNMP Management** – Basic foundations, standards, models and language **SNMPv1** – Managed network - Case study, Internet organization and standards, SNMP model - organization, information communication and functional model **SNMPv2** - Major changes, system architecture Structure of management information, Information Modules, definitions and conventions, Management Information Base **RMON –** SMI and MIB, RMON1, RMON2, ATM remote monitoring, case study. **Broadband Network Management –** Networks and services, ATM technology, ATM network management, ADSL management, **Telecommunication Management Network -** TMN conceptual model, standards, Management service architecture **Management tools and applications** - Tools, analyzer, network statistics measurement systems, NMS, system management and network management applications - configuration management, Fault and performance management, Security and Report management

Reference Books

1. Mani Subramanin, “Network Management - Principles and Practice”, Pearson Education, Fourth Edition, 2007.
2. William Stallings, “SNMP, SNMPv2, SNMPv2 and RMON1 and RMON2”,Addison Wesley, Third Edition, 2004
3. Divakara K.Udupa, “TMN Telecommunications Management Network”, McGraw-Hill, Fourth Edition,2003.
4. Stephen.B.Morris, “Network Management, MIBs and MPLS: Principles, Design and Implementation”, Prentice Hall, 2003.
5. Franz-Joachin Kauffels, “Network Management: Problems, Standards, Strategies” Addison Wesley, Second Edition, 1992
6. S.Paul, “SNMP Network Management”, MGH, 1999.

Course Contents and Lecture Schedule

Module No.	Topics	No of Lectures
1	**Data Communication and Network Management Overview**	
1.1	Analogy of Telephone Network Management, Data and Telecommunication Network	1
1.2	Case histories of networking and management	1
1.3	Network Management – Goals, organization and functions	1
2	**SNMP Management**	
2.1	Basic foundations, standards, models and language	2
2.2	**SNMPv1:** Managed network-Case study, Internet organization and standards	2
2.3	SNMP model – organization and information model	2
2.4	communication and functional model	2
2.5	**SNMPv2**: Major changes, system architecture	1
2.6	Structure of management information, Information Modules, definitions and conventions	2
2.8	SNMPv2 Management Information Base	2
3	**RMON**	
3.1	SMI and MIB	2
3.2	RMON1, RMON2	1

3.3	ATM remote monitoring, case study	2
4	**Broadband Network Management**	
4.1	Networks and services	1
4.2	ATM technology	1
4.3	ATM network management	1
4.4	ADSL management	1
5	**Telecommunication Management Network**	
5.1	TMN conceptual model, standards	1
5.2	Management service architecture	2
6	**Management tools and applications**	
6.1	Tools and analyzer	2
6.2	Network statistics measurement systems	2
6.3	NMS	2
6.3	system management	1
6.4	Applications – configuration management	1
6.4	Fault and performance management	1

Course Designers:

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

14CNPN0	BASEBAND ALGORITHMS ON FPGA	Category	L	T	P	Credit
		PE	3	1	0	4

Preamble

This course provides the students, the knowledge about implementation of Communication blocks on FPGA. It provides both the fixed point and floating point representation of data used for implementation. It considers algorithms and techniques for the optimal way of implementing the communication system blocks efficiently on FPGA.

Prerequisite

NIL

Course Outcomes

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

CO1. Compute nontrivial (transcendental) algebraic functions using CORDIC algorithm.	Apply
CO2. Write a VHDL/VerilogHDL program for FIR Filter using distributed arithmetic	Apply
CO3. Design and implement filter with pipelining and/or parallel processing.	Create
CO4. Explain the different types of FFT algorithms including Cooley-Tukey, Winograd and Good-Thomas .	Create
CO5. Implement FFT algorithms using Hardware Description languages .	Synthesis

Mapping with Programme Outcomes

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

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	30	20	20	20
Understand	40	30	30	30
Apply	30	40	30	30
Analyse	0	0	0	0
Evaluate	0	0	0	0
Create	0	10	20	20

Course Level Assessment Questions

Course Outcome 1 (CO1):

1 List out the sequence of steps involved to design an FPGA
2 Define LNS
3 Mention the advantages of an FPGA to meet the requirements of DSP technology.
4 State Bluestein chirp Z algorithm
5 Define Clock skew
6 State the properties of FIR filter

Course Outcome 2 (CO2):

1 Draw the design flow of FPGA
2 Convert the given decimal number 15 into equivalent optimal CSD
3 Explain the function of pipelined adder with neat diagram
4 Illustrate DA algorithm in VHDL coding
5 Explain in detail about the designing of FIR filter
6 Predict equivalent CSD coding for the decimal number 15.

Course Outcome 3 (CO3):

1 Calculate the number of bits necessary to represent the integer numbers having range -10 to -5.
2 Compute the number of multiplications and additions required to implement 12 point FFT using Cooley-Tucky.
3 Calculate the Eigen value and Eigen vectors for the given network
4 Consider the radix-2 9-bit LNS word with two sign-bits, 3 bits for integer precision and 4 bit for fractional precision. Compute the real number for the LNS coding 00011.0010.
5 Find the transfer function of second order IIR filter having poles at 0.5 and 0.25 using 2 pipelined stages by applying scattered Look-ahead method.
6 Consider the quadratic equation $x^2 \equiv (-1) \bmod 13$ has two roots: j =5 and j=-5 $\equiv$ 8 mod 13. Calculate the multiplication using QRNS of the complex numbers 2+j and 3+j2. Represent in CRNS domain.

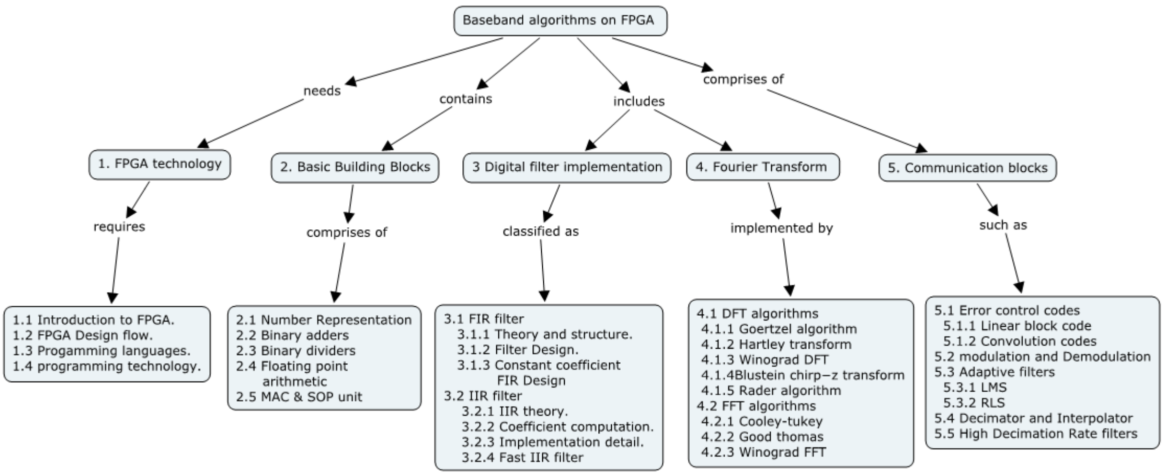
Course Outcome 4 (CO4):

1. Design and implement VHDL coding for an universal modulator
2. Construct the signal flow graph of FFT for N=12 using Good-Thomas FFT algorithm
3. Design and Implement FIR filter using signed DA algorithm
4. Design an parallel processing IIR to implement efficiently on FPGA
5. Design and implement viterbi decoder
6. Construct 2 stage pipelined IIR filter having poles at 0.5 and 0.75.

Course Outcome 5 (CO5):

1. Design and implement VHDL coding of FFT for N=12 using Good-Thomas FFT algorithm
2. Design and implement VHDL code for viterbi decoder

Concept Map



Syllabus

FPGA Technology : Introduction to FPGA, FPGA Design flow, Progamming languages, programming technology **Basic Building Blocks:** Number Representation, Binary adders, Binary dividers, Floating point arithmetic, MAC & SOP unit **Digital filter implementation: FIR filter,** Theory and structure, Filter Design, Constant coefficient, FIR Design **IIR filter,** IIR theory, Coefficient computation, Implementation detail, Fast IIR filter **Fourier Transform:** DFT algorithms, Goertzel algorithm, Hartley transform, Winograd DFT, Blustein chirp−z transform, Rader algorithm, FFT algorithms, Cooley-tukey, Good thomas, Winograd FFT **communication blocks:** Error control codes, Linear block code, Convolution codes, Modulation and Demodulation, Adaptive filters, LMS, RLS, Decimator and Interpolator, High Decimation Rate filters.

Reference Books

1. Uwe.Meyer-Baese, “Digital Signal Processing with Field Programmable Gate Arrays”, Springer, Third edition, May 2007
2. Keshab K. Parhi, “VLSI Digital Signal Processing systems, Design and implementation”, Wiley, Inter Science, 1999
3. John G. Proakis, “Digital Communications,” Fourth Ed. McGraw Hill International Edition, 2000.
4. Michael John Sebastian Smith, “ Applications Specific Integrated Circuits”, Pearson Education, Ninth Indian reprint,13th edition,2004.
5. Sophocles J. Orfanidis, “Introduction to Signal Processing”, Prentice Hall, 1996

Course Contents and Lecture Schedule

Module No.	Topic	No. Of Lectures
1.	**FPGA Technology**	
1.1	Introduction to FPGA.	1
1.2	FPGA Design flow.	1
1.3	Progamming languages.	1
1.4	programming technology.	1
2	**Basic Building Blocks**	
2.1	Number Representation	1

2.2	Binary adders	2
2.3	Binary dividers	1
2.4	Floating point arithmetic	3
2.5	MAC & SOP unit	2
3	**Digital filter implementation**	
3.1	**FIR filter**	
3.1.1	Theory and structure.	2
3.1.2	Filter Design.	1
3.1.3	Constant coefficient	2
3.1.4	FIR Design	1
3.2	**IIR filter**	
3.2.1	IIR theory.	1
3.2.2	Coefficient computation.	1
3.2.3	Implementation detail.	1
3.2.4	Fast IIR filter	1
4	**Fourier Transform**	
4.1	DFT algorithms	2
4.1.1	Goertzel algorithm	1
4.1.2	Hartley transform	2
4.1.3	Winograd DFT	1
4.1.4	Blustein chirp−z transform	2
4.1.5	Rader algorithm	1
4.2	FFT algorithms	
4.2.1	3.2.1 Cooley-tukey	2
4.2.2	3.2.2 Good thomas	2
4.2.3	3.2.3 Winograd FFT	2
5	**Communication blocks**	
5.1	Error control codes	2
5.1.1	Linear block code	2
5.1.2	Convolution codes	2
5.2	Modulation and Demodulation	1
5.3	Adaptive filters	1
5.3.1	LMS	1
5.3.2	RLS	1
5.4	Decimator and Interpolator	1
5.5	High Decimation Rate filters	1

Course Designers:

1.Dr.S. Rajaram rajaram_siva@tce.edu

2.Mr.V. Vinoth thyagarajan vvtece@tce.edu

14CNPO0	RF TEST AND MEASUREMENT	Category	L	T	P	Credit
		PE	3	1	0	4

Preamble

RF and wireless communication is becoming the standard in everyday devices design. In addition, the convergence of technologies has increased opportunities and challenges in the field of RF testing and measurements. The purpose of this course is to expose the students to the basics of traditional RF measurement techniques applied to RF components, antenna and Electromagnetic Interference and Compatibility. One of the main competencies that a present day RF and microwave measurement engineer has to posses is the capability to understand the RF parameters suitability of RF equipment for respective RF test and measurements. This course presents the fundamentals of RF and microwave power measurements, which tends to be timeless, and the modern RF measurement techniques and test equipment which represents the current state-of-the-art.

Prerequisite

Nil

Course Outcomes

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

CO1. Explain the basics of RF measurement and related parameters associated with the sample such as transmission line, RF components and EMI/EMC	Remember
CO2. Explain the measurement techniques and procedure	Understand
CO3. Experience testing of RF components/ systems and measurement of electromagnetic emission	Apply
CO4. Test, analyze and validate the performance of RF components and systems	Analyze
CO5. Understand and analyze the issues with EMI/EMC through RF testing	Analyze

Mapping with Programme Outcomes

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

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	30	30	20	20
Understand	40	30	40	40
Apply	30	40	40	40
Analyse	0	0	0	0
Evaluate	0	0	0	0
Create	0	0	0	0

Course Level Assessment Questions

Course Outcome 1 (CO1):

1 State the basic principle involved in RF measurement
2 Name some of the standard connectors used in RF testing
3 What are scattering parameters?
4 List some of the power measurement technique.
5 State the effects of environment on cellular phone?
6 State the need for compatibility test?

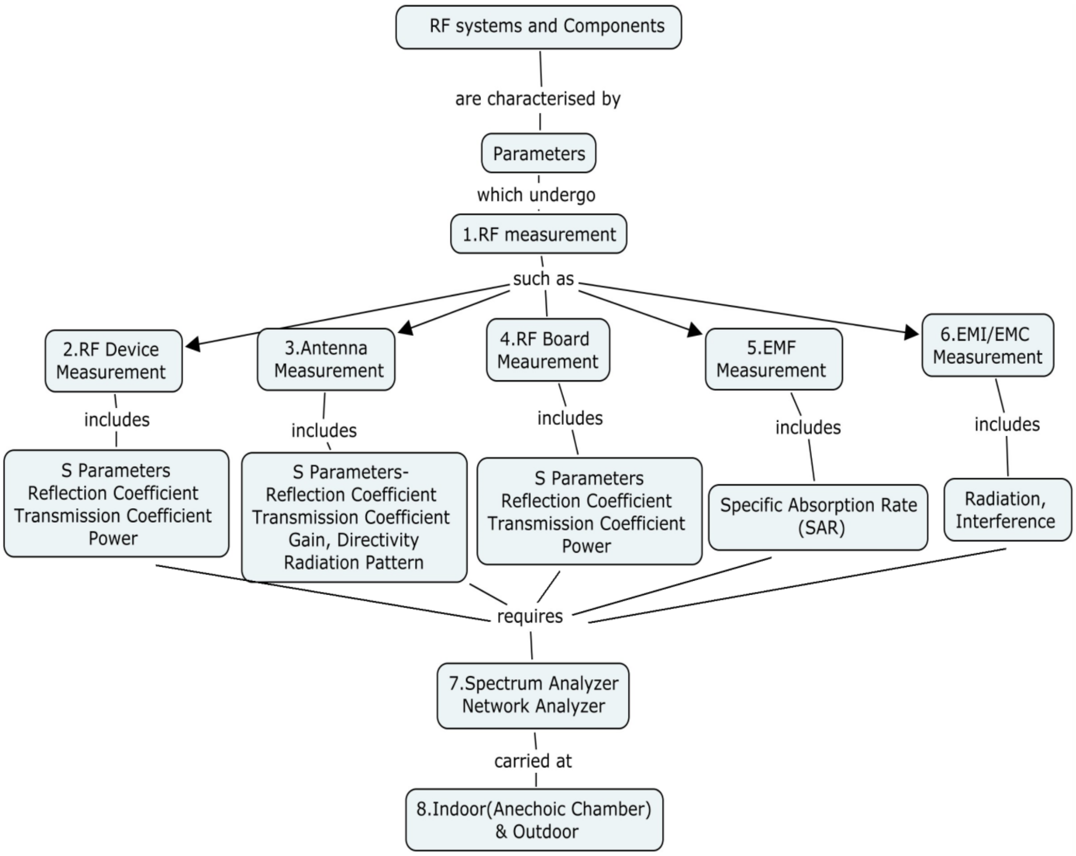
Course Outcome 2 (CO2):

1. Obtain the S parameter of hybrid coupler.
2. How do you measure Z_0 in a printed transmission line fabricated on an ideal dielectric?
3. Compare network analyzer with spectrum analyzer.
4. What are the mandatory requirements for measuring far field pattern of an antenna?
5. What are the effects of electromagnetic interference?
6. Explain the working principle of Spectrum analyzer.

Course Outcome 3 (CO3):

7. A 50-V signal generator is attached to a signal measurer whose input impedance is 25V. The dial on the signal generator indicates that it is putting out a level of -20 dBm. Determine the voltage at the input to the signal measurer in dBmV.
8. Convert the following dimensions to those indicated: (i) 30 miles to km (ii) 1 ft to mils (iii) 100 yds to meters (iv) 1 mm to mils, (v) 235 dBm to V (vi) 200A to db
9. The gains of antennas (Tx and Rx) of a microwave link operating at 10GHz are 40db each. Calculate the path loss for a transmitted power of 10W and a path distance of 80Km.
10. While measuring the gain of a horn antenna, the gain of the oscillator was set for 9GHz frequency and the attenuation inserted was found to be 9.8db. Determine the gain of the horn antenna provided the distance between the two horns was 35cm.
11. A 50V receiver is attached to an antenna via 200 m of RG58U coaxial cable. The receiver indicates a level of -20 dBm at 200 MHz. Determine the voltage at the base of the antenna in dBmV and in V if the cable loss at 200 MHz is 8 dB/100 ft.
6. Compute the reflection loss and absorption loss for a 20-mil steel (SAE 1045) barrier at 10 kHz, 100 kHz, and 1 MHz for a near-field electric source that is a distance of 5 cm from the shield

Concept Map



Syllabus

Introduction: RF Systems and components – Need for Characterization, evaluation and Certification. RF measurement, Measurement Parameters- S parameters, power. **RF equipment for Measurement**: Spectrum Analyzer- Principle, Measurement procedure, Network Analyzer- Principle, Measurement procedure, Calibration. **RF Device Measurement:** S parameters for Devices - transmission lines, coupler, filters, circulators, resonator, antenna etc. Measurement with Network Analyzer. **Antenna Measurement: Reflection coefficient, Return loss of different antennas,** Measurement with Spectrum and Network Analyzer, Gain Measurement, Radiation pattern measurement in both Indoor and Anechoic chamber, Test ranges. **RF Board Measurement:** Filter, coupler measurement, Amplifier testing, gain, phase noise and Noise margin measurement, Power measurement. **EMF Measurement:** Some International Precautionary Exposure Guidelines, EMF Measurement System, RF Exposure Measurements & Testing, Mobile phone SAR Measurements. **EMI/EMC Measurement:** Sources of EMI, conducted and radiated EMI, transient EMI, EMI- EMC definitions and units of parameters. EMI Coupling Principles: conducted, radiated and transient coupling, common impedance ground coupling, Common mode and differential mode coupling, near field cable to cable coupling, power main and power supply coupling. EMI Units of specifications, Civilian standards & Military standards. Limits

Reference Books

1. D. Pozar, “Microwave Engineering”, Wiley, 3rd ed., 2007
2. IET Electrical Measurement Series, “Microwave Measurements” 3rd Edition
3. Agilent’s, “Fundamentals of RF and Microwave Power Measurements”
4. John D. Kraus, “Antennas for all applications”, Tata McGraw Hill ,2002
5. V.P.Kodali, "Engineering EMC Principles, Measurements and Technologies", IEEE Press, 1996
6. Clayton R.Paul, “Introduction to Electromagnetic Compatibility” A John Wiley & Sons, Inc. Publication, 2006
7. http://edocs.soco.agilent.com

Course Contents and Lecture Schedule

Module No.	Topic	No. of Lectures
1	**Introduction**	
1.1	RF Systems and components	1
1.2	Need for Characterization, evaluation and Certification.	1
1.3	RF measurement	2
1.4	Measurement Parameters- S parameters	1
1.5	Power measurement	1
2	**RF equipment for Measurement**	
2.1	Spectrum Analyzer- Principle	1
2.2	Measurement procedure	2
2.3	Network Analyzer- Principle	1
2.4	Measurement procedure, Calibration.	2
3	**RF Device Measurement**	
3.1	S parameters for Devices - transmission lines	2
3.2	Coupler, filters Measurement with Network Analyzer.	2
3.3	Circulators, resonator Measurement with Network Analyzer.	1
4	**Antenna Measurement**	
4.1	Return loss Measurement with Spectrum and Network Analyzer,	2
4.2	Gain Measurement	1
4.3	Radiation pattern measurement (Indoor)	2
4.4	Measurement in Anechoic chamber,	2
4.5	Test ranges	1
5	**RF Board Measurement**	
5.1	Filter, coupler measurement	2
5.2	Amplifier testing	2
5.3	Gain, phase noise measurement,	1
5.4	Noise margin measurement	1
5.5	Power measurement	1
6	**EMF Measurement**	
6.1	Some International Precautionary Exposure Guidelines,	2
6.2	EMF Measurement System,	1
6.3	RF Exposure Measurements & Testing	1
6.4	Mobile phone SAR Measurements	2
7	**EMI/EMC Measurement**	
7.1	Sources of EMI, conducted and radiated EMI,	2
7.2	Transient EMI, EMI- EMC definitions and units of parameters.	2
7.3	EMI Coupling Principles: conducted, radiated and transient	2

	coupling,	
7.4	common impedance ground coupling, Common mode and differential mode coupling	2
7.5	near field cable to cable coupling, power main and power supply coupling	1
7.6	EMI Units of specifications, Civilian standards & Military standards. Limits	1
	Total Number of Hours	48

Course Designers:

1. Dr.B. Manimegalai naveenmegaa@tce.edu
2. Dr.S. Raju rajuabhai@tce.edu

14CNPP0	MEDICAL IMAGING AND CLASSIFICATION	Category	L	T	P	Credit
		PE	3	1	-	4

Preamble

The purpose of this course is 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. At the lowest level, the course introduces the terminology of medical imaging and explains how X-ray, CT, MRI and ultrasound images are generated. In the middle level, it addresses how to select the specific classification methods for extracting meaningful information from the medical imaging modalities. At highest level, it addresses how the algorithm is implemented in real life by observing some case studies and applications.

Prerequisite

NIL

Course Outcomes

CO1. Describe the various medical imaging modalities.	Understand
CO2. Estimate dose and exposures of x-ray, and observe how these influence the imaging system usage.	Apply
CO3. Analyze about the various reconstruction techniques by solving problems.	Analyze
CO4. Apply the registration techniques and able to choose the selective classifier with respect to the problem.	Apply
CO5. Visualize and analyse the given 3-D images.	Analyze

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

Mapping with Programme Outcomes

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

S- Strong; M-Medium; L-Low

Assessment Pattern

	Bloom's category	Continuous Assessment Tests			End Semester Examinations
		1	2	3	
1	Remember	20	20	20	20
2	Understand	40	40	20	20
3	Apply	40	40	40	40
4	Analyze	0	0	20	20
5	Evaluate	0	0	0	0
6	Create	0	0	0	0

Course Level Assessment Questions

COURSE OUT COME 1(CO1):

1. Explain photoelectric effect
2. How T1-weighted spin echo is generated in MRI.
3. Explain how B-mode images are useful in the display of moving structures
4. Mention the role of Affine transformation in medical imaging
5. Relate volume of interest with region of interest.
6. Differentiate surface rendering with volume rendering.
7. Mention the principal feature of gradient echo pulse sequence.
8. List out the properties of ultrasound waves.

COURSE OUT COME 2(CO2):

1. A narrow beam containing 2000 mono energetic photons is reduced to 1000 photons by a slab of copper 10−2 m thick. What is the total linear attenuation coefficient of the copper slab for these photons?
2. What are the total mass (μm), atomic (μa), and electronic (μe) attenuation coefficients of the copper slab described in Example 4-4? Copper has a density of 8.9×103 kg/m3, a gram-atomic mass of 63.6, and an atomic number of 29.
3. An x-ray beam produced at 200 kVp has an HVL of 1.5mmCu. The density of copper is 8900 kg/m3
    a. What are the effective linear and mass attenuation coefficients?
    b. What is the average effective energy of the beam?
4. What is the length of the Fresnel zone for a 10-mm-diameter, 2-MHz unfocused ultrasound transducer?
5. What is the estimated focal zone length for a 2-MHz (λ = 0.075 cm) focused ultrasound transducer with an *f*-number of 8?
6. An x-ray tube emits 10^{12} photons per second in a highly collimated beam that strikes a 0.l-mm-thick radiographic screen. For purposes of this example, the beam is assumed to consist entirely of 40-keV photons. The attenuation coefficient of the screen is 23 m^{-1}, and the mass energy absorption coefficient of the screen is 5 m^{-1} for 40-keV photons. Find the total energy in keV absorbed by the screen during a 0.5-sec exposure.
7. A 210-keV photon is scattered at an angle of 80 degrees during a Compton interaction. What are the energies of the scattered photon and the Compton electron?
8. Five minutes of fluoroscopy at 4 mA and 100 kVp are to be combined with eight 0.5-second spot films at 100 kVp and 100 mA. Is the technique permissible according to the energy rating chart and the anode thermal chart for a Machlett dynamax “25” rotating anode X-ray tube.
9. Specify the structure and weights of a neural network capable of performing exactly the same function as a minimum distance classifier for two pattern class in N-dimensional place.

COURSE OUT COME 3(CO3):

1. 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.

2. What is the use of Fourier transform in image reconstruction?
3. What is central slice theorem? Explain

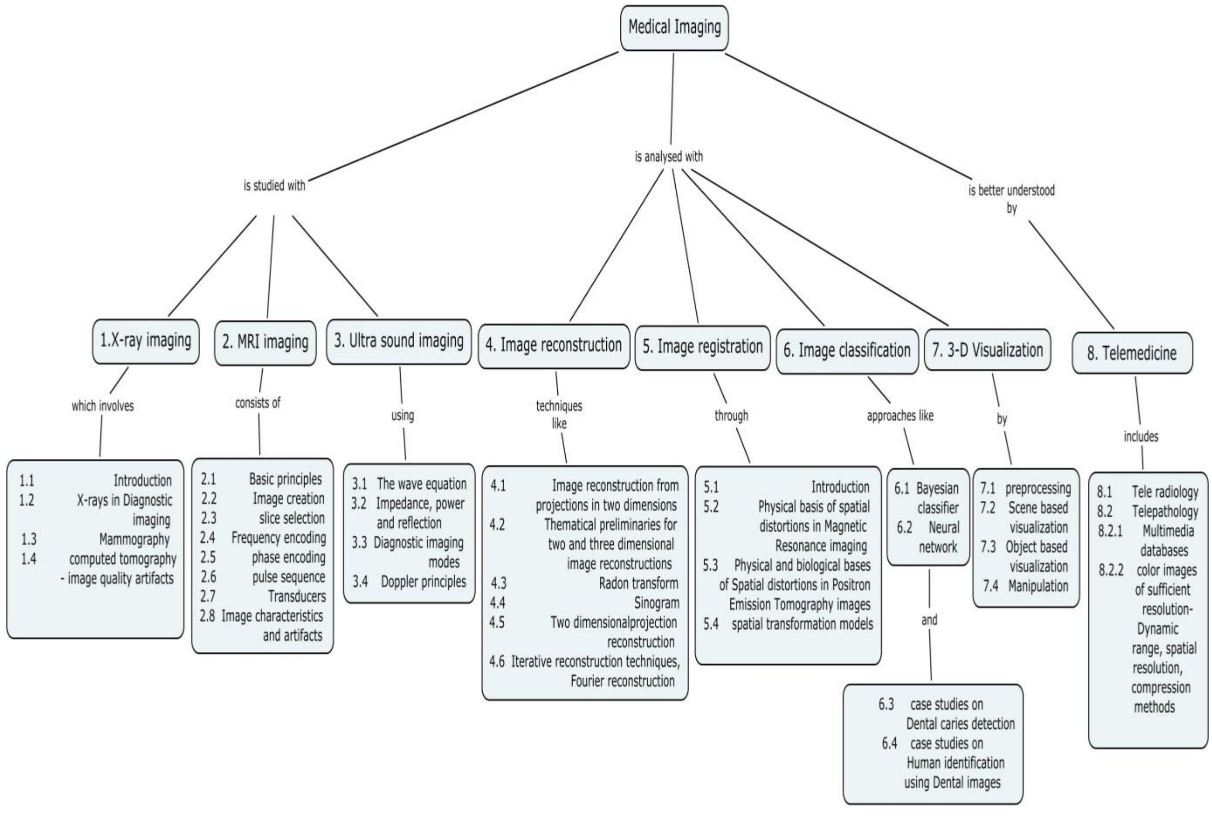
COURSE OUT COME 4(CO4):

1. Obtain the transformation matrix for the input image with the furnished details as given here: It is first rescaled by factors 3.7 along x-axis, 4.2 units along y-axis and 7.5 units along z-axis, then rotated around the x-axis by 9^0 around x-axis, 12^0 around y-axis and 2^0 around z-axis and finally translated 5 units along x, 4 units along y and 7 units along z
2. How various Spatial Transformation models are useful in Image registration?.Explain
3. The Bayes decision functions $d_j(x)=p(x/\omega_j)p(\omega_j)$, j=1,2,…W, were derived using a 0-1 loss function. Prove that these decision functions minimize the probability of error.(Hint: The probability of error p(e) is 1-p(c) where p(c) is the probability of being correct. For pattern vector x belonging to class ω_j $p(c/x)=p(\omega_j/x)$. Find p(c) and show that p(c) is maximum (p(e) is minimum when $p(x/\omega_j)\,p(\omega_j)$is maximum)
4. Design a neural net that classifies a sample as belonging to class 1 if the sample produces a positive value for $D = 34 + 8x_1-7x_2+x_3$ and classifies the samples as belonging to class 0 if the sample produces a negative value for D
5. Write about affine transform in Forensic dentistry

COURSE OUT COME 5(CO5):

1. List out the 3-D imaging operations
2. Write shortly about scene based visualization and object based visualization
3. Explain the necessity of manipulation and analysis in 3D visualization

Concept Map



Syllabus

Introduction to X-Ray Imaging- Introduction to imaging modalities-X-rays in Diagnostic imaging-Mammography-Computed tomography systems – Image quality artifacts-reconstruction techniques. **Magnetic Resonance Imaging & Ultrasound Imaging** – Basic principles of nuclear magnetic resonance-Image creation-slice selection-Frequency encoding, phase encoding- pulse sequence- Transducers- Image characteristics and artifacts- **Ultrasound Imaging**- The wave equation- Impedance, power and reflection – Diagnostic imaging modes- Doppler principles. **Image Reconstruction**- Image reconstruction from projections in two dimensions- Mathematical preliminaries for two and three dimensional image reconstructions-Radon transform-Sinogram- Two dimensional projection reconstruction-Iterative reconstruction techniques-Fourier reconstruction. **Image Registration & Classification** – Introduction - Physical basis of spatial distortions in Magnetic Resonance imaging- Physical and biological bases of Spatial distortions in Positron Emission Tomography images- spatial transformation models- Bayesian classifier-Neural network **3d Visualization** – Preprocessing – Scene based visualization- Object based visualization – Manipulation – Tele medicine: Teleradiology- Telepathology: Multimedia databases- color images of sufficient resolution: Dynamic range, spatial resolution, compression methods - case studies for classification: Dental caries detection-Human identification using Dental images.

Reference Books

1. William.R.Hendee and Russell Ritenour.E. Woods, “Medical Imaging Physics”, A John Wiley & sons , Inc. publications, 2002
2. Jacob Beutel and M.Sonka, “Handbook of Medical Imaging”, volume 2. “Medical Image Processing and Analysis” , SPIE press 2000
3. Issac Bankman and I.N.Bankman, “ Handbook of Medical Imaging: Processing and Analysis”, Academic press,2009
4. Atam.P.Dhawan, “Medical Image Analysis”, John Wiley and Sons ,2011
5. Zang-Hee Cho, Joie P. Jones, Manbir Singh, “Foundations of Medical Imaging”, A John Wiley & sons , Inc. publications, 1993
6. Krzysztof Iniewski, “Medical Imaging- Principles, Detectors and Electronics”, A John Wiley & sons , Inc. publications, 2009

Course Contents and Lecture Schedule

No.	Topic	No. of Lectures
1.	**X-ray imaging**	
1.1	Introduction	1
1.2	X-rays in Diagnostic imaging	
1.3	Mammography	2
1.4	computed tomography, image quality artifacts	2
2.0	**MRI imaging**	
2.1	Basic principles	1
2.2	Image creation	1
2.3	slice selection	
2.4	Frequency encoding	1
2.5	phase encoding	
2.6	pulse sequence	1
2.7	Transducers	1
2.8	Image characteristics and artifacts	1
3.0	**Ultra sound imaging**	
3.1	The wave equation	1

No.	Topic	No. of Lectures
3.2	Impedance, power and reflection	1
3.3	Diagnostic imaging modes	1
3.4	Doppler principles	1
4.0	**Image reconstruction**	
4.1	Image reconstruction from projections in two dimensions	2
4.2	Mathematical preliminaries for two and three dimensional image reconstructions	1
4.3	Radon transform	1
4.4	Sinogram	1
4.5	Two dimensional projection reconstruction	1
4.6	Iterative reconstruction techniques, Fourier reconstruction	2
5.0	**Image registration**	
5.1	Introduction	1
5.2	Physical basis of spatial distortions in Magnetic Resonance imaging	1
5.3	Physical and biological bases of Spatial distortions in Positron Emission Tomography images	1
5.4	spatial transformation models	2
6.0	**Image classification**	
6.1	Bayesian classifier	2
6.2	Neural network	2
6.3	Case studies on Dental caries detection	1
6.4	Case studies on Human identification using Dental images	1
7.0	**3-D Visualization**	
7.1	Preprocessing	1
7.2	Scene based visualization	1
7.3	Object based visualization	1
7.4	Manipulation	1
8.0	**Telemedicine**	
8.1	Teleradiology	1
8.2	Telepathology	1
8.2.1	Multimedia databases	1
8.2.2	color images of sufficient resolution: Dynamic range, spatial resolution, compression methods	2
	Total Number of Hours	44

Course Designers:

1. Dr.A.Banumathi, au_banu@tce.edu

14CNPQ0	SOFTWARE AND COGNITIVE RADIO SYSTEMS

Category	L	T	P	Credit
PE	3	1	-	4

Preamble

This course presents the state-of-the-art in the field of Software and Cognitive Radio Systems. The course will enable the students to learn about the architecture, design methodologies and spectrum sensing techniques used in Software and Cognitive Radio Systems.

Prerequisite

NIL

Course Outcomes

CO1. To expose the evolving next generation wireless networks and their associated challenges, describe the various requirements and functionalities of software /Cognitive radio.	Understand
CO2. Design the architecture of Software and Cognitive Radio Systems.	Apply

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

CO3. To apply and implement the design methodologies in the wireless applications	Apply
CO4. To demonstrate the impact of the evolved solutions in future wireless network design.	Analyze
CO5. To implement the spectrum sensing techniques in practical applications.	Analyze

Mapping with Programme Outcomes

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

S- Strong; M-Medium; L-Low

Assessment Pattern

	Bloom's category	Continuous Assessment Tests			End Semester Examinations
		1	2	3	
1	Remember	40	40	20	20
2	Understand	40	40	20	20
3	Apply	20	20	40	40
4	Analyze	0	0	20	20
5	Evaluate	0	0	0	0
6	Create	0	0	0	0

Course Level Assessment Questions

COURSE OUTCOME1 (CO1):

1. Define the term quick logic used in SDR design
2. Enlist the design tools available for SDR
3. In what way software reconfiguration relates to SDR?
4. Give the requirements of cognitive radio
5. list out the spectrum access problems in cognitive radio
6. Draw the system model of cognitive radio transmitter.
7. Mention the operating frequency bands & their usage in SDR application.
8. List the specifications &requirements needed for a candidate architecture SDR
9. Relate SDR& cognitive radio
10. Draw the timing diagram of cognitive cycle
11. How does UWB cognitive radio offer better solution
12. Define the term spectrum pooling.

COURSE OUTCOME2 (CO2):

1. Describe the features of Software tunable smart antenna in cognitive systems
2. Design a typical Digital front end for SDR transmitter

COURSE OUTCOME 3 (CO3):

1. With relevant figures explain the how energy detection is implemented in cognitive radio.
2. With suitable examples explain how Interference is managed in cognitive radio

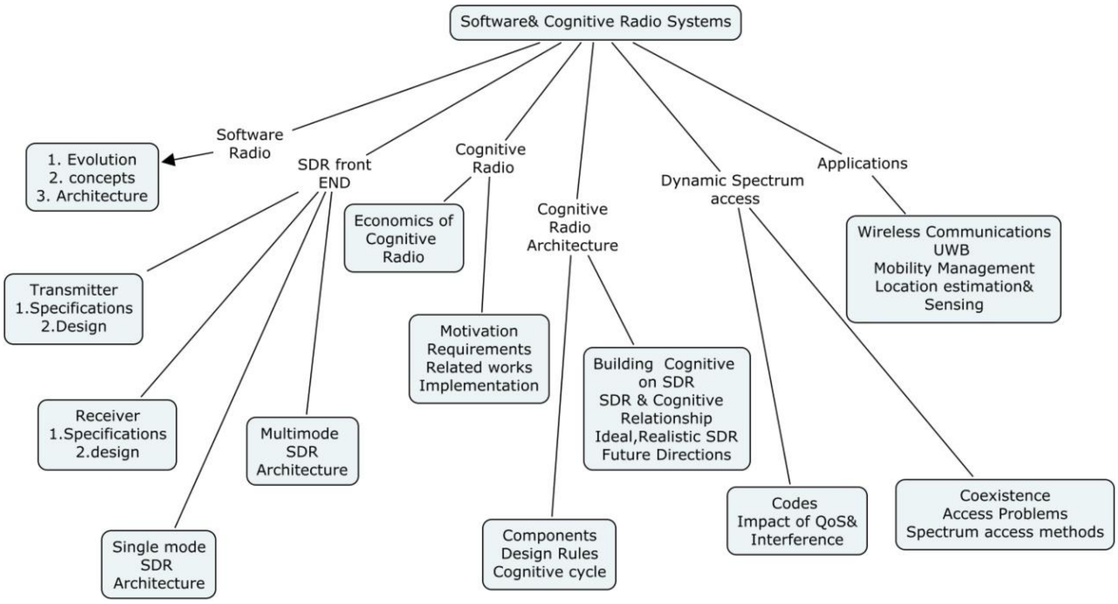
COURSE OUTCOME 4(CO4):

1. Give the goal of spectrum adaptation. Explain any one spectrum adaptation technique

COURSE OUTCOME 5(CO5):

1. Write a technical note on cognitive radio based location estimation

Concept Map



Syllabus

Software Radio: Evolution- architecture perspectives- Software radio concepts-SDR front end technology: Transmitter specifications- Receiver specifications- operating frequency bands- receiver design considerations- transmitter design considerations- Candidate architecture for SDR- Multimode SDR architecture. **Cognitive radio:** Introduction to cognitive radios –economics of cognitive radio-spectrum awareness, spectrum subleasing, spectrum sharing- cognitive networks:- motivation &requirements-foundation &related works in cognitive radio- cognitive radio implementation. **Cognitive radio architecture:** SDR technology underlies cognitive radio- **CR** architecture**-** CR components**-** CR design rules- cognitive cycle- building cognitive radio on SDR architecture- future directions **Software based radio architecture for Cognitive radio:-** SDR & Cognitive relationship, ideal SDR architecture, realistic SDR architecture. Software tunable analog radio components-antenna systems-reconfigurable digital radio technologies: economic value model-example scenarios **Dynamic spectrum Access: -** Coexistence of dissimilar secondary radio systems-impact of QoS & interference-codes for dynamic spectrum access- coexistence& access problems in Cognitive radios-spectrum sensing methods for Cognitive radios- spectrum sensing in current wireless standards. Cognitive OFDM standards and technologies. 802.11 AD standard a case study. **Cognitive Radio Applications:- Cognitive radios** in wireless communication, Mobility management, location estimation& sensing, UWB Cognitive radio.

Reference Books

1. Ekram Hossain, Dusit Niyato, Zhu Han, "Dynamic Spectrum Access and Management in Cognitive Radio Networks", Cambridge University Press, 2009.
2. Kwang-Cheng Chen, Ramjee Prasad, "Cognitive Radio Networks", John Wiley &Sons Ltd., 2009.
3. Bruce Fette, "Cognitive Radio Technology - Second Edition", Elsevier, 2009.
4. Huseyin Arslan, "Cognitive Radio, Software Defined Radio, and Adaptive Wireless Systems", Springer, 2007.
5. Francisco Rodrigo Porto Cavalcanti, Soren Andersson "Optimizing Wireless Communication Systems" Springer, 2009.
6. Linda Doyle, "Essentials of Cognitive Radio", Cambridge University Press, 2009.

Course Contents and Lecture Schedule

S. No	Topics	No. of Lectures
1	**Software Radio**	
1.1	Evolution	1
1.2	Architecture perspectives concepts	1
2	**SDR Front End Technology**	
2.1	Transmitter specifications	1
2.2	Receiver specifications	1
2.3	Operating frequency bands	1
2.4	Receiver Design considerations	1
2.5	Transmitter Design considerations	1
2.6	Candidate architecture for SDR	1
2.7	Multimode SDR Architecture	1
3	**Cognitive Radio**	
3.1	Introduction to cognitive radios	1
3.2	Economics of cognitive Radio- spectrum awareness, spectrum subleasing, spectrum sharing	2
3.3	**Cognitive Networks**	1
3.3.1	Motivation &Requirements	1
3.3.2	Related works in cognitive radios	1

3.3.3	Cognitive Radio implementation.	1
4	**Cognitive Radio Architecture**	
4.1	SDR technology underlies cognitive radio	1
4.2	CR Architecture- components, design rules, cognitive cycle	2
4.3	Building Cognitive Radio on SDR architecture	1
4.4	Future directions	1
5	**Software Based Radio Architecture for Cognitive Radio**	
5.1	SDR & Cognitive relationship	1
5.2	Ideal SDR architecture, realistic SDR architecture.	1
5.3	**Software Tunable Analog Radio Components**	1
5.4	Antenna systems	1
5.5	Reconfigurable digital radio technologies: economic value model, example scenarios	3
6	**Dynamic Spectrum Access**	
6.1	Coexistence of dissimilar secondary radio systems	1
6.2	Impact of QoS & interference	1
6.3	Codes for dynamic spectrum access	2
6.4	Coexistence& access problems in Cognitive radios	1
6.5	Spectrum sensing methods for Cognitive radios	2
6.6	Spectrum sensing in current wireless standards	1
6.7	Cognitive OFDM standards & technologies	1
6.8	802.11 AD standard a case study	1
7	**Cognitive Radio Applications**	
7.1	Cognitive radios in wireless communication	2
7.2	Mobility management	1
7.3	location Estimation& Sensing	2
7.4	UWB Cognitive Radio	1

Course Designers:

1. Dr.M. Suganthi msuganthiece@tce.edu
2. Dr.T. Aruna taece@tce.edu

14CNPR0	COMPUTER VISION	Category	L	T	P	Credit
		PE	3	1	-	4

Preamble

The purpose of this course is to provide the concepts and applications in computer vision. Topics include: Image sensing including cameras and projection models, low-level image processing methods such as filtering and edge detection; mid-level vision topics such as segmentation, clustering, feature extraction, as well as high-level vision tasks such as object recognition, scene recognition, and object and people tracking, human activity recognition through different classifiers.

Prerequisite

NIL

Course Outcomes

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

CO1. Explain about what is computer vision	Understand
CO2. Explain how image is formed through projections	Understand
CO3. Explain the essential topics such as segmentation and feature extraction	Understand
CO4. Apply the extracted features to computer vision applications such as object recognition and human activity recognition	Apply
CO5. Analyze different classifiers and choose suitable classifier for specific application	Analyze

Mapping with Programme Outcomes

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

S- Strong; M-Medium; L-Low

Assessment Pattern

	Bloom's category	Continuous Assessment Tests			End Semester Examinations
		1	2	3	
1	Remember	20	20	20	20
2	Understand	40	40	20	20
3	Apply	40	40	40	40
4	Analyze	0	0	20	20
5	Evaluate	0	0	0	0
6	Create	0	0	0	0

Course Level Assessment Questions

Course Outcome 1(CO1):

1. Define specular aberration?
2. Define snakes.
3. State the assumptions for object motion.
4. State structure from motion theorem
5. List the classifiers for object recognition.
6. Define diffusion.

Course Outcome 2(CO2):

1. Compare CCD vs CMOS Sensors.
2. How an image is formed through pin hole projection?
3. How segmentation by clustering is applied to shot boundary detection and background subtraction with neat sketch?
4. How mosaics and snakes are helpful for image analysis and understanding?
5. How corner detection is obtained using SIFT operator?

Course Outcome 3(CO3):

1. Apply any one of the computer vision algorithm for object recognition.
2. How color based subtraction and gradient based subtraction are used to find the foreground image?
3. How video tracker is applied to target tracking in activity analysis?
4. Apply SVM classifier to classify different fruits?
5. Apply Bag of words technique for object recognition?

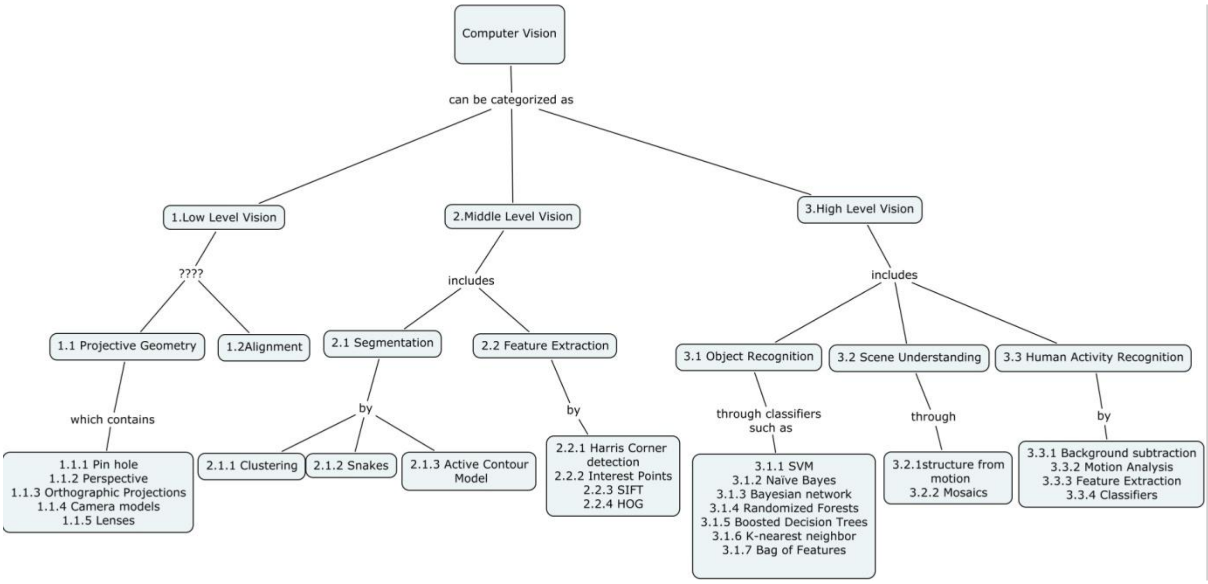
Course Outcome 4(CO4):

1. Analyze which classifier and feature extraction technique will be suitable for scene understanding?
2. Analyze Harris corner detection and SIFT corner detection for object recognition.
3. Analyze different feature extraction techniques for pattern recognition?
4. Analyze how bag of words technique will be suitable for scene understanding?
5. Analyze active contour model and snakes for segmenting the image?

Course Outcome 5(CO5):

1. Analyze which classifier and feature extraction technique will be suitable for activity Recognition?
2. Given many points in correspondence across several images, simultaneously compute the 3D location and camera (or) motion parameters using structure from motion theorem.
3. Apply K-Means clustering algorithm for segmenting different objects in a given scene?
4. Prove that, in the absence of external forces, a snake will always shrink to a smallcircle and eventually a single point, regardless of whether first- or second order smoothness (or some combination) is used. Also, illustrate how active contour models are used for object detection as a geodesic computation approach.
5. Illustrate how Naïve Bayes classifier and K- nearest neighbour classifier are used for object recognition and compare their merits and demerits.

Concept Map



Syllabus

Computer Vision- Introduction- computer vision applications**-Low Level Vision -** Geometry**-** Camera models - Projection-Pinhole-perspective – orthographic - Vanishing points-Lenses- Chromatic aberration - Photon's life choices-image formation- Alignment**- Middle Level Vision- Segmentation-** Clustering – snakes - Active contour model **- Feature Extraction-**Harris corner detection- Interest points-SIFT-HOG-**High Level Vision**-**Object Recognition**- SVM - -Naïve Bayes-Bayesian network-Randomized Forests-Boosted Decision Trees-K-nearest neighbor-Bag of Features- **Scene Understanding**- Mosaics-Structure from motion-Activity Recognition-Background subtraction-Motion Analysis-Feature Extraction-Classifiers

Reference Books:

1. Computer Vision: Algorithms and Applications, by Richard Szeliski, Springer, 2010.
2. Computer Vision: A Modern Approach, by D.A. Forsyth and J. Ponce, Prentice Hall, 2002.
3. Multiple View Geometry in Computer Vision, 2nd Edition, by R. Hartley, and A. Zisserman, Cambridge University Press, 2004.
4. Pattern Classification (2nd Edition), by R.O. Duda, P.E. Hart, and D.G. Stork, Wiley-Interscience, 2000.

Course Contents and Lecture Schedule

No.	Topic	No. of Lectures
1	**Computer Vision-** Introduction, computer vision applications-**Low Level Vision**	2
1.1	**Projective** Geometry	2
1.1.1	Projection-Pinhole	1
1.1.2	Perspective	1
1.1.3	orthographic	1
1.1.4	Vanishing points	1
1.1.5	Lenses	2
1.1.6	Camera models	1
1.1.7	Chrmatic aberration	1
1.1.8	Photon's life choices	2

No.	Topic	No. of Lectures
1.1.9	image formation	1
1.2	Alignment	1
2.1	**Middle Level Vision-Segmentation**	1
2.1.1	Clustering	1
2.1.2	Snakes	1
2.1.3	Active contour model	1
2.2	**Feature Extraction**	1
2.2.1	Harris corner detection	2
2.2.2	Interest points	1
2.2.3	SIFT	2
2.2.4	HOG	1
3.1	**High Level Vision-Object Recognition**	1
3.1.1	SVM	1
3.1.2	Naïve Bayes	2
3.1.3	Bayesian network	1
3.1.4	Randomized Forests	1
3.1.5	Boosted Decision Trees	1
3.1.6	K-nearest neighbor	1
3.1.7	Bag of Features	1
3.2	**Scene Understanding**	1
3.2.1	Structure from motion	2
3.2.2	Mosaics	1
3.3	**Activity Recognition**-Background subtraction	2
3.3.1	Video Tracker	1
3.3.2	Motion Analysis	1
3.3.3	Feature Extraction	1
3.3.4	Classifiers	2
	Total Number of Hours	49

Course Designer:

1. Dr. B.Yogameena, ymece@tce.edu

14CNPS0	ANTENNAS FOR WIRELESS APPLICATIONS	Category	L	T	P	Credit
		PE	3	1	0	4

Preamble

The tremendous success enjoyed by the cellular industry and advances in radio frequency integrated circuits have in recent years fostered the development of various wireless technologies, including RFID, mobile internet, body-centric communications, and UWB communication. For aesthetic reasons, all these systems require small antennas that can be embedded into the mobile units. Furthermore, the development of new services and radio technologies demand for low cost, light weight, miniaturized, efficient antennas for portable wireless devices. The radiation characteristics of antennas can be understood through Electromagnetic Simulators such as ADS Momentum, CST Microwave Studio etc. One of the main competencies that a present day antenna engineer has to posses is the capability to design antennas for portable wireless devices that have good bandwidth, gain and radiation characteristics. This course is essential to understand the need for designing miniaturized antennas for wireless applications such as Cellular Base station, Mobile handsets, Radio frequency identification, and Wide band communication. This course presents various types of antenna geometry suitable for wireless communication, the issues in respect of their design and development.

Prerequisite

NIL

Course Outcomes

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

CO1.	Explain the behavior of an antenna in terms its parameters	Apply
CO2.	Simulate the radiation pattern of antennas using EM CAD simulator software-ADS	Apply
CO3.	Explain the design issues in wireless device including cellular base station, handset and UWB communication	Analyze
CO4.	Select an antenna for the above mentioned wireless applications	Analyze
CO5.	Design planar antennas for given specifications	Create

Mapping with Programme Outcomes

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

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	40	20	20	20
Understand	40	20	20	20
Apply	20	20	20	20
Analyse	0	0	0	0
Evaluate	0	20	20	20
Create	0	20	20	20

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. What are the features of 3G wireless systems?
2. Explain the spectrum allocation for various wireless applications.
3. Define radiation resistance of an antenna.
4. What is meant by polarization of antenna?
5. List some of the antennas used in handset.
6. Explain the radiation mechanism of PIFA antenna and their parameters.

Course Outcome 2 (CO2):

1. Why microstrip antennas are preferred for space applications?
2. Why monopole antennas are preferred for wireless communication?
3. What are the effects of user on the mobile unit performance?
4. What wireless antenna can be used to cover a small campus area of a few buildings?
5. Compare active and passive RFID's
6. What are the constraints used in the design of handset antennas?

Course Outcome 3 (CO3):

1. Two identical isotropic radiators are spaced d= λ/2 meters apart and fed with currents of equal magnitude but in phase quadrature difference 'β'. Evaluate the resultant radiation and thereby identify the direction of maximum radiation.
2. Propose simulation steps to facilitate the design of patch antenna on a multilayer substrate having effective dielectric constant of 5.5.
3. Derive the maximum reading distance of a tag in a RFID system.
4. Evaluate the performance of PC card antenna and INF antenna in a laptop prototype. Prepare a model chart for developing antenna for wearable devices considering different RF constraints.
5. Explain in detail how conventional planar antenna can be modified to provide wide bandwidth

Course Outcome 4 (CO4):

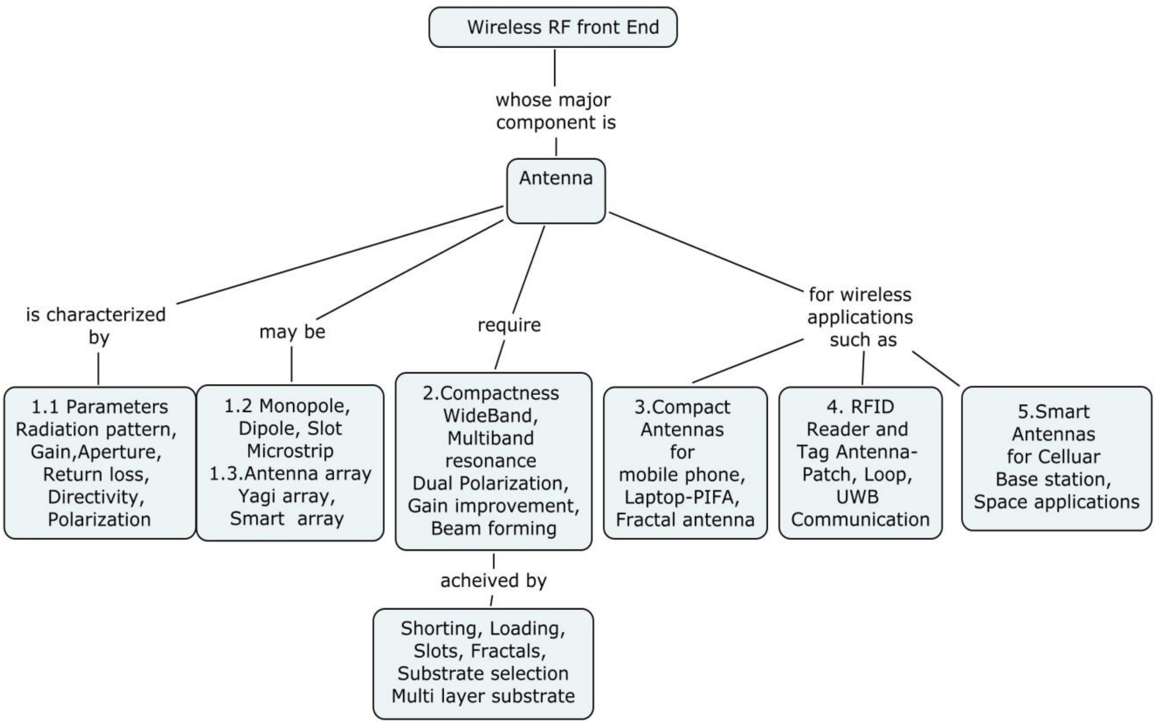
1. A two element end-fire array in free space consists of 2 vertical side by side λ/2 elements with equal out of phase currents. At what angles in the horizontal plane is the field intensity is maximum: (a) when the spacing is λ/2?
2. What spacing of two in phase side by side λ/2 antenna produces maximum gain? What is the gain in dBi?
3. Given a set of wire antennas having same resonant frequency 2.5GHz, find the suitable candidate for TV reception?

4. Two X band rectangular horns, with aperture dimensions of 5.5cm and 7.5cm and each with a gain of 16.3dB at 10GHz are used as transmitting and receiving antennas. If the input power is 200Mw, and the antennas are polarization matched, evaluate the amount of power received at a distance of 50m. Calculate the amount of power reduction if the propagation is disturbed to give VSWR of 1.1.
5. Compare the performance of two element in phase fed linear array of microstrip patches with the spacing d=λ/2 and d=λ/4 and thereby obtain the array condition for getting maximum radiation. Given the specification, Frequency= 6GHz, Gain =20Db, Find the number of elements and spacing in the smart antenna array. Evaluate the resultant radiation for the phase shifts: (a) $\beta=0^{\circ}$ (b) $\beta=-90^{\circ}$ (c) $\beta=+90^{\circ}$ the and propose the phase condition for making the array as broadside array.

Course Outcome 5 (CO5):

7. Design a mini wireless antenna for Laptop WLAN applications.
8. Design a 4 element array of λ/2 spacing between elements. The radiation pattern is to have maximum in the direction perpendicular to the array axis.
9. Design a compact microstrip antenna resonating at the frequency of 2.4GHz
10. Design a planar inverted F antenna operating in Cellular GSM lower band.
11. Suggest a suitable planar antenna system for the given specification:
    Center Frequency - 5GHz, Dielectric constant – 3.38, Thickness - 1.52mm, VSWR - 2:1 and Bandwidth > 500MHz
12. Design a 4 element MIMO antenna operating at 2.4GHz application.
    Design a wide band antenna suitable for blue tooth communication with the substrate having Dielectric constant 4.6, thickness - 0.3 mm.

Concept Map



Syllabus

Antenna Parameters & Types: RF Front end in Wireless system, Antenna fundamentals, Radiation mechanism, Antenna parameters- Radiation pattern, power density, radiation intensity, directivity, Gain, polarization, radiation efficiency, effective aperture. Types of antennas - Monopole, Dipole, Slot, Patch, Radiation mechanism, Radiation pattern, Antenna array: Active array- Two element array - broadside, end-fire, phased array concept Passive array – Yagi array. **Miniaturization and Bandwidth Enhancement:** Miniaturization- Shorting and loading of antenna, Use of Slots, Fractal techniques, Bandwidth Improvement- Substrate selection, Multilayer substrate antenna, Dual & Circular Polarization, Circularly Polarized MSAs, MSA with Modified Corners. **Compact Antenna for Mobile Handset and Laptop:** Performance Requirements, Electrically Small Antennas, Classes of Handset Antennas- External, Internal antenna, Microstrip patch antenna, Planar Inverted F antenna (PIFA), Fractal antennas, SAR, Practical Design for Mobile application, Wireless in Laptop, Laptop Antenna Issues, Possible Antennas for Laptop Applications, Mechanical and Industrial design constraints, Link budget model, Antenna Design Methodology. An INF Antenna, Antennas for WWAN, Integrated Antenna, Dualband antenna. **Antennas RFID Tag and UWB Communication:** RFID Fundamentals, RFID System Configuration, Classification of RFID Systems, Principles of Operation, Frequencies, Regulations and Standardization, Design Considerations for RFID Tag Antennas, UWB Wireless Systems, Challenges in UWB Antenna Design, Frequency-Independent Designs, Planar Broadband Designs, Planar Printed PCB Designs. **Antenna array for Cellular applications:** Smart Antenna array**-** Benefits of Smart antennas, Types of Smart antenna, Fixed & switched beam antenna system, Adaptive array system, Analog and Digital Beamforming, Multiple antenna design, Combining techniques, Diversity, Multi beam formation-Use of Buttler matrix, Smart antenna for Mobile Base stations. EM simulation with ADS Momentum and CST Microwave studio, Antenna Prototype development.

Reference Books

1. John D.Kraus, Ronald J.Marhefka “Antennas for all Applications” Fourth Edition, Tata McGraw- Hill, 2006.
2. Kin Lu Wong, “Planar Antennas for Wireless communication”, Wiley Interscience, 2003.
3. Grishkumar and K.P.Ray, “Broadband microstrip antennas” Artech House, 2003
4. Zhi Ning Chen, “Antennas for Portable devices” Wiley Publishers, 2007
5. J.C.Liberti, JR and Theodore Rappaport, “Smart Antennas for Wireless communication” Prentice Hall of India, 1999.
6. Ahmed El-Zooghby, “Smart Antenna Engineering” Artech House, 2008
7. http://ieeexplore.org
8. http://edocs.soco.agilent.com
9. http://cst.com

Course Contents and Lecture Schedule

Module No.	Topic	No. of Lectures
1	**Antenna Parameters & Types**	
1.1	RF Front end in Wireless system,	1
1.2	Antenna fundamentals, Radiation mechanism,	1
1.3	Antenna parameters- Radiation pattern,	2
1.4	power density, radiation intensity, directivity, Gain, polarization, radiation efficiency, effective aperture.	2

1.5	Types of antennas - Monopole, Dipole, Radiation mechanism	1
1.7	Antenna array: Active array- Two element array - broadside, end-fire, phased array	2
1.8	Passive array – Yagi array.	1
2	**Miniaturization and Bandwidth Enhancement**	
2.1	Miniaturization- Shorting and loading of antenna	1
2.2	Use of Slots, Fractal techniques,	1
2.3	Bandwidth Improvement- Multilayer substrate antenna, stacked resonator	1
2.4	Dual & Circular Polarization: Dual feed, Diagonal feed,	1
2.5	Edge shaping of MSA, Circularly Polarized MSAs, MSA with Modified Corners.	1
2.6	Low power antennas	1
3	**Compact Antenna for Mobile Handset and Laptop**	
3.1	Performance Requirements, Electrically Small Antennas,	2
3.2	Classes of Handset Antennas- External, Internal antenna, Microstrip patch antenna,	1
3.3	Planar Inverted F antenna (PIFA), SAR, Practical Design for Mobile application	2
3.4	Wireless in Laptop, Laptop Antenna Issues, Possible Antennas for Laptop Applications,	2
3.5	Mechanical and Industrial design constraints, Link budget model, Antenna Design Methodology.	2
3.6	An INF Antenna, Antennas for WWAN, Integrated Antenna, Dualband antenna.	2
4	**Antennas RFID Tag and UWB Communication**	
4.1	RFID Fundamentals, RFID System Configuration,	2
4.2	Classification of RFID Systems, Principles of Operation, Frequencies,	1
4.3	Regulations and Standardization, Design Considerations for RFID Tag Antennas,	1
4.4	UWB Wireless Systems, Challenges in UWB Antenna Design	1
4.5	Frequency-Independent Designs,	2
4.6	Planar Broadband Designs, Planar Printed PCB Designs	2
5	**Antenna array for Cellular applications**	
5.1	Smart Antenna array**-** Benefits of Smart antennas,	1
5.2	Types of Smart antenna, Fixed & switched beam antenna system,	2
5.3	Adaptive array system, design, Analog and Digital Beamforming,	2
5.4	Multiple antenna design, Combining techniques, Diversity, Use of Buttler matrix	2
5.5	Smart antenna for Mobile stations	2

Course Designers:

1. Dr.B. Manimegalai naveenmegaa@tce.edu
2. Dr.S.Raju rajuabhai@tce.edu

14CNPT0	CMOS ASIC DESIGN	Category	L	T	P	Credit
		PE	3	1	0	4

Preamble

This course is aimed to provide an opportunity for the students to acquire technical business insight into some of the vital aspects of ASIC Design. This course provides the students, the knowledge about ASICs chip design and construction. It considers programmable ASICs analysis, front-end, back-end design and improvement algorithms.

Prerequisite

Nil

Course Outcomes

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

CO1.	Provide useful insight into some of the vital issues in deep sub micron design.	Apply
CO2.	Explain the different phases of the design flow for digital ASICs	Apply
CO3.	Understand capabilities and limitations of CMOS logic and adjust designs to best use CMOS ASIC Technologies	Analyze
CO4.	Demonstrate an understanding of how to optimize the performance, area, and power of a complex digital functional block, and the tradeoffs between these.	Analyze
CO5.	Apply techniques to analyze the timing of the final implementation	Create

Mapping with Programme Outcomes

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

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	30	20	10	10
Understand	30	20	10	10
Apply	40	40	40	40
Analyse	0	20	40	40
Evaluate	0	0	0	0
Create	0	0	0	0

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. List out the are goal and objectives for CAD VLSI physical design
2. Define MTBU.
3. Mention the semi custom characteristics of an FPGA.
4. State Greedy algorithm
5. Make a difference between global routing and detailed routing
6. Recall the goals and objectives of system partitioning.
7. Define seeding in Floorplanning.

Course Outcome 2 (CO2):

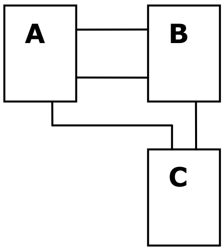
2 Draw the ASIC design flow
3 Explain different types of I/O requirements with example?
4 Illustrate channel definition in floor planning with suitable examples.
5 Compare the different types of Gate Array semi custom ASIC.
6 Explain in detail about routing algorithms.
7 Illustrate I/O and power planning with neat sketches.
7. Give the expression for sources of power dissipation in CMOS logic

Course Outcome 3 (CO3):

1 Draw the network graph for the given cost matrix and partition the graph using K-L algorithm

$$C = \begin{Bmatrix} 0 & 1 & 1 \\ 1 & 0 & 1 \end{Bmatrix}$$

2 Determine the local optimum solution for the above cost matrix
3 Calculate the Eigen value and Eigen vectors for the given network
4 Compute the interconnect delay for the given circuit.
5. Find the Eigen vector for the given network? And also place the cell in two dimensional.



6. Compute the shortest distance between the two nodes using partitioning algorithm.

Course Outcome 4 (CO4):

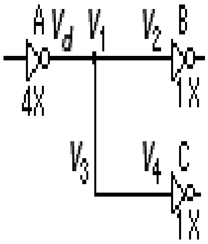
1. Identify the procedure to partition the network using iterative improvement algorithm
2. Distinguish the difference between Global routing inside flexible blocks and between blocks
3. Identify the steps involved to place logic cells of a network in two dimensional structures.

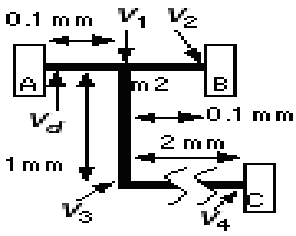
Course Outcome 5 (CO5):

1. Calculate the total chip power dissipation for following ACTEL 1020B FPGA. Consider an ACTEL with a 20 MHz clock. We shall initially assume 100 percent utilization of the 547 logic modules and assume that each switches at an average

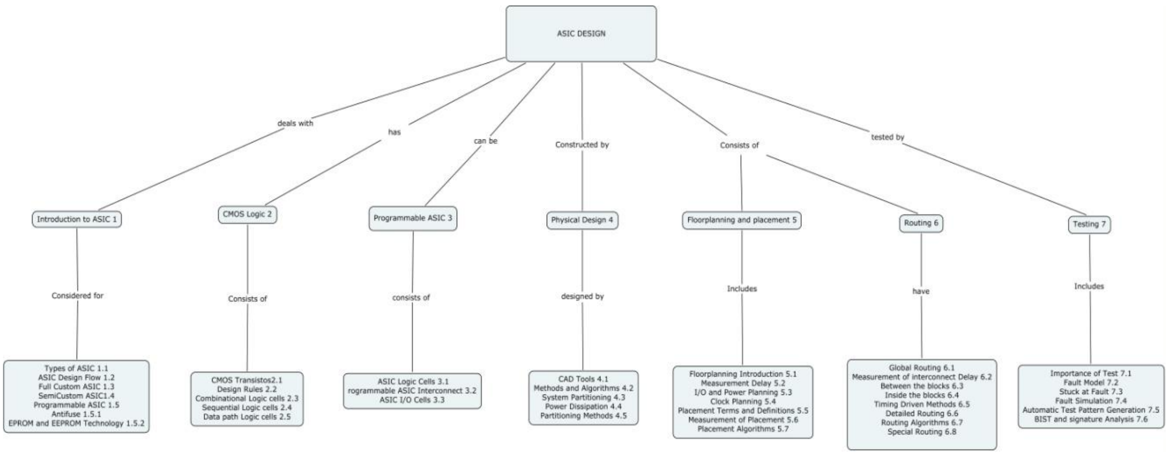
speed of 5MHz.We shall also assume that we use all of the 69 I/O modules and that each switches at an average speed of 5MHz.

2. Illustrate the measurement of interconnect delay in the given network.





Concept Map



Syllabus

Introduction to ASICs: ASIC Types- Full Custom, Semi Custom, Gate Array ASIC, Cell Based ASIC, ASIC Design Flow, Programmable ASIC- antifuse - Static RAM, EPROM & EEPROM Technology. **CMOS Logic:** CMOS transistors, Design Rules, Combinational and sequential Logic, Data path Logic and I/O cells. **Programmable ASICs Interconnect**: Programmable ASIC Logic Cells-Actel ACT, Xilinx LCA, Altera FLEX and MAX, Programmable ASIC I/O Cells – DC & AC inputs and outputs, Clock & Power inputs -Xilinx I/O blocks, Programmable ASIC Interconnect. **ASIC Construction :** Physical design – CAD Tools, Methods and Algorithms, System Partitioning – Estimating ASIC Size, Power Dissipation, Partitioning Methods-Connectivity Measurement, Constructive Partitioning, Iterative Partitioning Improvement, The K-L Algorithm, The Ratio-Cut Algorithm, The Look-Ahead Algorithm, Simulated Annealing, Simple Partitioning Example. **FloorPlanning and Placement**: Floor Planning, Goals and Objectives, Measurement of Delay, Tools, Channel Definition Placement Definitions, Goals and Objectives, Measurement of Placement, Goals, Placement Algorithms, Simple Placement Example, Physical Design Flow. **Routing**: Global Routing, Measurement of Interconnect delay, Methods, Fixed blocks and Flexible Blocks, Timing Driven Methods, Detailed Routing, Goals and Objectives, Measurement of Channel Density, Algorithms, Special Routing. **Testing:** The importance of test-boundary scan test, physical faults, Stuck at fault model-logical faults-IDDQ test, Fault Simulation, Automatic test pattern generation- ATPG algorithm- PODEM algorithm, BIST and signature Analysis.

Reference Books

1 Michael John Sebastian Smith, " Applications Specific Integrated Circuits", Pearson Education, Ninth Indian reprint,13th edition,2004.
2 Neil H.E.Weste, Eshraghian, "Principles of CMOS VLSI Design": Addison Wesley, 1999.
3 M.J Morant, "Integrated Circuit Design & Technology", Chapman and Hall,1990.
4 Wayne Wolf, "Modern VLSI Design-A System Approach", PTR Prentice Hall,1994.
5. Andrew Brown, "VLSI Circuits and Systems in Silicon", McGraw Hill,1991.

Course Contents and Lecture Schedule

Module No.	Topic	No. of Lectures
Module I: Introduction to ASICs		
1.	Types of ASIC :Full &semi Custom ASICs	1
2.	ASIC Design flow	1
3.	ASIC Library Design-Transistor as Resistors	2
4.	Programmable ASICs- antifuse ,Static RAM	1
5.	EPROM & EEPROM Technology	1
Module II : CMOS Logic		
6.	CMOS Transistors	1
7.	The CMOS Process	1
8.	CMOS Design Rules	1
9.	Combinational Logic Cells	2
10.	Sequential Logic Cells	2
11.	Datapath Logic Cells and I/O cells	1
Module III : Programmable ASICs Interconnect		
12.	Programmable ASIC Logic Cells	2
13.	Programmable ASIC I/O Cells – DC & AC inputs and outputs	1
14.	Clock & Power inputs –Xilinx I/O blocks.	1
15	Programmable ASIC Interconnect- Actel ACT -Xilinx LCA - Xilinx EPLD -Altera MAX and FLEX	1
Module IV : ASIC Construction		
16.	Physical design – CAD Tools	1
17..	System Partitioning – Estimating ASIC Size	1
18.	Power Dissipation – Switching current	1
19.	Short circuit current–subthreshold and leakage current	1
20.	Partitioning Methods.	2
Module V: Floor planning and Placement		
21.	Floor planning goals and Objectives	1
22.	Measurement of delay in floorplanning	1
23.	Floorplanning tools. Chennal Definition	1
24.	I/O and Power Planning- Clock Planning	1
25.	Placement: terms and Definitions	1
26.	Placement Algorithms	1
Module VI: Routing		
27.	Global Routing : Measurement of interconnect delay	1
28.	Global routing methods- Global routing between blocks	1
29.	Global routing inside flexible blocks	1
30.	Detailed Routing: Measurement of channel density	1

31.	Algorithms-left edge algorithm, Constraints and routing graphs-area routing algorithms	1
32.	Multi level routing-timing driven detailed routing	1
33.	Special routing-clock routing-power routing	1
	Module VII: Testing	
34.	The importance of test-boundary scan test	1
35.	Stuck at fault model-logical faults-IDDQ test	2
36.	Fault Simulation- simulation results	1
37.	Automatic test pattern generation- ATPG algorithm- PODEM algorithm	1
38.	Controllability and observability	1
39.	Scan test-built-in self test (BIST)_LFSR	1
	Total Number of hours	45

Course Designers:

1. Dr.S.Rajaram rajaram_siva@tce.edu
2. Dr.D.Gracia Nirmala Rani gracia@tce.edu

14CNPU0	NANO MOSFET MODELING	Category	L	T	P	Credit
		PE	3	1	0	4

Preamble

The present and future generation VLSI systems are all expected to be built using MOSFETs. Over the years, the VLSI industry has systematically adapted to the use of only MOSFET for all purposes. This is because of its potential from manufacturability point of view. Over the years, an advance in physics has given rise many new concepts including carbon nano tubes, organic electronics, single electron and molecular transistors and so on. Even in most of these and other emerging nanotechnology based systems, the MOSFET or devices with MOSFET like characteristics continue to play a very important role. The present course will introduce and cover in detail all the important techniques used for MOSFET device modeling. This course can be considered as an extension or advanced version of the course on 'SOLID STATE DEVICE MODELING AND SIMULATION'

Prerequisite

NIL

Course Outcomes

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

CO1: Discuss on the properties of semiconductor devices.	Understand
CO2: Make use of various mathematical models to construct optimum device.	Apply
CO3: Differentiate the various MOS technology.	Analyse
CO4:Develop simulation setup of a MOS device for the given specifications	Create.

Mapping with Programme Outcomes

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

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	15	10	0	0
Understand	15	20	10	10
Apply	60	40	40	40
Analyse	0	20	30	30
Evaluate	0	0	0	0
Create	0	10	20	20

Course Level Assessment Questions

Course Outcome 1 (CO1):

1 Draw the energy band diagram of PN Junction diode.
2 Illustrate the advantages of strained channel MOSFETS
3 Explain in detail about the current voltage characteristics of PN Junction diode.

Course Outcome 2 (CO2):

1 Calculate the I-V equation of SOI MOSFET.
2 Apply the concept of high-k dielectrics in the design of nano scaled MOSFET
3 Model Noise with the suitable models.

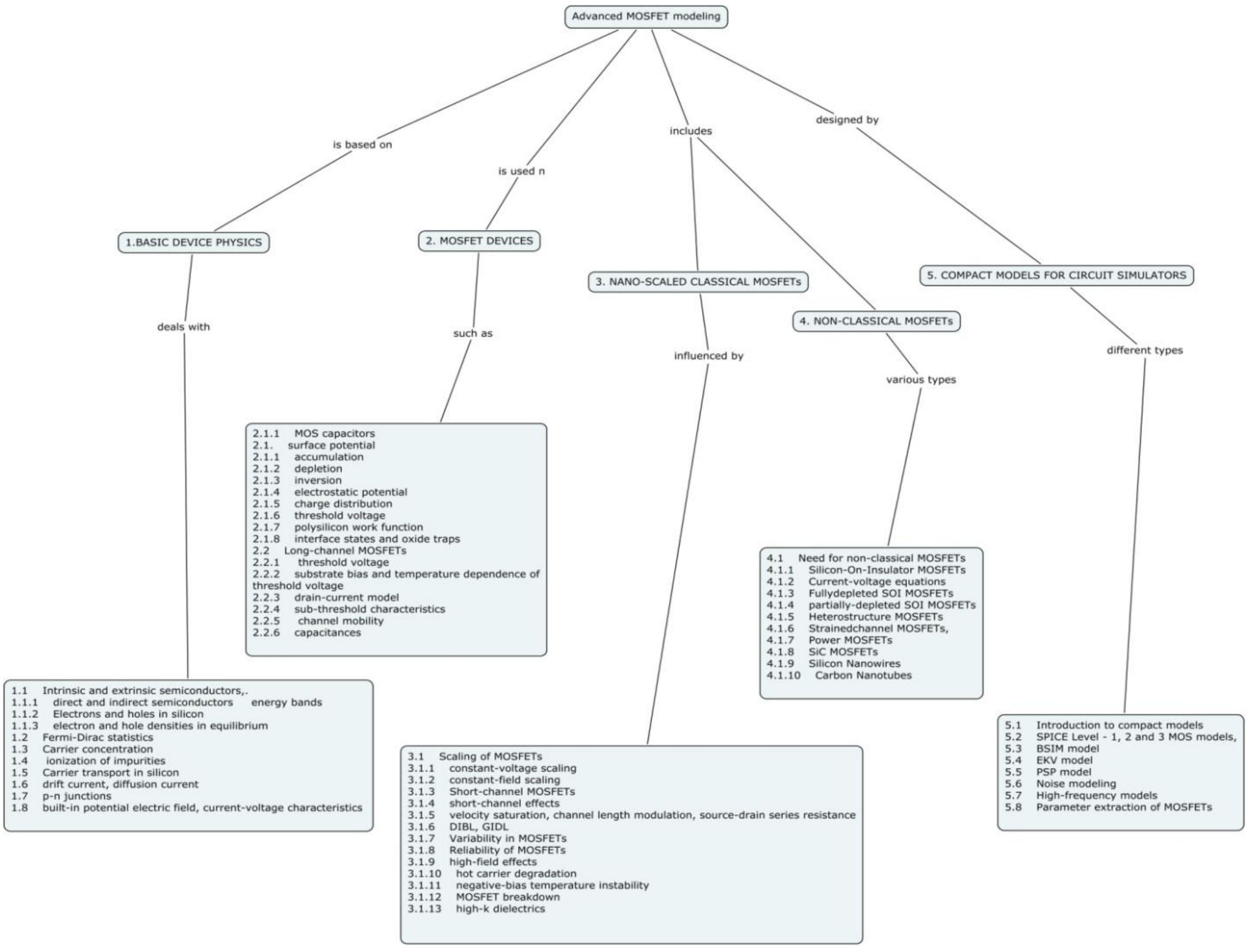
Course Outcome 3 (CO3):

1. Distinguish the direct and indirect semiconductor.
2. Compare Fully depleted & partially depleted SOI MOSFETs.
3. Identify the different types of scaling.
4. Identify the steps involved in the design of hetero structures.
5. Analyze the surface potential, electrostatic potential of MOSFET

Course Outcome 4 (CO4):

1. Generate the set of solutions of threshold voltage of MOSFET; also relate this expression with temperature
2. Build the compact model of bulk MOSFET using SPICE-1, 2.

Concept Map



Syllabus

Introduction: Basic Device Physics-Intrinsic and extrinsic semiconductors, direct and indirect semiconductors. Electrons and holes in silicon,energy bands, electron and hole densities in equilibrium, Fermi-Dirac statistics, carrier concentration, ionization of impurities. Carrier transport in silicon,drift current, diffusion current. p-n junctions,built-in potential, electric field, current-voltage characteristics

Mosfet Devices: MOS capacitors - surface potential, accumulation, depletion, inversion, electrostatic potential and charge distribution, threshold voltage, polysilicon work function, interface states and oxide traps. Long-channel MOSFETs – threshold voltage, substrate bias and temperature dependence of threshold voltage, drain-current model, sub-threshold characteristics, channel mobility, capacitances.

Nano-Scaled Classical MOSFETs: Scaling of MOSFETs – constant-voltage scaling, constant-field scaling. Short-channel MOSFETs – short-channel effects, velocity saturation, channel length modulation, source-drain series resistance,DIBL, GIDL. Variability in MOSFETs. Reliability of MOSFETs , high-field effects, hot carrier degradation, negative-bias temperature instability, MOSFET breakdown, high-k dielectrics

Non-Classical MOSFETs: Need for non-classical MOSFETs, Silicon-On-Insulator MOSFETs- Current-voltage equations, fullydepleted SOI MOSFETs, partially-depleted SOI MOSFETs, Heterostructure MOSFETs , strainedchannel MOSFETs, Power MOSFETs , SiC MOSFETs, Silicon Nanowires, Carbon Nanotubes.

Compact Models For Circuit Simulators: Introduction to compact models, SPICE Level - 1, 2 and 3 MOS models, BSIM model, EKV model, PSP model, Noise modeling, High a frequency models, Parameter extraction of MOSFETs.

Reference Books

1. Y. Taur and T. H. Ning, “Fundamentals of Modern VLSI Devices”, Cambridge University Press, Cambridge, United Kingdom.
2. B. G. Streetman and S. Banarjee, “Solid State Electronic Devices”, Prentice-Hall of India Pvt. Ltd,New Delhi, India.
3. N. DasGupta and A. DasGupta, “Semiconductor Devices – Modeling and Technology”, Prentice- Hall of India Pvt. Ltd, New Delhi, India.
4. B. Bhattacharyya, “Compact MOSFET Models for VLSI Design”, John Wiley & Sons Inc., 2009.
5. K. Maiti, N. B. Chakrabarti, S. K. Ray, "Strained silicon heterostructures: materials and devices”,The Institution of Electrical Engineers, London, United Kingdom.
6. 1.B. Bhattacharyya, “Compact MOSFET Models for VLSI Design”, John Wiley & Sons Inc., 2009

Course Contents and Lecture Schedule

No.	Topic	No. of Lectures
1	**BASIC DEVICE PHYSICS**	
1.1	Intrinsic and extrinsic semiconductors,.	1
1.1.1	direct and indirect semiconductors	
1.1.2	energy bands	1
1.1.3	Electrons and holes insilicon	
1.1.4	electron and hole densities in equilibrium	1
1.2	Fermi-Dirac statistics	1
1.3	Carrier concentration	1
1.4	ionization of impurities	1
1.5	Carrier transport in silicon	1
1.6	drift current, diffusion current	1
1.7	p-n junctions	1

1.8	built-in potential electric field, current-voltage characteristics	
2	**MOSFET DEVICES**	
2.1.1	MOS capacitors	1
2.1.	surface potential	2
2.1.1	Accumulation	
2.1.2	Depletion	
2.1.3	Inversion	
2.1.4	electrostatic potential	2
2.1.5	charge distribution	
2.1.6	threshold voltage	
2.1.7	polysilicon work function	
2.1.8	interface states and oxide traps	
2.2	Long-channel MOSFETs	2
2.2.1	threshold voltage	
2.2.2	substrate bias and temperature dependence ofthreshold voltage	
2.2.3	drain-current model	2
2.2.4	sub-threshold characteristics	
2.2.5	channel mobility	
2.2.6	Capacitances	
3	**NANO-SCALED CLASSICAL MOSFETs**	
3.1	Scaling of MOSFETs	2
3.1.1	constant-voltage scaling	1
3.1.2	constant-field scaling	
3.1.3	Short-channel MOSFETs	1
3.1.4	short-channel effects	
3.1.5	velocity saturation, channel length modulation, source-drain series resistance	2
3.1.6	DIBL, GIDL	
3.1.7	Variability in MOSFETs	
3.1.8	Reliability of MOSFETs	
3.1.9	high-field effects	
3.1.10	hot carrier degradation	
3.1.11	negative-bias temperature instability	1
3.1.12	MOSFET breakdown	1
3.1.13	high-k dielectrics	1
4	**NON-CLASSICAL MOSFETs**	
4.1	Need for non-classical MOSFETs	1
4.1.1	Silicon-On-Insulator MOSFETs	2
4.1.2	Current-voltage equations	
4.1.3	Fullydepleted SOI MOSFETs	
4.1.4	partially-depleted SOI MOSFETs	
4.1.5	Heterostructure MOSFETs	1
4.1.6	Strainedchannel MOSFETs,	1
4.1.7	Power MOSFETs	1
4.1.8	SiC MOSFETs	1
4.1.9	Silicon Nanowires	1
4.1.10	Carbon Nanotubes	1
5	**COMPACT MODELS FOR CIRCUIT SIMULATORS**	
5.1	Introduction to compact models	1
5.2	SPICE Level - 1, 2 and 3 MOS models,	2
5.3	BSIM model	1
5.4	EKV model	1

5.5	PSP model	1
5.6	Noise modelling	1
5.7	High-frequency models	1
5.8	Parameter extraction of MOSFETs	1
	Total Hours	45

Course Designers:

1. Dr.N.B.Balamurugan nbbalamurugan@tce.edu

14CNPV0	NANOSCALE TRANSISTORS	Category	L	T	P	Credit
		PE	3	1	0	4

Preamble

This course provides a comprehensive description of the physics, technology and circuit applications of multigate field-effect transistors (FETs). It explains the physics and properties of these devices, how they are fabricated and how circuit designers can use them to improve the performances of integrated circuits.

Prerequisite

NIL

Course Outcomes

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

CO1: Recall the MOSFET device physics & the small geometry effects.	Remember
CO2: Compare and contrast various MOS technology.	Understand
CO3: Make use of various mathematical models to derive electrical parameters of shrink MOSFETs.	Apply
CO4: Examine small geometry effects to model a high performance MOSFETs.	Analyze

Mapping with Programme Outcomes

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

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	10	10	10	10
Understand	20	20	20	20
Apply	20	20	20	20
Analyse	20	20	20	20
Evaluate	10	10	10	10
Create	20	20	20	20

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. State Moore's Law.
2. List the small geometry effects.
3. List the various geometrics of MOSFETs.
4. Tabulate natural length(λ) for single gate ,double gate ,triple gate MOSFETs.
5. Define corner effects.
6. What is DIBL?

Course Outcome 2 (CO2):

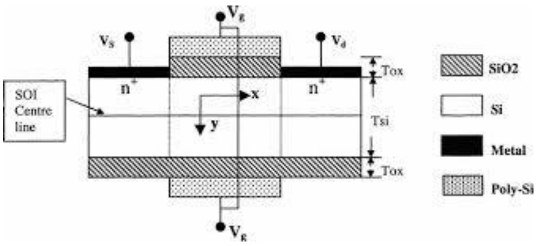
1. Interpret about short channel effects.
2. Express the need for multigate structures.
3. Demonstrate Quantum effects.
4. Summarize about surface roughness.
5. Compare g_m of MuGFET and bulk MOSFET.
6. Indicate the overview of various SoC design & technology aspects.

Course Outcome 3 (CO3):

1. Use the Poisson-Schrödinger wave equation to figure out the quantum mechanical effects.
2. Apply Multigate structure to mitigate Short channel effects.
3. Illustrate the impact of device performance on digital circuit design.

Course Outcome 4 (CO4):

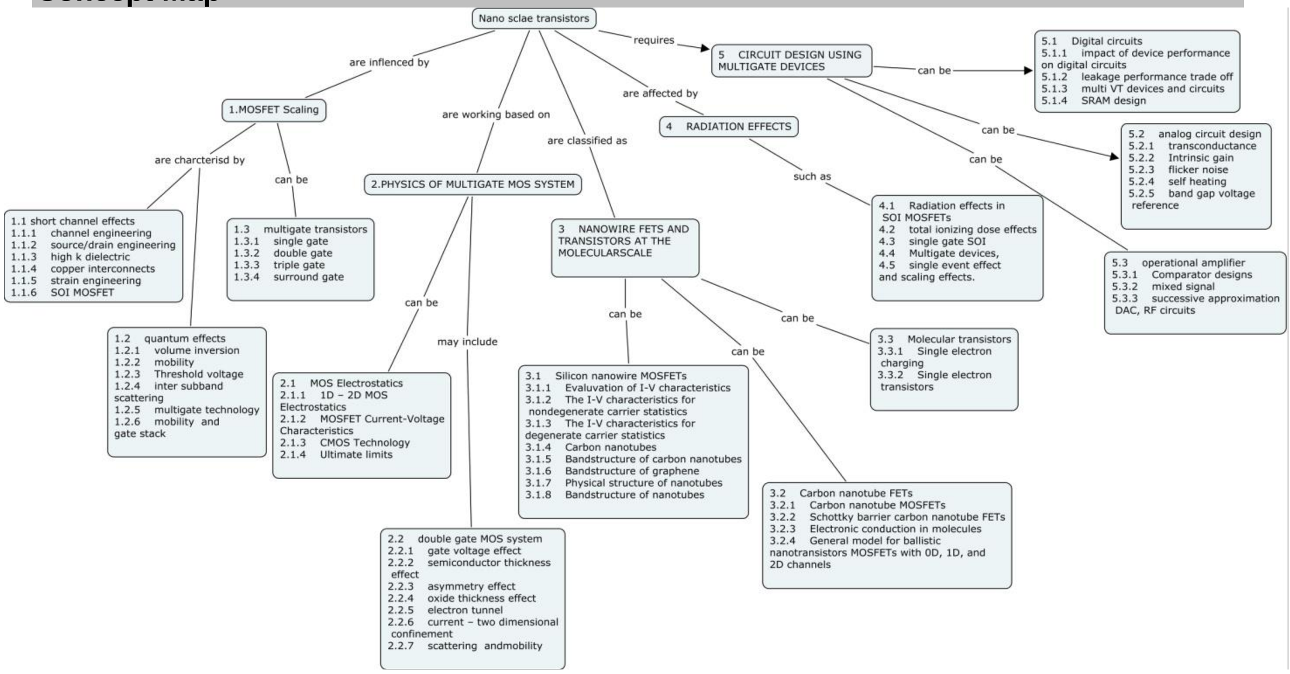
1. Analyze various quantum mechanical effects influenced in the short channel MOSFET.
2. Point out various short channel effects influenced in the short channel MOSFET
3. Analyze the Semiconductor thickness effect.
4. Analyze the single-event effects.
5. Evaluate the electro static potential of given structure with the suitable boundary conditions.



6. Evaluate the following electrostatic parameters of DG-MOS System..
7. Evaluate 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.

8. Evaluate the threshold voltage shift due to radiation effects.

Concept Map



Syllabus

Introduction to Novel -MOSFETs: MOSFET scaling: short channel effects,channel engineering , source/drain engineering , high k dielectric , copper interconnects , strain engineering, SOI MOSFET: multigate transistors, single gate, double gate, triple gate surround gate. quantum effects : volume inversion, mobility, threshold voltage , inter subband scattering, multigate technology ,mobility, gate stack.
Physics of Multigate MOS System: Mos Electrostatics: 1D – 2D MOS Electrostatics, MOSFET Current-Voltage Characteristics ,CMOS Technology , Ultimate limits. double gate MOS system : gate voltage effect ,semiconductor thickness effect , asymmetry effect , oxide thickness effect , electron tunnel current ,two dimensional confinement, scattering – mobility.
Nanowire FETs And Transistors At The Molecular Scale: Silicon nanowire MOSFETs: Evaluvation of I-V characteristics,The I-V characteristics for nondegenerate carrier statistics, The I-V characteristics for degenerate carrier statistics, Carbon nanotubes , Bandstructure of carbon nanotubes, Bandstructure of graphene , Physical structure of nanotubes, Bandstructure of nanotubes, Carbon nanotube FETs.Carbon nanotube MOSFETs: Schottky barrier carbon nanotube FETs, Electronic conduction in molecules , General model for ballistic nanotransistors, MOSFETs with 0D, 1D, and 2D channels .Molecular transistors : Single electron charging, Single electron transistors.
Radiation Effects: Radiation effects in SOI MOSFETs, total ionizing dose effects,single gate SOI,multigate devices, single event effect, scaling effects.
Circuit Design Using Multigate Devices: Digital Circuits: impact of device performance on digital circuits,leakage performance trade off,multi VT devices and circuits,SRAM design.Analog circuit design: transconductance,intrinsic gain,flicker noise,self heating,band gap voltage reference.Operational amplifier: comparator designs, mixed signal,successive approximation DAC, RF circuits.

Reference Books

1. J P Colinge, FINFETs and other multi-gate transistors, Springer – Series on integrated circuits and systems, 2008
2. Mark Lundstrom Jing Guo, Nanoscale Transistors: Device Physics, Modeling and Simulation, Springer, 2006.

Course Contents and Lecture Schedule

No.	Topic	No. of Lectures
	INTRODUCTION TO NOVEL -MOSFETS	
1	**MOSFET scaling**	
1.1	**Short channel effects**	1
1.1.1	Channel engineering	
1.1.2	Source/drain engineering	1
1.1.3	High k dielectric	
1.1.4	Copper interconnects	1
1.1.5	Strain engineering	
1.1.6	SOI MOSFET	
1.2	**Quantum effects**	
1.2.1	Volume inversion	1
1.2.2	Mobility	
1.2.3	Threshold voltage	1
1.2.4	Inter subband scattering	
1.2.5	Multigate technology	
1.2.6	Mobility and gate stack	
1.3	**Multigate transistors**	**1**
1.3.1	Single gate	1

1.3.2	Double gate	
1.3.3	Triple gate	1
1.3.4	Surround gate	
2	**PHYSICS OF MULTIGATE MOS SYSTEM**	
2.1	**MOS Electrostatics**	**1**
2.1.1	1D – 2D MOS Electrostatics	
2.1.2	MOSFET Current-Voltage Characteristics	
2.1.3	CMOS Technology	
2.1.4	Ultimate limits	
2.2	**Double gate MOS system**	
2.2.1	Gate voltage effect	1
2.2.2	Semiconductor thickness effect	1
2.2.3	Asymmetry effect	1
2.2.4	Oxide thickness effect	1
2.2.5	Electron tunnel	1
2.2.6	Current – two dimensional confinement	1
2.2.7	Scattering andmobility	1
3	**NANOWIRE FETS & TRANSISTORS AT THE MOLECULAR SCALE**	
3.1	**Silicon nanowire MOSFETs**	1
3.1.1	Evaluvation of I-V characteristics	
3.1.2	The I-V characteristics for nondegenerate carrier statistics	1
3.1.3	The I-V characteristics for degenerate carrier statistics	
3.1.4	Carbon nanotubes	1
3.1.5	Bandstructure of carbon nanotubes	
3.1.6	Bandstructure of grapheme	1
3.1.7	Physical structure of nanotubes	
3.1.8	Bandstructure of nanotubes	1
3.2	**Carbon nanotube FETs**	1
3.2.1	Carbon nanotube MOSFETs	
3.2.2	Schottky barrier carbon nanotube FETs	1
3.2.3	Electronic conduction in molecules	
3.2.4	General model for ballistic nanotransistors MOSFETs with 0D, 1D, and 2D channels	1
3.3	**Molecular transistors**	
3.3.1	Single electron charging	1
3.3.2	Single electron transistors	1
4	**RADIATION EFFECTS**	
4.1	Radiation effects in SOI MOSFETs	1
4.2	Total ionizing dose effects	1
4.3	Single gate SOI	1
4.4	Multigate devices,	2
4.5	Single event effect and scaling effects.	2
5	**CIRCUIT DESIGN USING MULTIGATE DEVICES**	
5.1	**Digital circuits**	1
5.1.1	Impact of device performance on digital circuits	2
5.1.2	Leakage performance trade off	2
5.1.3	Multi VT devices and circuits	1
5.1.4	SRAM design	**2**
5.2	**Analog circuit design**	
5.2.1	Transconductance	2
5.2.2	Intrinsic gain	1
5.2.3	Flicker noise	2

5.2.4	Self heating	2
5.2.5	Band gap voltage reference	
5.3	**Operational amplifier**	
5.3.1	Comparator designs	1
5.3.2	Mixed signal	1
5.3.3	Successive approximation DAC, RF circuits	1
	Total hours	45

Course Designers:

1. Dr.N.B.Balamurugan nbbalamurugan@tce.edu

14CNPW0	SOLID STATE DEVICE MODELING AND SIMULATION	Category	L	T	P	Credit
		PE	3	1	0	4

Preamble

This course is acquainting the students with fundamentals of building device and circuit simulators, and efficient use of simulators, and efficient use of simulators. The knowledge of different analysis of device modeling and solving network equations will motivate students towards device modeling. The three areas of circuit design, device modeling and CAD tools are the main pillars based on which all VLSI system designs are carried out. This course introduces the principles of device modeling where in device physics and experimentally observed device performances characteristics combined so as to lead to predictable equations and expressions for device performance under scenarios of excitation.

Prerequisite

NIL

Course Outcomes

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

CO1. Explain the importance of MOS capacitor and Small signal modeling	Understand
CO2. Apply and determine the drift diffusion equation and stiff system equation.	Apply
CO3. Analyze circuits using parasitic BJT parameters and newton raphson method.	Analyze
CO4. Model the MOS transistor using schrodinger equation and Multistep methods.	Create

Mapping with Programme Outcomes

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

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	20	10	10	10
Understand	20	10	10	10
Apply	40	40	40	40
Analyse	20	20	20	20
Evaluate	0	10	10	10
Create	0	10	10	10

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Recall the basic operation of MOSFET capacitor.
2. State the prime importance of circuit and device simulations.
3. List out the general purpose circuit simulators.
4. State continuity equation.
5. Define small signal analysis.

Course Outcome 2 (CO2):

1 Draw the equivalent circuit representation of MOS capacitor.
2 Explain the hybrid analysis equations.
3 Illustrate the solutions of stiff systems of equations.
4 Give the formula used in drift-diffusion equation.
5 Explain in detail about the finite difference solutions

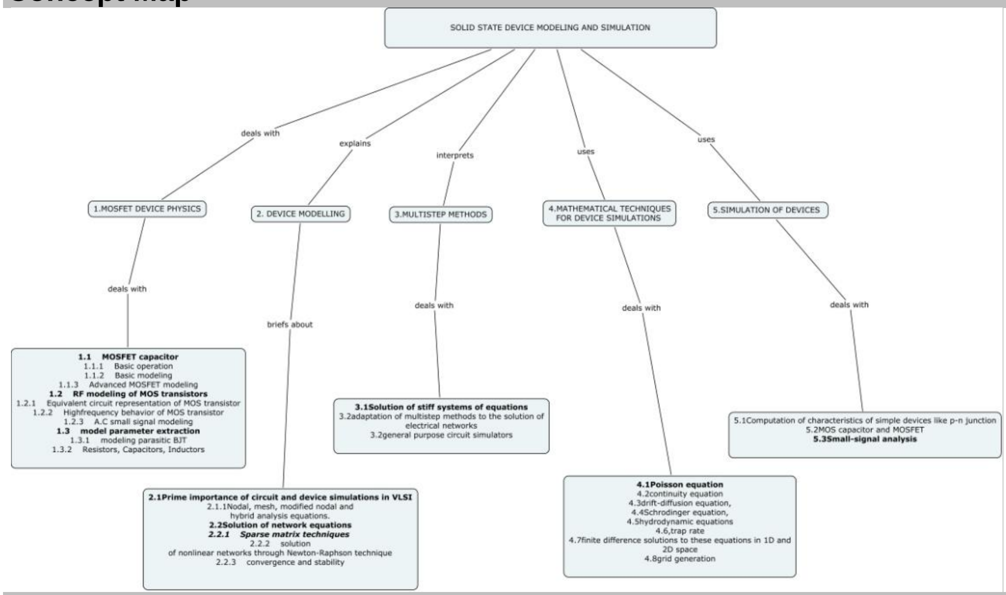
Course Outcome 3 (CO3):

1 Calculate the modeling parameters of parasitic BJT.
2 Implement non-linear networks device modeling through newton-raphson technique.
3 Compute trap rate by solving suitable mathematical model.
4 Find the PN diode characteristic through simulation.
5 Estimate the convergence of newton-raphson technique.

Course Outcome 4 (CO4):

1. Distinguish the different types of device modeling technique.
2. Identify the procedure to model the network equations.
3. Identify the steps involved in multistep methods.
4. Analyze the Schrödinger wave equation.
5. Calculate hydrodynamic equations.

Concept Map



Syllabus

MOSFET DEVICE PHYSICS MOSFET capacitor, Basic operation, Basic modeling,Advanced MOSFET modeling, RF modeling of MOS transistors, Equivalent circuit representation of MOS transistor,Highfrequency behavior of MOS transistor and A.C small signal modeling, model parameterextraction, modeling parasitic BJT, Resistors, Capacitors, Inductors.

DEVICE MODELLING Prime importance of circuit and device simulations in VLSI; Nodal, mesh, modified nodal andhybrid analysis equations. Solution of network equations: Sparse matrix techniques, solution of nonlinear networks through Newton-Raphson technique, convergence and stability.

MULTISTEP METHODS Solution of stiff systems of equations, adaptation of multistep methods to the solution of electrical networks, general purpose circuit simulators. **MATHEMATICAL TECHNIQUES FOR DEVICE SIMULATIONS** Poisson equation, continuity equation, drift-diffusion equation, Schrodinger equation, hydrodynamic equations, trap rate, finite difference solutions to these equations in 1D and 2D space, grid generation. **SIMULATION OF DEVICES** Computation of characteristics of simple devices like p-n junction, MOS capacitor and MOSFET; Small-signal analysis.
Reference:

Reference Books

1. Arora, N., "MOSFET Modeling for VLSI Simulation", Cadence Design Systems, 2007
2. Selberherr, S., "Analysis and Simulation of Semiconductor Devices", Springer-Verlag.,1984
3. Fjeldly, T., Yetterdal, T. and Shur, M., "Introduction to Device Modeling and Circuit Simulation", Wiley-Interscience., 1997
4. Grasser, T., "Advanced Device Modeling and Simulation", World Scientific Publishing Company., 2003
5. Chua, L.O. and Lin, P.M., "Computer-Aided Analysis of Electronic Circuits: Algorithms and Computational Techniques", Prentice-Hall., 1975
6. Trond Ytterdal, Yuhua Cheng and Tor A. FjeldlyWayne Wolf, "Device Modeling for Analog and RF CMOS Circuit Design", John Wiley & Sons Ltd.

Course Contents and Lecture Schedule

No.	**Topic**	**No. of Lectures**
1	**MOSFET DEVICE PHYSICS**	
1.1	**MOSFET capacitor**	
1.1.1	Basic operation	1
1.1.2	Basic modeling	1
1.1.3	Advanced MOSFET modeling	1
1.2	**RF modeling of MOS transistors**	
1.2.1	Equivalent circuit representation of MOS transistor	1
1.2.2	High frequency behaviour of MOS transistor	1
1.2.3	A.C small signal modeling	1
1.3	**Model parameter extraction**	
1.3.1	modeling parasitic BJT	1
1.3.2	Resistors, Capacitors, Inductors	2
2	**DEVICE MODELLING**	
2.1	**Prime importance of circuit and device simulations in VLSI**	
2.1.1	Nodal, mesh, modified nodal and hybrid analysis equations.	3
2.2	**Solution of network equations**	
2.2.1	Sparse matrix techniques	2
2.2.2	solution of nonlinear networks through Newton-Raphson technique	3
2.2.3	convergence and stability	1
3	**MULTISTEP METHODS,**.	
3.1	Solution of stiff systems of equations	
3.2	adaptation of multistep methods to the solution of electrical networks	3
3.2	general purpose circuit simulators	3
4	**MATHEMATICAL TECHNIQUES FOR DEVICE SIMULATIONS**	
4.1	Poisson equation,	1

4.2	continuity equation	1
4.3	drift-diffusion equation,	1
4.4	Schrodinger equation,	2

Course Designers:

1. Dr.N.B.Balamurugan nbbalamurugan@tce.edu

14CNPX0	PHOTONIC CRYSTALS- PRINCIPLES AND APPLICATIONS	Category	L	T	P	Credit
		PE	4	-	-	4

Preamble

This course presents the state-of-the-art in the field of Photonics which encompasses the usage of photonic crystal in a very high speed all- optical communication and networking. The course will enable the students to learn about all optical devices that form the backbone of future all-optical networks. The course will provide students with a fundamental understanding of photonic crystal, fabrication, design, testing and application. Students will do the design of all optical devices, optical logic gates and combinational circuits using photonic crystal.

Prerequisite

NIL

Course Outcomes

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

CO1	Understand the basic concepts, properties, fabrication techniques and the role of photonic crystals in the photonic technology	Understand
CO2	Analyze the structure of photonic crystal using rod slab and hole slab	Analyze
CO3	Analyze the behaviour of light inside the photonic crystal	Analyze
CO4	Focus the mechanism for all-optical photonic crystal switching	Apply
CO5	Designing various optical devices using photonic crystal	Create

Mapping with Programme Outcomes

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

S- Strong; M-Medium; L-Low

Assessment Pattern

	Bloom's category	Continuous Assessment Tests			End Semester Examinations
		1	2	3	
1	Remember	20	20	10	10
2	Understand	20	20	20	20
3	Apply	40	40	40	40
4	Analyze	20	20	0	15
5	Evaluate	0	0	0	0
6	Create	0	0	30	15

Course Level Assessment Questions

Course Outcome 1 (CO1):

9. Derive the wave equation of photonic crystal using Maxwell equation.
10. For one-dimensional photonic crystal, the central wavelength of the photonic band gap is 600 nm. The refractive index of the high and low dielectric layers *n*1 and *n*2 is 2.3 and 1.6, respectively. Design the thickness of the high and low dielectric layers *d*1 and *d*2
11. For a polystyrene opal with a photonic band gap centered at 800 nm, calculate the diameter of polystyrene sphere according to the Bragg equation

$$\lambda = 2\sqrt{f_1\varepsilon_1 + f_2\varepsilon_2}\cdot d$$

where λ is the center wavelength of the photonic band gap, *f*1 and *f*2 are the filling rates of air and polystyrene, respectively, €1 and €2 are the dielectric constants of air and polystyrene, respectively, and *d* is the spacing of (111) crystal planes.

Course Outcome 2 (CO2):

1. Differentiate rode slab and hole slab.
2. Write the mechanism for high Q with incomplete gaps.
3. Explain in detail about the line defects in slab.

Course Outcome 3 (CO3):

1. Explain in detail about plane wave expansion method.
2. Study and analyze 1D, 2D, 3D finite difference time domain method (FDTD) for the propagation of electromagnetic wave into the photonic crystal.
3. Apply transfer matrix method for solving 1D photonic crystal slab.

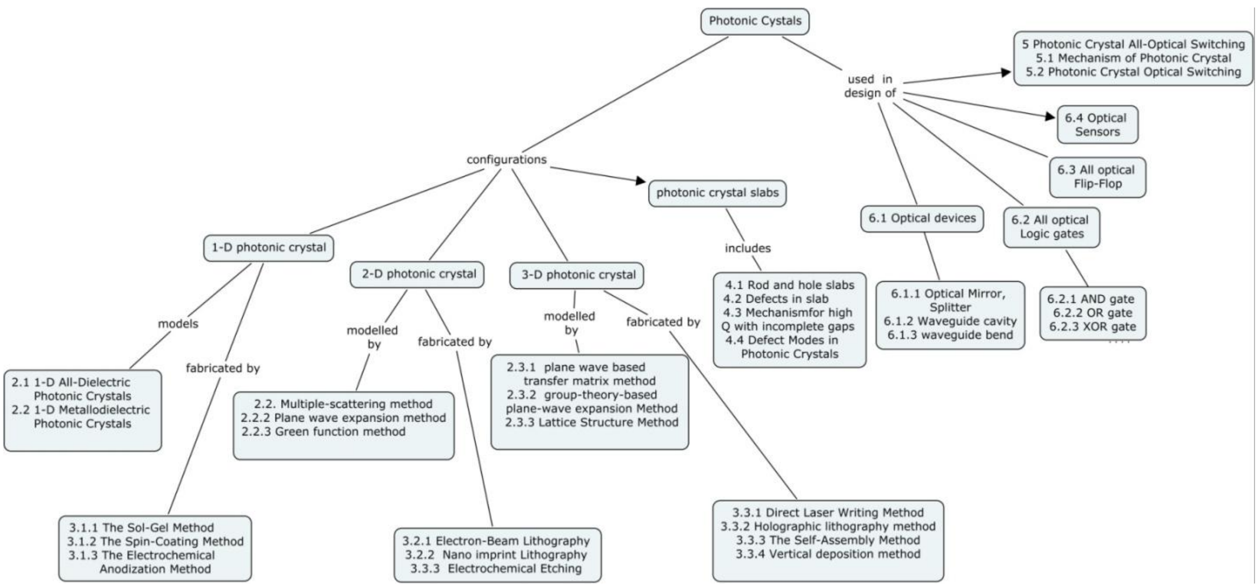
Course Outcome 4 (CO4):

1. Write the mechanism of Photonic Crystal All-Optical Switching.
2. Explain Nonlinear Chiral Photonic Crystal Optical Switching.
3. Explain Photonic Crystal Thermal-Optic Switching.
4. Illustrate the working of Photonic Crystal Electro-Optic Switching.

Course Outcome 5 (CO5):

1. Design all optical logic gates using photonic crystal?
2. Design all-optical logic flip flop using photonic crystal?
3. Design a mirror, waveguide, cavity, waveguide bend, splitter using photonic crystal?
4. Design nonlinear filters using photonic crystal?

Concept Map



Syllabus

Fundamental Properties of Photonic Crystals: Configuration of Photonic Crystals- one dimensional Photonic crystal- two dimensional photonic crystal- three dimensional photonic crystal- Origination of Photonic Band gap- Characterization of Photonic Band gap **Fabrication Technique of Photonic Crystals:** One-Dimensional Photonic Crystals- Two Dimensional Photonic Crystals- Three Dimensional Photonic Crystals **Photonic crystal slabs:** rod and hole slabs- line defect in slab- point defect in slab- mechanism for high Q with incomplete gaps, Defect Modes in Photonic Crystals, Dielectric Loss and Quality Factor **Photonic Crystal All-Optical Switching:** Mechanism of Photonic Crystal All-Optical Switching, Optical Bistable Switching -Photonic Crystal Optical Switching **Designing photonic crystal for Application:** designing a mirror, waveguide, cavity, waveguide bend, splitter, nonlinear filters and bistability, photonic crystal logical devices

Reference Books

1. Qihuang Gong, Xiaoyong Hu, “Photonic Crystals Principles and Applications”, CRC Press, 2013.
2. John D Joannopoulos, Steven G. Johnson, “Photonic Crystals- Moulding the flow of light” 2nd edition, Princeton University Press, 2008.
3. Kazuaki Sakoda," Optical Properties of Photonic Crystals", Second Edition, Springer
4. C. Sibilia· T.M. Benson · M. Marciniak· T. Szoplik , “ Photonic Crystals: Physics and Technology”, Springer 2008
5. Alessandro Massaro “Photonic Crystals – Introduction, Applications and Theory”, InTech
6. Maksim Skorobogatiy, Jianke Yang , Fundamentals of Photonic Crystal Guiding, Cambridge University Press 2009

Course Contents and Lecture Schedule

S. No	Topics	No. of Lectures
1	**Introduction to Photonic Crystals**	1
1.1 1.2	Fundamental principles Configurations of photonic crystals	2
1.3	Origination of photonic band gap	1
1.4	Characterization of Photonic Band gap	1
2	**Photonic crystal configuration**	
2.1 2.1.1 2.1.2	One dimensional Photonic crystal One-Dimensional All-Dielectric Photonic Crystals One-Dimensional Metallodielectric Photonic Crystals	3
2.2 2.2.1 2.1.2 2.1.3	Two dimensional Photonic crystal The multiple-scattering method The plane wave expansion method The Green function method	3
2.3 2.3.1 2.3.2 2.3.3	Three dimensional Photonic crystal The plane wave based transfer matrix method The group-theory-based plane-wave expansion Method Lattice Structure Method	3
3	**Fabrication Technique of Photonic Crystals**	
3.1	**One Dimensional Photonic crystal**	
3.1.1 3.1.2 3.1.3	The Sol-Gel Method The Spin-Coating Method The Electrochemical Anodization Method	2

3.2	**Two dimensional Photonic crystal**	
3.2.1 3.2.2 3.2.3	The Electron-Beam Lithography Method The Nano imprint Lithography Method The Electrochemical Etching Method	2
3.3	Three Dimensional Photonic crystal	
3.3.1 3.3.2 3.3.3 3.3.4	The Direct Laser Writing Method Holographic lithography method The Self-Assembly Method Vertical deposition method	2
4	**Photonic crystal slabs**	
4.1	Rod and hole slabs	2
4.2	**Defects in slab**	
4.2.1 4.2.2	Point defect in slab Line defect in slab	3
4.3	**Mechanismfor high Q with incomplete gaps**	1
4.4	**Defect Modes in Photonic Crystals**	2
4.4.1	Dielectric Loss and Quality Factor	1
5	**Photonic Crystal All-Optical Switching**	
5.1	**Mechanism of Photonic Crystal switching**	
5.1.1 5.1.2	Photonic Band gap Shift Method Defect Mode Shift Method	1
5.1.3	Optical Bistable Switching	1
5.1.4	Waveguide–Micro cavity Coupling Method	1
5.1.5 5.1.6	Waveguide coupling method Nonlinear Chiral Photonic Crystal Optical Switching	2
5.2	**Photonic Crystal Optical Switching**	
5.2.1 5.2.2 5.2.3	Photonic Crystal Electro-OpticSwitching Photonic Crystal Thermal-OpticSwitching Photonic Crystal All-Optical Switching	1 1 1
6	**Designing photonic crystal for Application**	
6.1	**Optical devices**	
6.1.1	Optical mirror, splitter	2
6.1.2 6.1.3	Waveguide, cavity waveguide bend	2
6.1.4	Tunable photonic crystal fiber	2
6.3	**All optical logic gates**	
6.3.1	AND gate	1
6.3.2 6.3.3	OR gate XOR gate	2
6.4	**All-Optical Flip-Flop**	1
6.5	**Photonic crystal sensors**	2
	Total	48

Course Designers:

2. Dr. S.Ponmalar spmece@tce.edu

14CNRA0	TELEHEALTH TECHNOLOGY

Category	L	T	P	Credit
PE	4	0	0	4

Preamble

The Course aims at application of developments in wireless Technologies to the Health Field. Wearable wireless monitoring devices for continuous monitoring of health conditions help a lot in patient health care systems. This has paved the way for Telehealth technologies which contributes to the public health scenario both in rural and urban areas.

Prerequisite

NIL

Course Outcomes

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

CO1.Match the concepts of Telemedicine in Health Monitoring.	Understand
CO2.Apply multimedia technologies in telemedicine	Apply
CO3.Illustrate the standards and Protocols behind encryption techniques for secure transmission of data	Understand
CO4.Categorize the various Mobile Telemedical technologies.	Analyse
CO5.Identify the recent trends in Telemedical Scenario and how it is used in day to day applications	Apply

Mapping with Programme Outcomes

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

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	20	10	0	0
Understand	20	30	20	20
Apply	30	30	40	40
Analyse	30	30	40	40
Evaluate	0	0	0	0
Create	0	0	0	0

Course Level Assessment Questions

Course Outcome 1(CO1):

1. Define Telemedicine
2. List the organs of Telemedicine
3. State some of the ethical and legal practices of Telemedicine
4. Draw the functional Diagram of telemedicine system
5. List out some of the advances in Telemedicial technologies

Course Outcome 2 (CO2):

1. Identify the usage of Multimedia technologies in Telemedicine.
2. Interpret the applications of GSM in Telemedical applications.
3. Identify the various types of antennas used for Telemedical Transmission.
4. Explain how Mobile hand held device and mobile communication can be related to Telehealth.

Course Outcome 3 (CO3):

1. Illustrate how telemedicine can be integrated with doctors and hospitals.
2. Summarize the various cyber laws related to Telemedicine.
3. Discuss about some of the protocols used for Telemedical applications.
4. Illustrate the need for Data security in Telehealth.
5. Classify the various phases of Encryption.

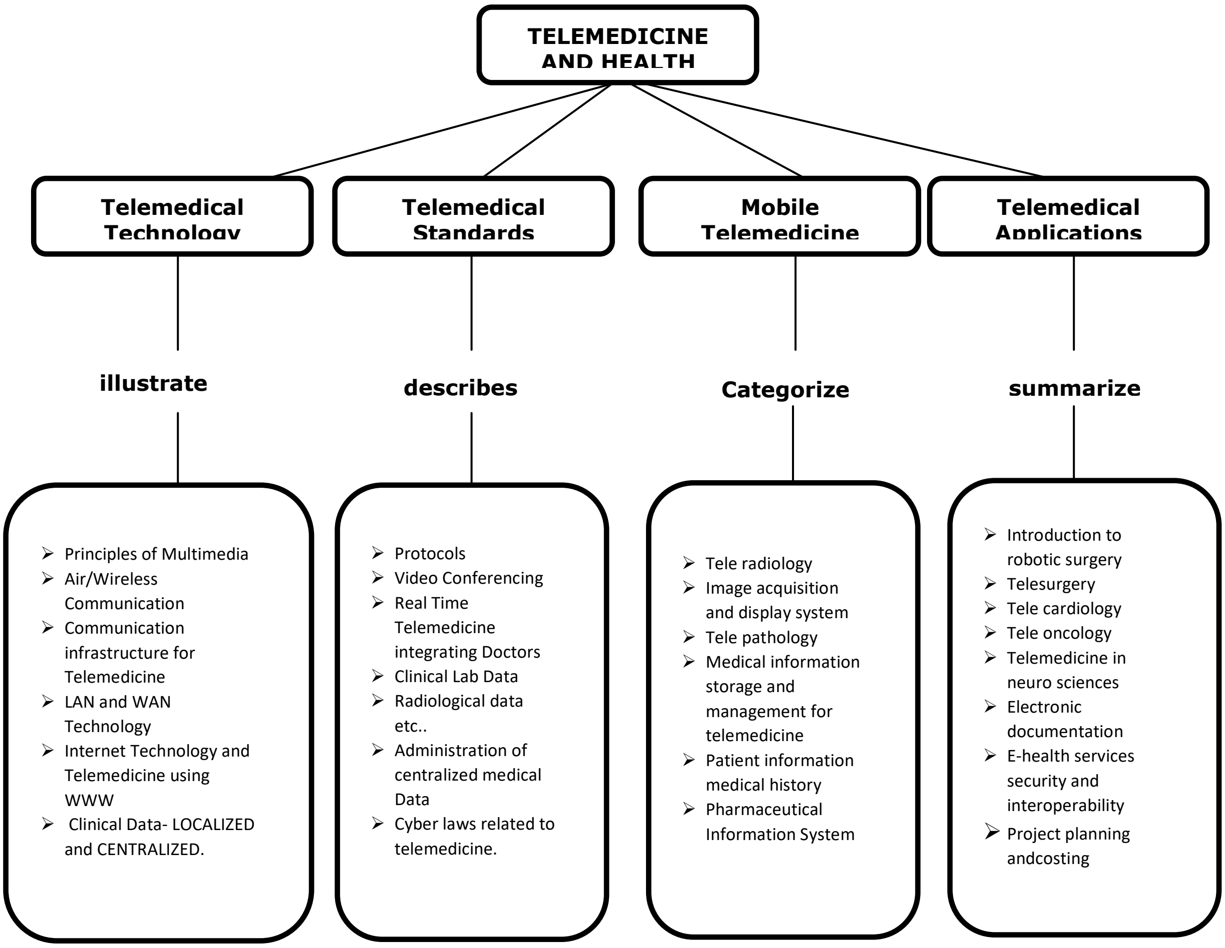
Course Outcome 4 (CO4):

1. Analyze the need of an Image acquisition system in Teleradiology.
2. Categorize the various multimedia databases.
3. Analyze how medical information is stored and managed.
4. Relate the function of a Pharmaceutical Information system
5. List the needs of Mobile Telemedicine.

Course Outcome 5 (CO5):

1. Identify the areas where Telemedicine can be deployed.
2. Apply the concept of robotic surgery in real time scenario and give its pros and cons.
3. Make use of the Telecardiology concept and explain how it can be used to treat a patient from a remote distance.
4. Illustrate the need of Teleoncology and provide some of its applications in Health care.
5. Identify the need of telesurgery in this modern era.

Concept Map



Syllabus

TELEMEDICINE AND HEALTH History and Evolution of telemedicine, Functional diagram of telemedicine system, Telemedicine, Telehealth, Tele care, Organs of telemedicine, Global and Indian scenario, Ethical and legal aspects of Telemedicine - Confidentiality, Social and legal issues, Safety and regulatory issues, Advances in Telemedicine. **TELEMEDICAL TECHNOLOGY** Principles of Multimedia - Text, Audio, Video, data, Data communications and networks, PSTN,POTS, ANT, ISDN, Internet, Air/ wireless communications: GSM satellite, and Micro wave, Modulation techniques, Types of Antenna, Integration and operational issues, Communication infrastructure for telemedicine – LAN and WAN technology. Satellite communication. Mobile hand held devices and mobile communication. Internet technology and telemedicine using world wide web (www). Video and audio conferencing. Clinical data – local and centralized. **TELEMEDICAL STANDARDS** Data Security and Standards: Encryption, Cryptography, Mechanisms of encryption, phases of Encryption. Protocols: TCP/IP, ISO-OSI, Standards to followed DICOM, HL7, H. 320 series (Video phone based ISBN) T. 120, H.324 (Video phone based PSTN), Video Conferencing, Real-time Telemedicine integrating doctors / Hospitals, Clinical laboratory data, Radiological data, and other clinically significant biomedical data, Administration of centralized medical data, security and confidentiality of medical records and access control, Cyber laws related to telemedicine. **MOBILE TELEMEDICINE** Tele radiology: Definition, Basic parts of teleradiology system: Image Acquisition system, Display system, Tele pathology, multimedia databases, color images of sufficient resolution, Dynamic range, spatial resolution, compression methods, Interactive control of color, Medical information storage and management for telemedicine- patient information medical history, test reports, medical images diagnosis and treatment. Hospital information system - Doctors, paramedics, facilities available. Pharmaceutical information system. **TELEMEDICAL APPLICATIONS** Telemedicine access to health care services – health education and self-care. · Introduction to robotics surgery, telesurgery, Telecardiology, Teleoncology, Telemedicine in neurosciences, Electronic Documentation, e-health services security and interoperability, Telemedicine access to health care services – health education and self-care, Business aspects - Project planning and costing, Usage of telemedicine.

Reference Books:

1. Norris, A.C. “Essentials of Telemedicine and Telecare”, Wiley, 2002
2. Wootton, R., Craig, J., Patterson, V. (Eds.), “Introduction to Telemedicine. Royal Society of Medicine” Press Ltd, Taylor & Francis 2006
3. O'Carroll, P.W., Yasnoff, W.A., Ward, E., Ripp, L.H., Martin, E.L. (Eds), “Public Health Informatics and Information Systems”, Springer, 2003.
4. Ferrer-Roca, O., Sosa - Iudicissa, M. (Eds.), Handbook of Telemedicine. IOS Press (Studies in Health Technology and Informatics, Volume 54, 2002.
5. Simpson, W. Video over IP. A practical guide to technology and applications. Focal Press Elsevier, 2006. 5. Bemmel, J.H. van, Musen, M.A. (Eds.) Handbook of Medical Informatics. Heidelberg, Germany: Springer, 1997.
6. Mohan Bansal, “Medical Informatics”, Tata McGraw-Hill, 2004

Course Contents and Lecture Schedule

Module No.	Topic	No. of Lectures
1	**Telemedicine and Health**	
1.1	History and Evolution of Telemedicine	1
1.2	Functional Diagram of Telemedicine system	1
1.3	Telemedicine, Telehealth, Telecare	2
1.4	Organs of Telemedicine	1
1.5	Ethical and legal aspects of Telemedicine	1
1.6	Advances in Telemedicine	1
2	**Telemedical Technology**	
2.1	Principles of Multimedia – Text, audio, video, Data	3
2.2	Data communication and Networks – PSTN, POTS, ISDN, ANT	2
2.3	Air/Wireless Communications – GSM Satellite	1
2.4	Types of Antenna, Integration and operational issues	2
2.5	Communication Infrastructure for Telemedicine – LAN and WAN	1

	technology	
2.6	Internet technology and telemedicine using world wide web (www).	1
2.7	Video and Audio Conferencing, Clinical Data – Localized and Centralized	1
3.	**Telemedical Standards**	
3.1	Data encryption and standards	2
3.2	Protocols: TCP/IP, ISO-OSI	1
3.3	Video Conferencing	1
3.4	Real-time Telemedicine integrating doctors / Hospitals	1
3.5	Clinical laboratory data, Radiological data, and other clinically significant biomedical data	2
3.6	Administration of centralized medical data	1
3.7	security and confidentiality of medical records and access control	1
3.8	Cyber laws related to telemedicine.	1
4	**Mobile Telemedicine**	
4.1	Teleradiology	1
4.2	Telepathology	1
4.3	Dynamic range, spatial resolution	1
4.4	Medical information storage and management for telemedicine	1
4.5	Patient information medical history, test reports	1
4.6	Medical images diagnosis and treatment.	1
4.7	Hospital information system - Doctors, paramedics, facilities available	1
4.8	Pharmaceutical information system	1
5	**Telemedical Applications**	
5.1	Telemedicine access to health care services	1
5.2	Health education and Self-Care	1
5.3	Introduction to robotics surgery	1
5.4	Telesurgery, Telecardiology, Teleoncology	1
5.5	Telemedicine in neurosciences, Electronic Documentation	2
5.6	e-health services security and interoperability	1
5.7	Telemedicine access to health care services	1
5.8	Project planning and costing, Usage of telemedicine.	1
	Total	45

Course Designers:

3. Dr. (Mrs.) R. Sukanesh sukanesh@tce.edu

14CNRB0	RADIO FREQUENCY INTEGRATED CIRCUIT SYSTEM DESIGN

Category	L	T	P	Credit
PE	3	1	0	4

Preamble

This course introduces the principles, analysis, and design of CMOS Radio frequency (RF) integrated circuits for wireless communication systems. Besides system level design considerations for RFIC, this course also presents rule-of-thumbs in designing RF main blocks such as Low-Noise-Amplifier (LNA), mixer, Voltage-Controlled-Oscillator (VCO), and Phase-Locked-Loop (PLL). Students are supposed to understand architectures of RF system and master the keypoint of designing RF Integrated circuits. They are also required to design circuits and do simulation with Cadence SpectreRF

Prerequisite

Digital Integrated Systems

Course Outcomes

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

CO1	Understand the fundamentals of RF integrated circuits operating at Radio Frequencies	Understand
CO2	Discuss active and passive device technologies relevant to RFICs and their relative performance advantages and disadvantages	Apply
CO3	Design and Implementation of Low Noise Amplifier based on foundry models for Wireless Communication Systems	Apply
CO4	Design and Implementation of Power amplifier for portable applications	Apply
CO5	Design and analyze different types of Phase Locked Loops.	Analyse
CO6	Analyse the RF mixer circuit based on noise figure, conversion gain and implementation in CMOS technology	Analyse

Mapping with Programme Outcomes

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

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's category	Continuous Assessment Tests			End Semester Examinations
	1	2	3	
Remember	20	20	10	0
Understand	40	30	10	20
Apply	40	50	60	60
Analyze	0	0	20	20
Evaluate	0	0	0	0
Create	0	0	0	0

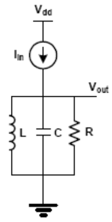
Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Distinguish between a heterodyne receiver and homodyne receiver.
2. Define: ACPR.
3. List out the various circuit level parameters used in RFIC.

Course Outcome 2 (CO2):

1. Determine the quality factor of the tank with respect to R, C, and L.



2. The mean square thermal noise density of a resistor in the room temperature is . If this resistor is used in a first-order *RC* filter as shown in Fig. 1, and the noise bandwidth of the *RC* filter is , calculate the value of *C* in Fig.1. Present the details of your calculations. 33£10¡17V2=Hz50MHz.

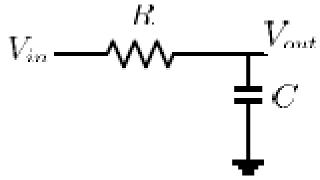
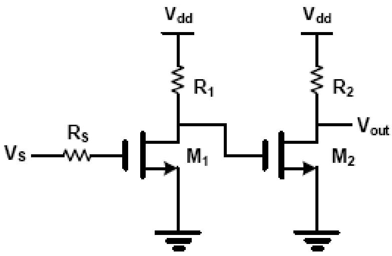


Fig. 1. A single-pole RC filter.

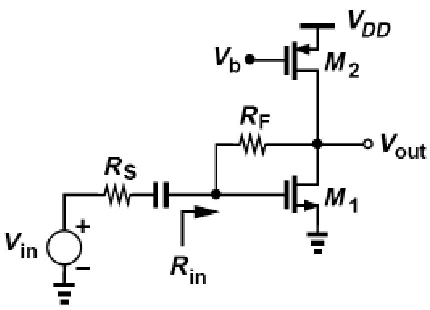
3. Explain the different choices of reaiization of RF inductors and capacitors in CMOS technology. Why these are different in compared to the conventional lumped component inductors and capacitors.

Course Outcome 3 (CO3):

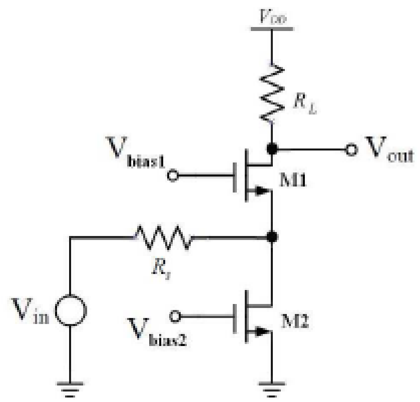
1. Figure shows a two-stage amplifier schematic. Determine the noise factor of this amplifier. Consider only the thermal noise sources and ignore the gate noise of the transistors. Ignore all the parasitics and assume that the transistors are long-channel devices and λ_n =0.



2. A common-source low noise amplifier (LNA) with feedback is shown in Fig. is the input source resistance. Assume that the transistors are long-channel devices and



3. Consider the wideband common-gate low noise amplifier (LNA) shown in Figure is the input source resistance. Assume that the transistors are long-channel devices with . Also assume that γ*body effect* = 0.



a. Calculate the input impedance of the LNA. Assume that we can neglect all parasitic associated with the transistors.
b. Derive an expression for the noise figure of the LNA. Only consider the thermal noise sources and ignore the gate noise of the transistors. Also assume that is a noiseless resistor.

Course Outcome 4 (CO4):

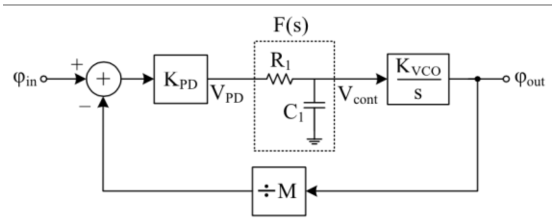
1. The following table lists three different properties for the A, B, C, D, and E power amplifier classes and their typical values. Identify the power amplifier class for each column.

Maximum drain efficiency [%]	100	78.5	100	50	100
Peak drain voltage [*V_{DD}]	2	2	1	2	3.6
Normalized power output capability [Pout/(max V and I)]	0.125	0.125	0.32	0.125	0.098
Power Amplifer Class					

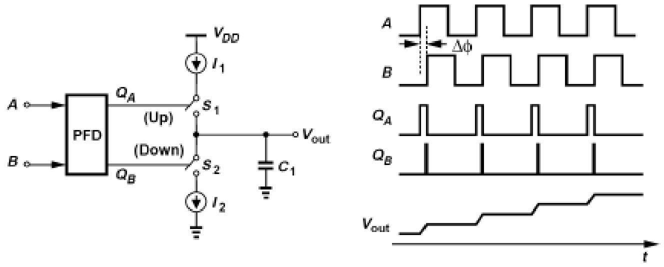
2. What are the performance trade-offs when choosing this Vg,bias-value?
3. What is the purpose of a ”load-pull characterization” of a power amplifier?

Course Outcome 5 (CO5):

1. For the frequency-multiplying PLL shown below, determine the:
   a. closed-loop transfer function
   b. damping factor ζ
   c. natural frequency ωn
   d. loop bandwidth

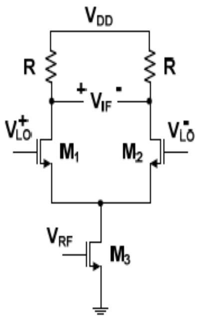


2. Explain how a type-I PLL operates as a FSK demodulator, if the VCO control voltage is considered as the output.
3. Figure shows the waveforms of PFD and charge pump in a type-II PLL. Using this figure, determine the transfer function of this combination.



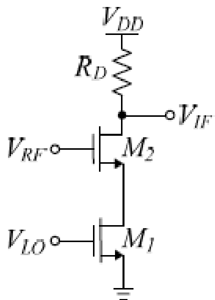
Course Outcome 6 (CO6):

1. A single-balanced mixer is shown in Fig. Assume that the switching transistors M1 and M2 are ideal switches with zero on-resistance and .



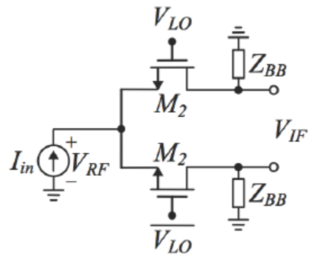
   a. Derive an expression for the conversion gain of this mixer.
   b. Derive an expression for the noise figure of this mixer. Assume the switching transistors do not generate noise. The total noise is contributed by transistor M3, load resistors R and source resistor R_s connected to the RF input (is not shown in the figure). Consider only the thermal noise sources and ignore the gate noise of the transistor.

2. The circuit shown in Fig. is a dual-gate mixer used in traditional microwave design. Assume abrupt edges and a 50% duty cycle for the LO, and neglect channel-length modulation and body effect.

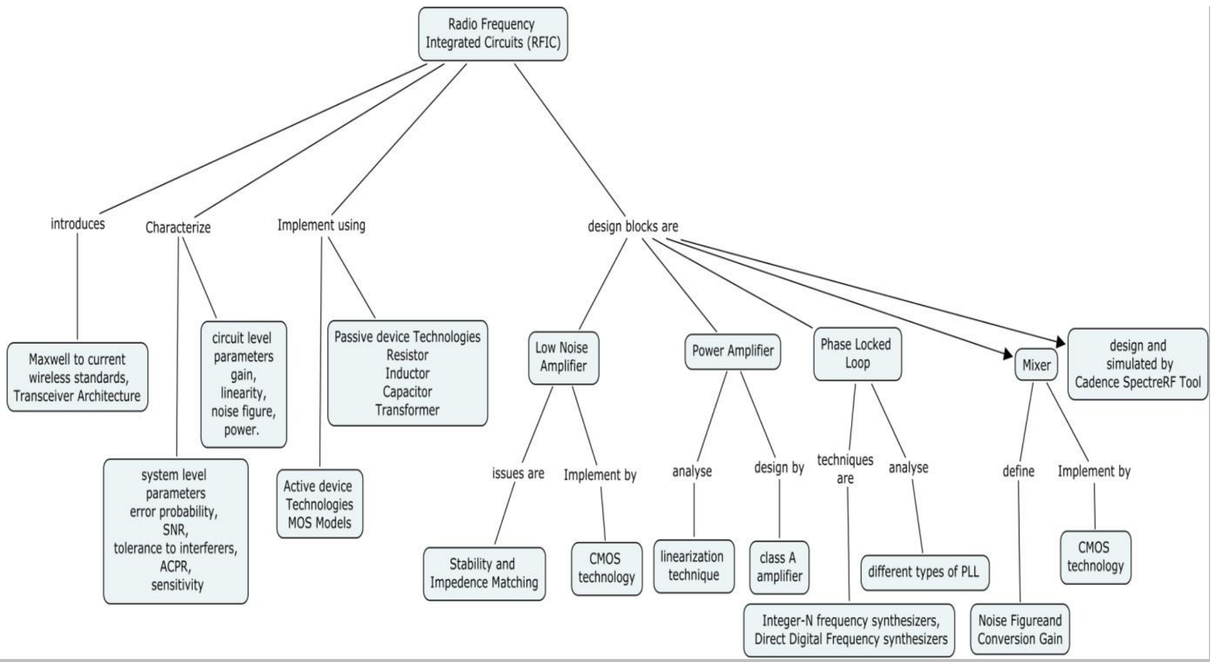


   a. Assume that *M*1 is an ideal switch. Determine all the frequency components which appear at the mixer IF port.
   b. Assume when *M*1 is on, it has an on-resistance of *R*on1. Compute the voltage conversion gain of the circuit. Assume *M*2 does not enter the triode region and denote its transconductance by *gm*2.
   c. Assume that *M*1 is an ideal switch (noise contribution is zero). Derive the expression for the noise figure of the mixer.

3. Prove that the voltage conversion gain of a sampling mixer approaches 6 dB as the width of the LO pulses tends to zero (i.e., as the hold time approaches the LO period).



Concept Map



Syllabus

Introduce RFIC Design Basics: Historical Aspects – From Maxwell to Current Wireless standards, The bridge between communication system designer and RF IC Designer: Comm. System characterization, RF System characterization, Transceiver Architectures, System-level parameters: error probability, SNR, tolerance to interferers, ACPR, sensitivity, Circuit-level parameters: gain, linearity, noise figure, power. **The CMOS technology for RF:** MOS models for RF, Characteristics of passive IC components at RF frequencies – interconnects, resistors, capacitors, inductors and transformers Transmission lines Classical two-port noise theory, Noise models for active and passive components. **Low Noise Amplifier:** Tuned Low-Noise Amplifiers, Other LNA topologies, Design of LNA using Cadence SpectreRF. **Power Amplifier:** Stability of feedback systems: Gain and phase margin, Root-locus techniques, Time and Frequency domain considerations, Compensation, Class A, AB, B, C, D, E and F amplifiers, Design of Power amplifier using Cadence SpectreRF. **Phase-Looked Loop:** Resonant LC-CMOS VCO design, Other VCO topologies: QVCOs Linearized PLL Model, Loop filters and Charge pumps, Integer-N frequency synthesizers, Direct Digital Frequency synthesizers, Design of Phase Locked Loop and performance analysis using Cadence SpectreRF, Hardware Demos of PLL chipset. **Mixer:** Active mixers, Passive and polyphase filters, Design of a mixer based on a Gilbert cell using SpectreRF, Hardware Demos of Mixer.

Reference Books:

1. Behzad Razavi, RF Microelectronics, 2nd Ed., Prentice Hall, Reprint 2012.
2. Thomas. H. Lee, The Design of CMOS Radio Frequency Integrated Circuits, Cambridge, U.K., Cambridge University Press, 2004.
3. John W.M.Rogers and Calvin Plett, "Radio Frequency Integrated Circuit Design", 2nd Edition,Artech House, Norwood, 2010.
4. Devendra.K. Misra, "Radio Frequency and Microwave Communication Circuits – Analysis and Design", John Wiley and Sons, Newyork, 2004.
5. Wayne Wolf, Modern VLSI design, Pearson Education, 2003

Course Contents and Lecture Schedule

Module No	Topic	No.of Lectures
1	**Introduce RFIC Design Basics**	
1.1	Historical Aspects – From Maxwell to Current Wireless standards	1
1.2	The bridge between communication system designer and RF IC Designer: Comm. System characterization, RF System characterization	1
1.3	Transceiver Architectures	1
1.4	System-level parameters: error probability, SNR, tolerance to interferers, ACPR, sensitivity	2
1.5	Circuit-level parameters: gain, linearity, noise figure, power	2
2	**The CMOS technology for RF**	
2.1	MOS models for RF	2
2.1	Characteristics of passive IC components at RF frequencies – interconnects, resistors, capacitors, inductors and transformers	3
2.3	Transmission lines Classical two-port noise theory, ,	2
2.4	Noise models for active and passive components	3
3	**LNA Design**	
3.1	Tuned Low-Noise Amplifiers	2
3.2	Other LNA topologies	2
3.3	Specific analysis for RF using Cadence SpectreRF.	3
4	**Power Amplifier**	
4.1	Stability of feedback systems: Gain and phase margin, Root-locus techniques, Time and Frequency domain considerations, Compensation	2
4.2	Class A, AB, B, C, D, E and F amplifiers	3
4.3	Design of Power amplifier using Cadence SpectreRF	3
5	**Oscillators & Synthesizers**	
5.1	Resonant LC-CMOS VCO design	1
5.2	Other VCO topologies: QVCOs	1
5.3	Linearized PLL Model	1
5.4	Loop filters and Charge pumps	2
5.5	Integer-N frequency synthesizers, Direct Digital Frequency synthesizers.	2
5.6	Design of an Oscillators & Synthesizers and performance analysis using Cadence SpectreRF	2
5.7	Hardware Demos of PLL chipset	1
6	**Mixer Design**	
6.1	Active mixers	1
6.2	Passive and polyphase filters	2
6.3	Design of a mixer based on a Gilbert cell using SpectreRF	2
6.4	Hardware Demos of Mixer	1

Course Designers:

1.	Dr.S.Raju	rajuabhai@tce.edu
2.	Dr.D.Gracia Nirmala Rani	gracia@tce.edu