CURRICULUM AND DETAILED SYLLABI

FOR

M.E. DEGREE (WIRELESS TECHNOLOGIES) PROGRAMME

FOR THE STUDENTS ADMITTED IN THE

ACADEMIC YEAR 2014-15 ONWARDS

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

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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

PEO1. Graduates will be capable of developing and providing feasible and optimal solutions to Physical, Medium Access Control and Network layer aspects of modern wireless systems.

PEO2. Graduates will be capable of carrying out system oriented multidisciplinary scientific research in allied areas of wireless technologies through personal success and life long learning.

PEO3. Graduates will be able to identify and analyze societal problem and can provide solutions using appropriate wireless technologies 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

PO1. **Scholarship of Knowledge:** Acquire in-depth knowledge of various aspects of wireless technologies namely wireless standards, RF, antenna, baseband, VLSI and networks in wider and global perspective, with an ability to evaluate, analyze and synthesize existing and evolving application.

PO2. **Critical Thinking:** Analyse complex engineering problems in emerging Wireless Technologies pertaining to challenges in RF, antenna, baseband, VLSI and networking and apply the acquired knowledge for conducting research in a wider theoretical and practical context.

PO3. **Problem Solving:** Model complex engineering problems in wireless technologies and evaluate a wide range of potential solutions for those problems and provide cost effective technologies after considering public health and safety, cultural, societal and environmental factors.

PO4. **Research Skill:** Conduct literature survey, apply appropriate research methodologies, design algorithms/circuits, validate through simulation/prototype for complex engineering problems in wireless technologies.

PO5. **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.

PO6. **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.

PO7. **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.

PO8. **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.

PO9. **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.

PO10. **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.

PO11. **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.

PEO –PO Mapping

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

THIAGARAJAR COLLEGE OF ENGINEERING, MADURAI-625015

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

SCHEDULING OF COURSES

Semester	**Theory**						**Laboratory/ Project**	**Credits**
I	14WT110 Linear Algebra and Optimization (3:1)	14WT120 Baseband Wireless Communications (3:1)	14WT130 Wireless Adhoc and Sensor Networks (3:0)	14WT140 RF Passive Circuits for Wireless Systems (3:1)	14WT150 Multimedia Compression Techniques (3:1)	14WT160 Digital Logic Design with HDL (3:1)	14WT170 Communication Network Laboratory (0:1)	24
II	14WT210 Space Time Wireless Communications (3:1)	14WT220 Wireless Network Security (3:1)	14WT230 RF Active Circuits for Wireless Systems (3:0)	14WTPX0 Elective I (3:1)	14WTPX0 Elective II (3:1)	14WTPX0 Elective III (3:1)	14WT270 RF Systems Laboratory (0:1)	24
III	14WT310 Modeling and Simulation of Communication Systems (3:1)	14WTPX0 Elective IV (3:1)	14WTPX0 Elective V (3:1)				14WT340 Project I (0:4)	16
IV							14WT410 Project II (0:12)	12

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

List of Programme Electives:

14WTPA0	Antennas for Wireless Applications	(Common with 14CNPS0)
14WTPB0	Radar Signal Processing	(Common with 14CNPB0)
14WTPC0	Multimedia Communication Systems	(Common with 14CNPC0)
14WTPD0	High Performance Wireless Networks	
14WTPE0	Real Time Embedded Systems	(Common with 14CNPE0)
14WTPF0	CMOS ASIC Design	(Common with 14CNPT0)
14WTPG0	Adaptive Signal Processing	
14WTPH0	MIMO OFDM Systems	(Common with 14CNPI0)
14WTPI0	Physical Layer LTE Systems	(Common with 14CNPJ0)
14WTPJ0	RF MEMS	(Common with 14CNPK0)
14WTPK0	Video Surveillance Systems	(Common with 14CNPL0)
14WTPL0	Network Management	(Common with14CNPM0)
14WTPM0	Baseband Algorithms on FPGA	(Common with 14CNPN0)
14WTPN0	RF Test and Measurement	(Common with14CNPO0)
14WTPO0	Cryptography and Coding Theory	
14WTPP0	Applied Cryptography	
14WTPQ0	Satellite Remote Sensing and Data Analysis	(Common with14CNPG0)
14WTPR0	Analog CMOS Circuit Design	(Common with 14CNPD0)

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015
(An Autonomous Institution Affiliated to Anna University)

M.E. Degree (Wireless Technologies) Program
COURSES OF STUDY
(For the Students admitted from the academic year 2014- 2015)

FIRST SEMESTER

Course code	Name of the Course	Category	Number of Hours /Week			Credits
			L	T	P	
THEORY						
14WT110	Linear Algebra and Optimization	BS	3	1	-	4
14WT120	Baseband Wireless Communications	PC	3	1	-	4
14WT130	Wireless Adhoc and Sensor Networks	PC	3	-	-	3
14WT140	RF Passive Circuits for Wireless Systems	PC	3	1	-	4
14WT150	Multimedia Compression Techniques	PC	3	1	-	4
14WT160	Digital Logic Design with HDL	PC	3	1	-	4
PRACTICAL						
14WT170	Communication Network Lab	PC	-	-	2	1
Total			**18**	**5**	**2**	**24**

SECOND SEMESTER

Course code	Name of the Course	Category	Number of Hours /Week			Credits
			L	T	P	
THEORY						
14WT210	Space Time Wireless Communications	PC	3	1	-	4
14WT220	Wireless Network Security	PC	3	1	-	4
14WT230	RF Active Circuits for Wireless Systems	PC	3	-	-	3
14WTPX0	Elective I	PC	3	1	-	4
14WTPX0	Elective II	PC	3	1	-	4
14WTPX0	Elective III	PC	3	1	-	4
PRACTICAL						
14WT270	RF Systems Laboratory	PC	-	-	2	1
Total			**18**	**5**	**2**	**24**

THIRD SEMESTER

Course code	Name of the Course	Category	Number of Hours / Week			Credits
			L	T	P	
THEORY						
14WT310	Modeling and Simulation of Communication Systems	PC	3	1	-	4
14WT320	Elective – IV	PC	3	1	-	4
14WTPX0	Elective – V	PC	3	1	-	4
PRACTICAL						
14WT340	Project I	P	-	-	8	4
Total			**9**	**3**	**8**	**16**

FOURTH SEMESTER

Course code	Name of the Course	Category	Number of Hours / Week			Credits
			L	T	P	
PRACTICAL						
14WT410	Project II	PC	-	-	24	12
Total			**-**	**-**	**24**	**12**

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

BS : Basic Science
PC : Programme Core
PE : Programme Elective
L : Lecture
T : Tutorial
P : Practical

Note:

1 hour lecture/week is equivalent to 1 Credit
1 hour Tutorial/week is equivalent to 1 Credit
2 hours Practical/week is equivalent to 1 Credit

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015
M.E Degree (Wireless Technologies) 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							
14WT110	Linear Algebra and Optimization	3	50	50	100	25	50
14WT120	Baseband Wireless Communications	3	50	50	100	25	50
14WT130	Wireless Adhoc and Sensor Networks	3	50	50	100	25	50
14WT140	RF Passive Circuits for Wireless Systems	3	50	50	100	25	50
14WT150	Multimedia Compression Techniques	3	50	50	100	25	50
14WT160	Digital Logic Design with HDL	3	50	50	100	25	50
PRACTICAL							
14WT170	Communication Network Lab	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							
14WT210	Space Time Wireless Communications	3	50	50	100	25	50
14WT220	Wireless Network Security	3	50	50	100	25	50
14WT230	RF Active Circuits for Wireless Systems	3	50	50	100	25	50
14WTPX0	Elective I	3	50	50	100	25	50
14WTPX0	Elective II	3	50	50	100	25	50
14WTPX0	Elective III	3	50	50	100	25	50
PRACTICAL							
14WT270	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							
14WT310	Modeling and Simulation of Communication Systems	3	50	50	100	25	50
14WTPX0	Elective – IV	3	50	50	100	25	50
14WTPX0	Elective – V	3	50	50	100	25	50
PRACTICAL							
14WT340	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							
14WT410	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.

14WT110	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

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

$\{ 1, x, x^2 \}$

4. 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.

Course Outcome 4 (CO4):

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

Course Outcome 5 (CO5):

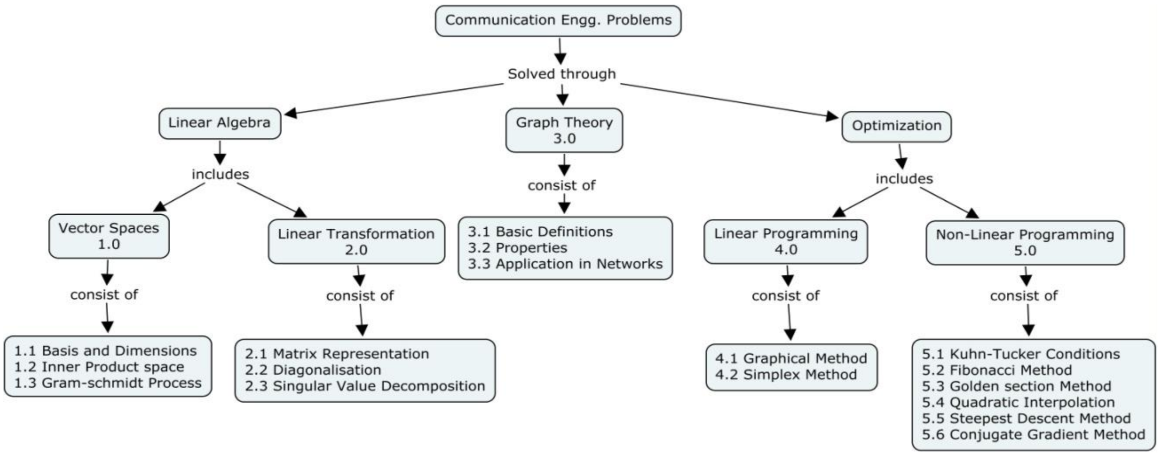
1. Determine the maximum value of the non-linear programming problem using Kuhn-tucker conditions, Max Z = $8x_1+10x_2-x_1^2-x_2^2$
   Subject to $3x_1+2x_2 \le 6$; $x_1, x_2 \ge 0$

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:

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2. Dr.G.Jothilakshmi gjlmat@tce.edu

14WT120	BASEBAND WIRELESS COMMUNICATIONS	Category	L	T	P	Credit
		PC	3	1	0	4

Preamble

Wireless communications is the fast growing segment of the communication industry. It has been the most vibrant area in the communication field for the past 10 years, though this has been the topic over 100 years with the invention of the radio telegraph by Guglielmo Marconi. Compared to the wire-line communication, dealing with the fading and multipath interference is vital to the design of wireless communication systems on meeting the increasing demand for higher data rates and techniques to improve spectral efficiency and link reliability. Now, the use of multiple antennas at the transmitter and /or the receiver in a wireless system, popularly known as Multiple Input Multiple Output (MIMO) wireless systems has become as a matured and promising technology for dealing with the fading and interference. The objective of this course is to present the techniques in the physical layer aspects of wireless communication systems and determine the performance of Wireless systems in terms of capacity and probability of error.

Prerequisite

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 base band wireless communication systems.	Apply
CO2. Describe and determine the performance of different error control coding schemes for the reliable transmission of digital information over the channel	Apply
CO3. Characterize the wireless channel in terms of small scale and large scale fading parameters	Analyze
CO4. Describe a Mathematical model of digital communication system to provide a frame work for bit error rate and capacity analysis in AWGN, Rayleigh fading and frequency selective fading environment.	Analyze
CO5. Architect a wireless communication system as per given specification	Analyze

Mapping with Programme Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
1.	S	M	S	-	-	-	--	-	-	-	-	-
2.	M	S	S	M	-	-	-	-	-	-	-	-
3.	M	M	S	S	M	-	-	M	M	-	-	-
4.	L	M	S	S	S	L	-	L	M	-	-	-
5.	L	S	S	S	S	S	-	M	S	-	-	-

S- Strong; M-Medium; L-Low

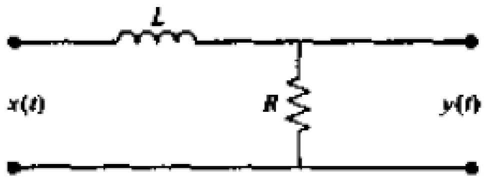
Assessment Pattern

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	10	10	0	0
Understand	30	30	20	20
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):

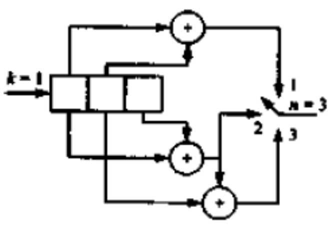
1. Assume that X is a random variable with mean μ_x and variance σ_x^2 . If a linear transformation $Y = aX + b$ is applied, find the values of a and b such that the mean of Y is $\mu_y = 0$ and variance $\sigma_y^2 = 1$.
2. Assume that random processes $X(t)$ and $Y(t)$ are individually and jointly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

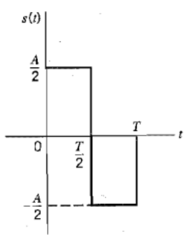


4. Find the power spectral density of the output sequence $y(t)$ and find the autocorrelation sequence of $y(t)$.

Course Outcome 2 (CO2):

1. A 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 $(x_1 \quad x_2 \quad x_3 \quad x_4)$, 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.





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 3 (CO3):

1. A Wireless channel has a multipath spread of 1msec. The total channel bandwidth at bandpass available for signal transmission is 5KHz. Determine the coherence bandwidth. Is the channel frequency selective? Justify.
2. In mobile multipath channels, if the baseband signal bandwidth is much greater than Doppler spread how do you name the channel? Why is it called so?
3. Assume a mobile traveling at a velocity of 10m/sec receives two multipath components at a carrier frequency of 1000MHz.The first component is assumed to arrive at $\tau = 0$ with an initial phase of 0 degree and the power of -70dBm and the second component which is 3dB weaker that the first component is assumed to arrive at $\tau = 1\mu s$ also with a initial phase of 0 dB. If the mobile moves directly towards the direction of arrival of the first component and directly away from the direction of arrival the second component, compute the average narrow band power received over this observation interval.
4. Consider a transmitter which radiates a sinusoidal carrier frequency of 1850MHz for a vehicle moving 60m/Hr, Compute the received carrier frequency if the mobile is moving (i) Directly towards the transmitter (ii) Directly away from the transmitter and (iii) in a direction which is perpendicular to the direction of arrival of the transmitter signal.

Course Outcome 4 (CO4):

1. Find the capacity of AWGN Channel has a bandwidth of 1MHz,signal power is 10watts and noise spectral density is 10^{-9}Watts/Hz.
2. Determine the capacity of slow fading channel and prove that the outage probability is $P_{out}(R) = \frac{2^R - 1}{SNR}$ where R is the data rate.
3. 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.

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 wireless 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 wireless 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 wireless communication transceiver to transmit the audio.

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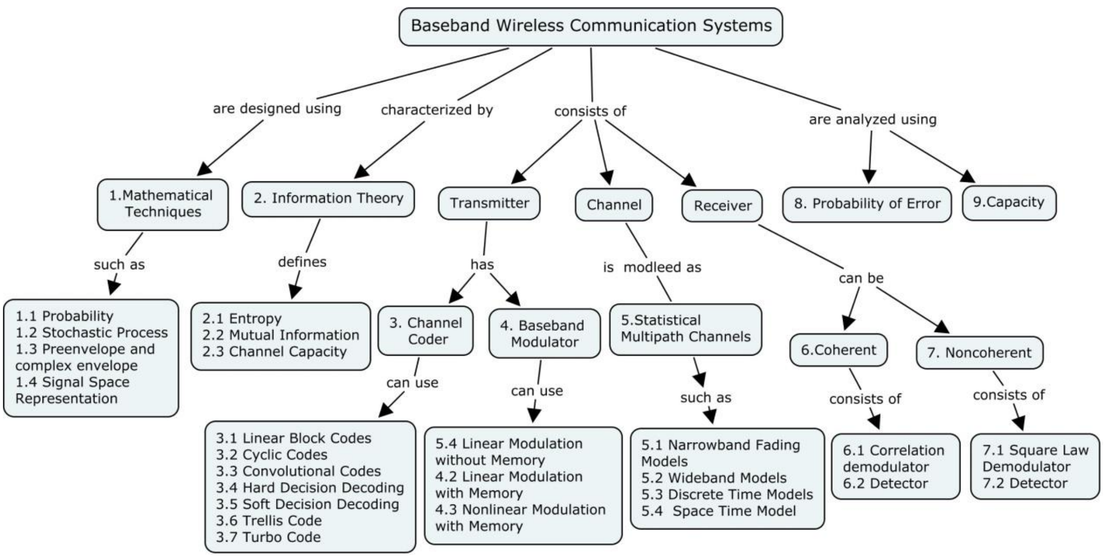
Concept Map



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, **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, Channels Impulse response model, Multipath Parameters: Coherence time and Doppler spread, Coherence bandwidth and Delay spread, **Statistical Multipath Models:** Narrow band Fading Models: Autocorrelation, Cross Correlation and Power spectral density, Envelope and power distributions, Level Crossing rate and average fade duration, Finite rate Markov Channels, Wideband Fading Models: Power delay profile, Coherence bandwidth, Doppler power spectrum and channel coherence time, Transforms for autocorrelation and scattering functions, Discrete-Time Channel, Space-Time Channel, **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, **Capacity Analysis:** Capacity in AWGN, Capacity of Flat fading Channels

Reference Books

1. Andrea Goldsmith, " Wireless Communications", Cambridge University Press, 2005
2. Theddore S.Rappaport, " Wreless Communications: Principles and Practice", Second Edition, PHI,2006
3. David Tse and Pramod Viswanath, "Fundamentals of Wireless Communications", Cambridge University Press, 2005 (First Asian Edition, 2006)
4. A. Paulraj, R. Nabar and D Gore, "Introduction to Space-Time Wireless Communications", Cambridge University Press, 2003.
5. John G. Proakis, "Digital Communications", McGraw Hill, 2000

Course Contents and Lecture Schedule

Module No.	Topic	No.of Lectures
1.	**Mathematical Techniques**	
1.1	Probability: Functions of Random Variables – statistical averages of Random variables	2
1.2	Stochastic Process: Statistical averages, power density spectrum, Response of LTI system	2
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	**Channel Coder**	
3.1	Channel Coding Theorem: Linear Block Code	2
3.2	Cyclic Codes	2
3.3	Convolutional Codes	2
3.4	Hard Decision Decoding	2
3.5	Soft Decision Decoding	1
3.6	Trellis Codes	1
3.7	Turbo Code	1
4	**Statistical Multipath Channel Models**	**4**
4.1	Narrow Band Fading Models	2
4.2	Wideband Fading Models	2
4.3	Discrete Time Model	2
4.4	Space Time Channel Model	2
5	**Baseband Modulator**	
5.1	Linear Modulation Without Memory	2
5.2	Linear Modulation With Memory	2
5.3	Nonlinear Modulation with memory	2
6	**Coherent Receiver**	
6.1	Correlation Demodulator: Matched Filter Demodulator	2
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	2
9	**Capacity**	
9.1	Capacity in Flat Fading Channels	2
9.2	Capacity in Frequency Selective Fading Channels	2

Course Designers:

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14WT130	WIRELESS AD-HOC AND SENSOR NETWORKS	Category	L	T	P	Credit
		PC	3	0	0	3

Preamble

The objective of this course is to introduce students with fundamental concepts, design issues and solutions to the issues – architectures and protocols- and the state-of-the –art research developments in ad hoc and sensor networks.

Prerequisite

Computer Networks

Course Outcomes

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

CO1	Analyze the MAC issues in Adhoc and sensor networks	Analyze
CO2	Classify and describe the operation of the routing and localization	Analyze
CO3	Design sensor network for indoor applications	Apply
CO4	Analyze self configuration and auto configuration in mesh networks	Analyze
CO5	Identify the necessity of heterogeneous and vehicular mesh networks	Understand

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
1.	M	M	-	S	S	L	L	L	M	-	-
2.	M	M	M	S	S	M	L	S	S	-	-
3.	S	S	S	S	S	S	M	M	M	-	-
4.	M	M	-	S	S	L	L	L	M	-	-
5.	M	M	M	S	M	-	-	M	M	-	-

Assessment Pattern

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	0	0	0	0
Understand	50	40	30	30
Apply	40	40	40	40
Analyse	10	20	30	30
Evaluate	0	0	0	0
Create	0	0	0	0

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. How is hidden terminal problem alleviated at the MAC layer?
2. How is loop-free property ensured in on-demand routing protocols?
3. Identify and elaborate some of the important issues in pricing for multi hop wireless communication.
4. Why is power management important for ad hoc wireless networks?
5. What role does the routing protocol play in the provisioning of QoS guarantees for ad hoc wireless networks?

Course Outcome 2 (CO2):

1. Identify the advantages and limitations of routing protocol that uses GPS information for an ad hoc wireless network for search and rescue operations.
2. Give application scenarios where contention-based, reservation-based and packet scheduling-based MAC protocols can be used.
3. Calculate the probability of data packet collision in the MACA protocol. Assume that T_c is the control packet transmission and propagation delay, T_w is the optimal maximum back-off time, β is the percentage of ready nodes, and R is the transmission range of each node.
4. For the given topology, find the zone link state packets for the various zones marked.
5. Assume that the current size of the congestion window is 48 KB, the TCP sender experiences a time out. What will be the congestion window size if the next three transmission bursts are successful? Assume that MSS is 1 KB. Consider TCP Tahoe and TCP Reno.

Course Outcome 3 (CO3):

1. Find out the probability of a path break for an eight-hop path, given that the probability of a link break is .2.
2. Consider the third iteration of LEACH protocol. If the desired number of nodes per cluster is ten, what is the threshold calculated for a node during its random number generation?
3. In FPRP, can a situation occur where a requesting node is not able to detect collisions that have occurred in the reservation request phase? If so, suggest simple modifications to solve the problem.
4. Analyze the effect of the carrier sensing zone of a transmission on the performance of a MAC protocol.

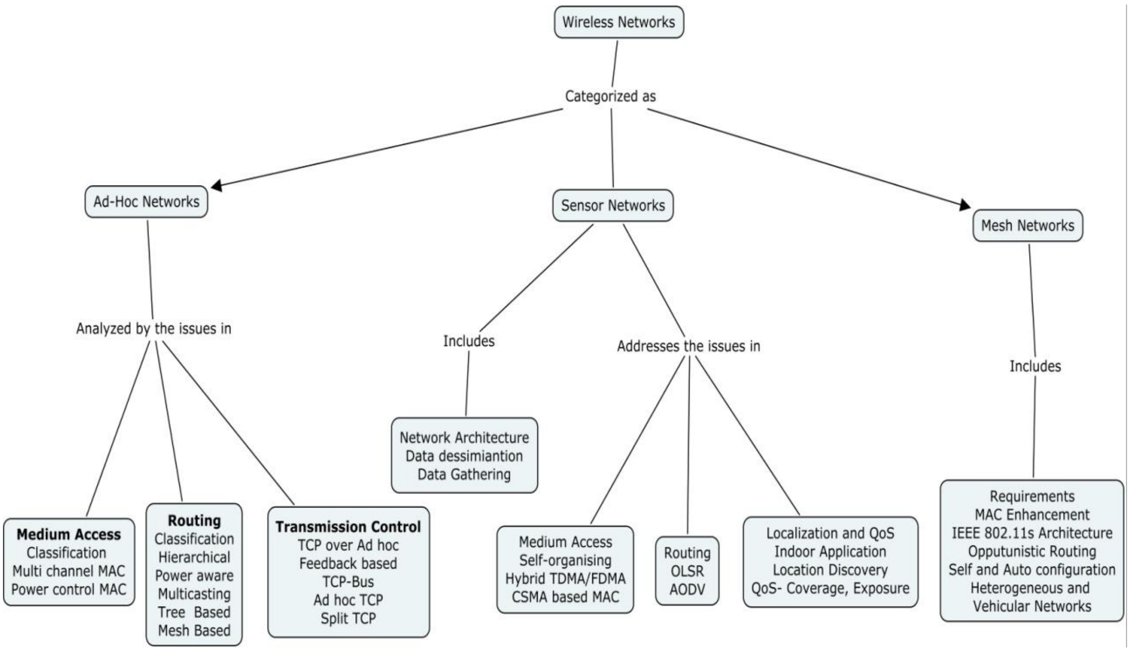
Course Outcome 4 (CO4):

1. Channel quality estimation can be done both at the sender and receiver. Which is more advantageous? Why?
2. In the CGSR protocol, the resources of the node chosen as the cluster-head get drained very quickly, more rapidly than the other nodes in the cluster. How can this problem be overcome?

Course Outcome 5 (CO5):

1. During a research discussion, one of your colleagues suggested an extension of split-TCP where every intermediate node acts as proxy node. What would be the implications of such a protocol?
2. Determine the back-off calculation mechanism used in DWOP. Is it guaranteed to be accurate at all times? If not, explain why?

Concept Map



Syllabus

Ad-Hoc MAC: Introduction – Issues in Ad-Hoc Wireless Networks. MAC Protocols – Issues, Classifications of MAC protocols, Multi channel MAC & Power control MAC protocol **Ad-Hoc Network Routing & TCP:** Issues – Classifications of routing protocols – Hierarchical and Power aware. Multicast routing – Classifications, Tree based, Mesh based. Ad Hoc Transport Layer Issues. TCP Over Ad Hoc – Feedback based, TCP with explicit link, TCP-Bus, Ad Hoc TCP, and Split TCP **WSN –Mac:** Introduction – Sensor Network Architecture, Data dissemination, Gathering. MAC Protocols – self-organizing, Hybrid TDMA/FDMA and CSMA based MAC **WSN Routing, Localization & QoS:** Issues in WSN routing – OLSR, AODV Localization – Indoor and Sensor Network Localization. QoS in WSN. **Mesh Networks:** Necessity for Mesh Networks – MAC enhancements – IEEE 802.11s Architecture –Opportunistic routing – Self configuration and Auto configuration – Capacity Models – Fairness – Heterogeneous Mesh Networks – Vehicular Mesh Networks.

Reference Books

1. C.Siva Ram Murthy and B.S. Manoj, “Ad Hoc Wireless Networks – Architectures and Protocols”, Pearson Education, 2004.
2. Feng Zhao and Leonidas Guibas, “Wireless Sensor Networks”, Morgan Kaufman Publishers, 2004.
3. C.K.Toh, “Ad Hoc Mobile Wireless Networks”, Pearson Education, 2002.
4. Thomas Krag and Sebastin Buettrich, “Wireless Mesh Networking”, O’Reilly Publishers, 2007

Course Contents and Lecture Schedule

Module No.	Topic	No.of Lectures
1	**Ad-Hoc Mac**	
1.1	Introduction – Issues in Ad-Hoc Wireless Networks	3
1.2	MAC Protocols – Issues, Classifications of MAC protocols	4

1.3	Multi channel MAC & Power control MAC protocol	4
2	**Ad-Hoc Network Routing & TCP**	
2.1	Issues – Classifications of routing protocols Hierarchical and Power aware.	3
2.2	Multicast routing – Classifications, Tree based, Mesh based	3
2.3	Ad Hoc Transport Layer Issues, TCP Over Ad Hoc	3
2.4	Feedback based, TCP with explicit link, TCP-BuS, Ad Hoc TCP, and Split TCP	3
2.5	**WSN –MAC**	
2.6	Data dissemination, Gathering. MAC Protocols self-organizing,	3
3	Hybrid TDMA/FDMA and CSMA based MAC	2
3.1	**WSN Routing, Localization & QoS:**	
3.2	Issues in WSN routing – OLSR, AODV	3
3.3	QoS in WSN	2
4	**Mesh Networks**	
4.1	Necessity for Mesh Networks	1
4.2	MAC enhancements – IEEE 802.11s Architecture	2
5	Opportunistic routing – Self configuration and Auto configuration	4
5.1	Capacity Models – Fairness	2
5.2	Heterogeneous Mesh Networks – Vehicular Mesh Networks	3
	Total Number of Hours	45

Course Designers:

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

14WT140	RF PASSIVE CIRCUITS FOR WIRELESS SYSTEMS

Category	L	T	P	Credit
PC	3	1	0	4

Preamble

The objective of this course is to provide strong fundamentals in the area of RF passive circuit design for wireless systems. Both circuit and system level perspective will be addressed, supported by impedance matching techniques, modeling of passive components and resonant circuits. Simulation using CAE/CAD tools aid the students to analyze, synthesize and optimize RF passive circuits to meet the desired performance.

Prerequisite

Nil

Course Outcomes

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

CO1. Understand the fundamentals of RF passive elements and transmission lines.	Understand
CO2. Understand the basic building blocks of RF transceiver system and how to evaluate its performance.	Understand
CO3. Analyze the impedance mismatch effects in RF system and various techniques to circumvent impedance mismatch effects.	Analyze
CO4. Design the equivalent circuit model of passive components at high frequencies.	Apply
CO5. Design and simulate microwave filters and resonators.	Apply
CO6. Synthesize, Analyze and Optimization of RF passive circuits using CAD Tools.	Analyze

Mapping with Programme Outcomes

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

S-Strong, M-Medium, L-low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	10	0	0	0
Understand	30	40	20	20
Apply	60	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. Justify why dBm scale is more preferable than dBW scale for low power applications.
2. Mention parameter is used to evaluate the lossy nature of given passive component.
3. Define: self-resonance.
4. Define: Parasitic inductance and capacitance.
5. State the differences between lumped and distributed circuit design.

Course Outcome 2 (CO2):

1. Assume the length of a long conductor laid out on a PCB board is L=1.27cm, with Eeff=2.25. How should this conductor be treated at 10MHz, 100MHz & 1GHz?
2. Mention the process steps to calculate spurious free dynamic range of RF front end?
3. A signal has an SNR of 20dB. How much can the SNR decrease if the bandwidth is doubled, assuming the same information throughput?
4. How multisection impedance matching is used to reduce the transmission bandwidth?
5. Find the skin depth of the copper wire at 1GHz. Assume, the conductivity of copper is 5.8e7 s/m.

Course Outcome 3 (CO3):

1. The power output (Pt) transmitted from a cellular phone is +30DBm. At the receiver the signal power (Pr) is down to 5pW. What is the attenuation A(dB) of the signal path between the transmitter and receiver?
2. How can you determine the dynamic range of the receiver?
3. Distinguish the differences between homodyne and heterodyne receivers?
4. How can you nullify the parasitic effects of source and load terminations?
5. Find the order and transmission zero distribution of the two-element circuit whose values are L=15nH, C=28pF. Using a 10 Ω source and a 50 Ω load, what is the loss of the circuit at low frequencies, and what is the gain slope at the high frequencies.

Course Outcome 4 (CO4):

1. Illustrate the high frequency equivalent circuit model of an inductor. Also, derive the expression for equivalent circuit components.
2. Illustrate the high frequency equivalent circuit model of a capacitor. Also, derive the expression for equivalent circuit components.
3. Illustrate the high frequency equivalent circuit model of a resistor. Also, derive the expression for equivalent circuit components.

Course Outcome 5 (CO5):

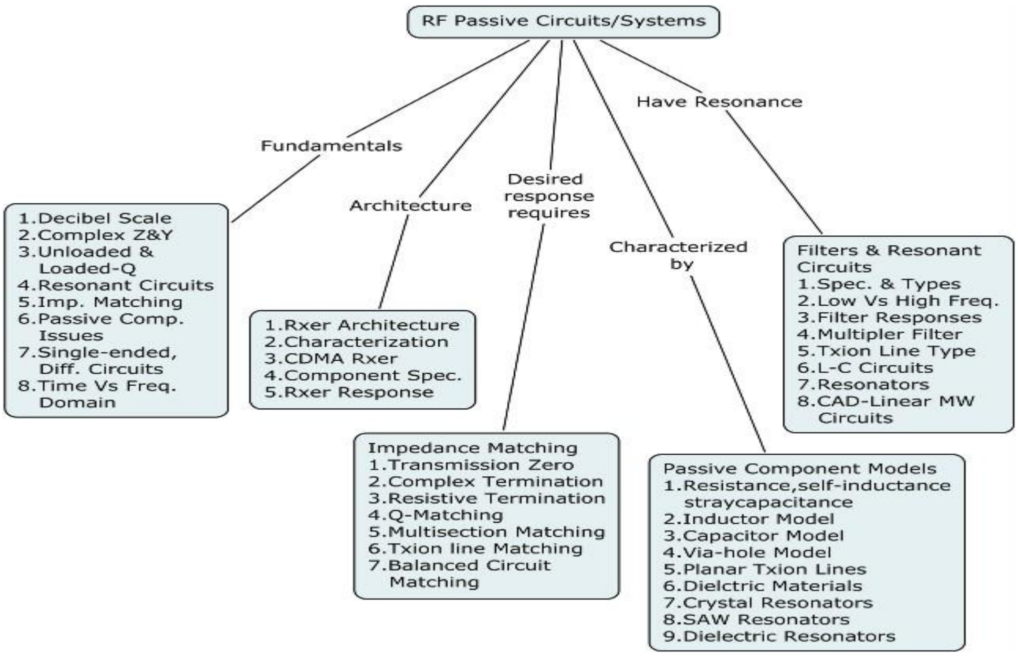
1. Match the 10Ω output impedance of a differential amplifier to the 100Ω input impedance of the second amplifier at 850MHz using the analytical Q-matching approach and lowpass L-C circuits.
2. Synthesize an L-C matching network to operate between two complex terminations. The source has an equivalent circuit of 5 Ω in series with the Ls=0.42nH inductance and the load consists of 50 Ω resistance in parallel with an Ll=16.5nH inductance.
3. Design a bandpass filter with a single resonant circuit for a center frequency of 500MHz and a desired 3-dB bandwidth of 50MHz. Use a 50Ω source and 50Ω load termination.
4. Design a chebyshev filter with 0.1dB equal ripple passband of 400MHz, 50Ω source and load termination with a min. number of inductors in the filter. Minimum required stopband attenuation is 40dB at 900MHz.

5. Optimize the matching circuit to match 5 Ω to 50 Ω at 850MHz. The octave bandwidth from 600MHz to 1200MHz with a maximum acceptable ripple of 0.2dB. Start with the single frequency matching circuit and then repeat the exercise with arbitrary component values.

Course Outcome 6 (CO6):

1. Design and simulate a matching circuit using agilent ads to match 5 Ω to 50 Ω at 850MHz. The octave bandwidth from 600MHz to 1200MHz with a maximum acceptable ripple of 0.2dB. Start with the single frequency matching circuit and then repeat the exercise with arbitrary component values.
2. Design and simulate a bandpass filter with a single resonant circuit for a center frequency of 600MHz and a desired 3-dB bandwidth of 50MHz. Use a 50Ω source and 50Ω load termination.

Concept Map



Syllabus

RF Circuit Fundamentals - Decibel scale, Complex impedance and admittance system, Unloaded and loaded Q, Series and parallel resonant circuits, Importance of impedance matching, RF components and related issues, Lumped elements versus transmission lines, Circuit parameters using wave relations, Impedance transformation and matching, Single-ended versus differential circuits, Time domain versus Frequency domain. **The radio of typical RF system** – Receiver architecture, Receiver characterization, Analysis of CDMA receiver architecture, Receiver component specification, Receiver response. **Impedance Matching Techniques** – The impedance match, Transmission zero definitions, Impedance matching into complex termination, Impedance matching with uneven resistive terminations, The Q matching technique with L-C sections, Multi-section impedance matching with bandwidth considerations, Matching with transmission line components on the Smith chart, Balanced circuits matching. **Passive Component Models -** Introduction - Resistance, self-inductance and stray capacitance of conductors, Frequency response of physical resistors, Modeling physical inductors, Ferrite beads, Physical capacitor models, Via hole models, Planar Transmission lines for RF/MW applications, Dielectric board materials, Transformers, Crystal resonators and models, Surface acoustic wave resonators, Dielectric resonators, Components measurement and modeling. **Filters and resonant circuits -** Introduction, Filter specifications, Various filter types, Low frequency versus RF/MW filters, Comparison of filter responses, Multiplexer filters, Filter design outline, Transmission line (distributed-element) filters, Network transformations, L-C resonant circuits in filter design, Other forms of resonators. **CAD of linear RF/MW circuits -** Analysis versus synthesis and optimisation, Circuit simulation techniques, Impedance mapping, Component tuning, Circuit optimisation, Statistical design techniques, Circuit synthesis, EM field simulation, CAD program descriptions.

Reference Books

1. Les Besser and Rowan Gilmore, “Practical RF Circuit Design for Modern Wireless Systems– Passive Circuits and Systems”, Vol.I, Artech House Publishers, 2003.
2. D.M.Pozar, “Microwave Engineering”, John Wiley & Sons, 2004.
3. R.E.Collin, “Foundations of Microwave Engineering”, McGraw Hill, 1995.

Course Contents and Lecture Schedule

Module No.	Topic	No.of Lectures
1	**RF Circuit Fundamentals**	
1.1	Decibel scale, Complex impedance and admittance system, Unloaded and loaded Q	2
1.2	Series and parallel resonant circuits, Importance of impedance matching, RF components and related issues	2
1.3	Lumped elements versus transmission lines, Circuit parameters using wave relations, Impedance transformation and matching	2
1.4	Single-ended versus differential circuits, Time domain versus Frequency domain	2
2	**The radio of typical RF system**	
2.1	Receiver architecture, Receiver characterization	2
2.2	Analysis of a CDMA receiver architecture	2
2.3	Receiver component specification, Receiver response	2
3	**Impedance Matching Techniques**	
3.1	The impedance match, Transmission zero definitions	2
3.2	Impedance matching into complex termination, Impedance matching with uneven resistive terminations	2
3.3	The Q matching technique with L-C sections, Multi-section impedance matching with bandwidth considerations	2
3.4	Matching with transmission line components on the Smith chart, Balanced circuits matching	2
4	**Passive Component Models**	
4.1	Introduction - Resistance, self-inductance and stray capacitance of conductors, Frequency response of physical resistors	2
4.2	Modeling physical inductors, Ferrite beads, Physical capacitor models, Via hole models	2
4.3	Planar Transmission lines for RF/MW applications, Dielectric board materials, Transformers, Crystal resonators and models	2
4.4	Surface acoustic wave resonators, Dielectric resonators, Components measurement and modeling	2
5	**Filters and resonant circuits**	
5.1	Introduction, Filter specifications, Various filter types	2
5.2	Low frequency versus RF/MW filters, Comparison of filter responses,	3

	Multiplexer filters	
5.3	Filter design outline, Transmission line (distributed-element) filters	2
5.4	Network transformations, L-C resonant circuits in filter design, Other forms of resonators	2
	CAD of linear RF/MW circuits	
5.5	Analysis versus synthesis and optimization, Circuit simulation techniques, Impedance mapping	2
5.6	Component tuning, Circuit optimization, Statistical design techniques	2
5.7	Circuit synthesis, EM field simulation, CAD program descriptions	2

Course Designers:

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14WT150	MULTIMEDIA COMPRESSION TECHNIQUES	Category	L	T	P	Credit
		PC	3	1	0	4

Preamble

This course aims at understanding characteristics of various multimedia data and design a suitable coding/compression technique to efficiently represent the data.

Prerequisite

NIL

Course Outcomes

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

CO1. Explain multimedia and its digital representation.	Understand
CO2. Determine the performance of various lossy and lossless compression techniques.	Apply
CO3. Illustrate and determine the performance of different Image compression standards.	Apply
CO4. Analyze and determine the performance of different video compression schemes	Analyze
CO5. Apply mathematical model of Vocoder, to provide a frame work for speech compression and compare different audio compression standards.	Apply

Mapping with Programme Outcomes

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

Assessment Pattern

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

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. What is the term “rate” in compression?
2. What are Digrams?
3. What is E3 mapping?
4. Describe the ITU G.726 standard for ADPCM system.

5. Describe the G.728 speech standard.
6. Explain the bi-level lossless compression standard.
7. Explain CCITT V.42 bits compression scheme for MODEM.
8. Explain linear prediction model.
9. Explain MPEG-1 standard for video information.

Course Outcome 2 (CO2):

1. How integer arithmetic could be used to generate binary code and examine the same for the typical scenario of u(n) = 54 and l(n) = 33 with m = 6.
2. How do you estimate pitch period in the linear predictive coding of speech?
3. How binary Huffman code is extended to non – binary Huffman code?
4. Compare Discrete cosine and walsh transform.
5. How do we start decoding in arithmetic coding process?
6. How LZW algorithm is implemented to achieve graphic interchange format?
7. Write a program for encoding image using rice code with all options split sample = 5, j = 16. For prediction (previous value).

Course Outcome 3 (CO3):

1. Encode the sequence with lossy differential scheme:4.2, 1.8, 6.2, 9.7, 13.2, 5.9, 8.7, 0.4
2. For an alphabet A = {a1, a2, a3} with p(a1) = 0.7, p(a2) = 0.2, p(a3) = 0.1. Design a '3' bit tunstall code.
3. Build the dictionary of diagram coding for '3' letter alphabet S = {a, b, c}
4. Encode the following sequence by LZ77 approach with window = 14 , LAB = 5 a b c a r a d a b r a r r a a d r r

Course Outcome 4 (CO4):

1. If we obtain co-efficient as 28.5, 5.8, -2.3, 1.2, -0.8, 2.1. Quantize it with flooring function.
2. Find adaptive Huffman code for {a, a, r, d, v} and continue this with the next letters in the sequence {a, r, k}, if two more alphabets (r) comes, what is the structure of the tree?
3. Show that for any sequence x= (x1, x2, …. xn), upper bound and lower results in a recursive expression. Provide comparison of facsimile coding algorithms.

Course Outcome 5 (CO5):

1. A source emits letters from an alphabet A = {a1, a2, a3, a4, a5} with probabilities

   P (a1) = 0.15, P (a2) = 0.04, P (a3) = 0.26, P (a4) = 0.05 & P (a5) = 0.5

   a. Calculate the entropy
   b. Find Huffman code
   c. Average length of the code and its redundancy

2. For an alphabet A = {a1, a2, a3, a4} with probabilities

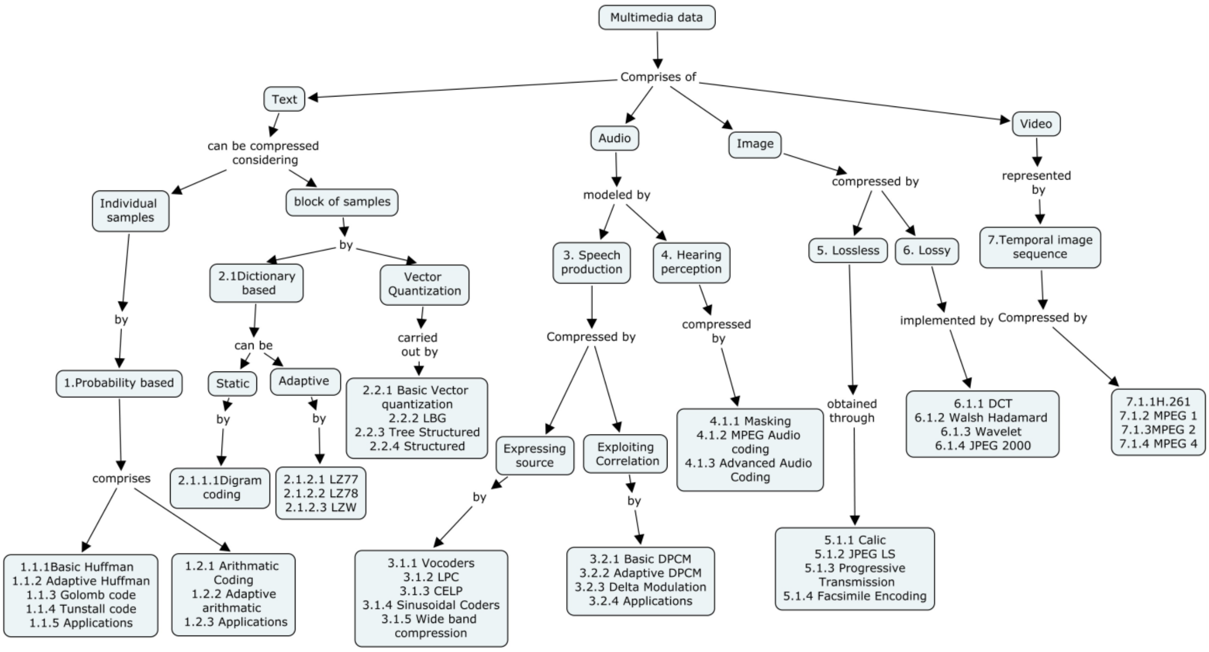
   P (a1) = 0.1, P (a2) = 0.3, P (a3) = 0.25, P (a4) = 0.35

   a. Find Huffman code and compare with the minimum variance procedure
   b. Comment on the difference

Course Outcome 6 (CO6):

3. For a binary source with probabilities p (0) = 0.9, p (1) = 0.1. Design a Huffman code with the source by blocking 'm' bits together m=1, 2 … 8. Plot the average lengths versus 'm'.
4. Consider a '5' letter alphabet source S1, S2, S3, S4, S5 with probabilities 0.4, 0.3, 0.1, 0.15, 0.05. Generate the tag for the sequence S1, S3, S2, S5, S1, and S4.

Concept Map



Syllabus

Text data: **Individual Samples** - ***Huffman Coding:*** Basic Huffman - Adaptive Huffman- Golomb code- Tunstall code - Applications; ***Arithmetic Coding:*** Basic Arithmetic Coding - Adaptive arithmetic coding- Applications; ***Dictionary coding:*** static dictionary-Diagram coding; Adaptive Dictionary- LZ77-LZ78 - LZW. **Block of Samples- Vector Quantization-** Basic Algorithm- **Audio data:** ***Speech production:*** Expressing source- Vocoders- LPC – CELP - Sinusoidal Coders - Wide band Compression; Exploiting Correlation- Basic DPCM- Adaptive DPCM- Delta Modulation – Applications; ***Hearing perception***: Masking-MPEG Audio coding- Advanced Audio Coding. **Image data:** ***Lossless compression***: Calic - JPEG LS - Progressive Transmission- Facsimile Encoding; ***Lossy compression:*** DCT - Walsh Hadamard - Wavelet - JPEG 2000, **Video data** - H.261- MPEG 1 - MPEG 2 - MPEG 4

Reference Books

1. Khalid Sayood, "Introduction to Data Compression" Third Edition, Morgan Kauffmann Publishers, Inc. California, 2010.
2. Mark Nelson, Jean Louf Goilly, "The Data Compression Book", BPB Publications, 1996.
3. Rafel C.Gonzalez, "Digital Image Processing", Addison Wesley, 1998.
4. Darrel Hankerson, Greg A Harris, Peter D Johnson, 'Introduction to Information Theory and Data Compression' Second Edition, Chapman and Hall ,CRC press company, 2007.

Course Contents and Lecture Schedule

Module No.	Topic	No. of Lectures
	Introduction	1
	Text Data	
1.	**Individual Samples-Probability based techniques**	
1.1	Huffman coding	
1.1.1	Basic Huffman	1
1.1.2	Adaptive Huffman	1
1.1.3	Golomb code	1
1.1.4	Tunstall code	1
1.1.5	Applications	1
1.2	Arithmetic Coding	
1.2.1	Basic Arithmetic Coding	1
1.2.2	Adaptive Arithmetic coding	1
1.2.3	Applications	1
2	**Block of Samples**	
2.1	**Dictionary based approaches**	
2.1.1	static dictionary	
2.1.1.1	Diagram coding	1
2.1.2	Adaptive Dictionary	
2.1.2.1	LZ77	1
2.1.2.2	LZ78	1
2.1.2.3	LZW	1
2.2	**Vector Quantization**	
2.2.1	Basic Vector Quantization	1
2.2.2	LBG	1
2.2.3	Tree Structured	1
2.2.4	Structured Approach	1
	Audio data	1
3.	**Speech production**	
3.1	Expressing source	
3.1.1	Vocoders	1
3.1.2	LPC	1
3.1.3	CELP	1
3.1.4	Sinusoidal Coders	1
3.1.5	Wide band Compression	1
3.2	Exploiting Correlation	
3.2.1	Basic DPCM	1
3.2.2	Adaptive DPCM	1
3.2.3	Delta Modulation	1
3.2.4	Applications	1
4.	**Hearing perception**	
4.1.1	Masking	1
4.1.2	MPEG Audio coding	1
4.1.3	Advanced Audio Coding	1
	Image data	
5	**Lossless compression**	
5.1.1	Calic	1
5.1.2	JPEG LS	1
5.1.3	Progressive Transmission	1
5.1.4	Facsimile Encoding	1
6	**Lossy compression:**	
6.1.1	DCT	1

Module No.	Topic	No. of Lectures
6.1.2	Walsh Hadamard	1
6.1.3	Wavelet	1
6.1.4	JPEG 2000	1
	video data	
7	**Video Compression**	
7.1.1	H.261	1
7.1.2	MPEG 1	1
7.1.3	MPEG 2	1
7.1.4	MPEG 4	1

Course Designers:

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14WT160	DIGITAL LOGIC DESIGN WITH VHDL	Category	L	T	P	Credit
		PC	3	1	0	4

Preamble

The course ‘14WT160: Digital Logic Design with VHDL’ is offered in the first semester of the Post Graduate Programme. This course needs basic knowledge of digital circuits as pre-requisite. This course describes the different ways of coding the building blocks of the digital circuits and systems. Further, it also aims at the design and optimization of combinational and sequential logic circuits along with the testing strategies for the digital circuits.

Prerequisite

Nil

Course Outcomes

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

CO1. Illustrate the combinational and sequential building blocks using VHDL	Apply
CO2. Implement combinational logic circuits for a given specification	Apply
CO3. Analyze optimal synchronous/asynchronous sequential logic circuits for a given requirements.	Analyze
CO4. Investigate the need for testing and the strategies to generate test vectors.	Analyze
CO5. Examine the digital systems, designed for the given specifications, by generating test vectors	Analyze

Mapping with Programme Outcomes

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

Assessment Pattern

Bloom’s Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	10	10	0	0
Understand	30	10	20	20
Apply	40	50	40	40
Analyse	20	30	40	40
Evaluate	0	0	0	0
Create	0	0	0	0

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Design an 16-to-1 multiplexer using 4-to-1 multiplexer in VHDL
2. Illustrate conditional signal assignment using priority encoder
3. Write VHDL code for 4-to-16 decoder using generate statement
4. Design an n-bit register with asynchronous clear
5. Define four bit up counter in VHDL using INTEGER type

Course Outcome 2 (CO2):

1. Assume that the exclusive –OR gate has propagation delay of 10ns and that the AND or OR gates have a propagation delay of 5ns. Calculate the total propagation delay time of a four-bit carry look ahead adder?
2. Find a hazard free minimum cost implementation of the function
   a. F(x1,...x4)=m(0,4,11,13)+D(2,3,5,10)
3. Show that how the function f(w1,w2,w3)=Σm(1,2,3,4,5,6) can be implemented using 3-8 binary decoder and an OR gate.
4. Consider the function f(w1,w2,w3)=Σm(0,1,3,6,8,9,14,15). Derive an implementation using the minimum possible number of three input LUTs.
5. Implement the function $f = \overline{w_2}\,\overline{w_3} + w_1 w_2$ using two inputs multiplexer.

Course Outcome 3 (CO3):

1. Design a sequential circuit that has two inputs, w1 and w2 and an output z. Its function is to compare the input sequences on the two inputs. If w1=w2 during any four consecutive clock cycles, the circuit produces z=1; otherwise, z=0.
2. Design a three-bit counter like circuit controlled by the input w. If w=1, then the counter adds 2 to its contents, wrapping around if the count reaches 8 or 9. If w=1 then the counter subtracts 1 from its contends, acting as a normal down-counter. Use D flip flop in the circuit.
3. Draw the state diagram for an FSM that has an input w and an output z. The machine has to generate z=1 when the previous four values of w were 1001 or 1111; otherwise, z=0. Overlapping input patterns are allowed.
4. Design an FSM that implements the vending machine control using as few states as possible. Find a suitable state assignment and derive the next-state and output expression.
5. Design a modulo-6 counter which counts the sequence 0, 1, 2, 3, 4, 5, 0, 1 . . . that counts the clock pulses if its enable input w is equal to 1.

Course Outcome 4 (CO4):

1. Determine the optimal test vectors to detect the stuck at faults for the given logic expression Y=AB+C.
2. Find test vectors for any circuit using PODEM algorithm.
3. Illustrate test vector generation for any circuit by using path sensitizing technique
4. Describe boundary scan test
5. Distinguish various fault simulation techniques

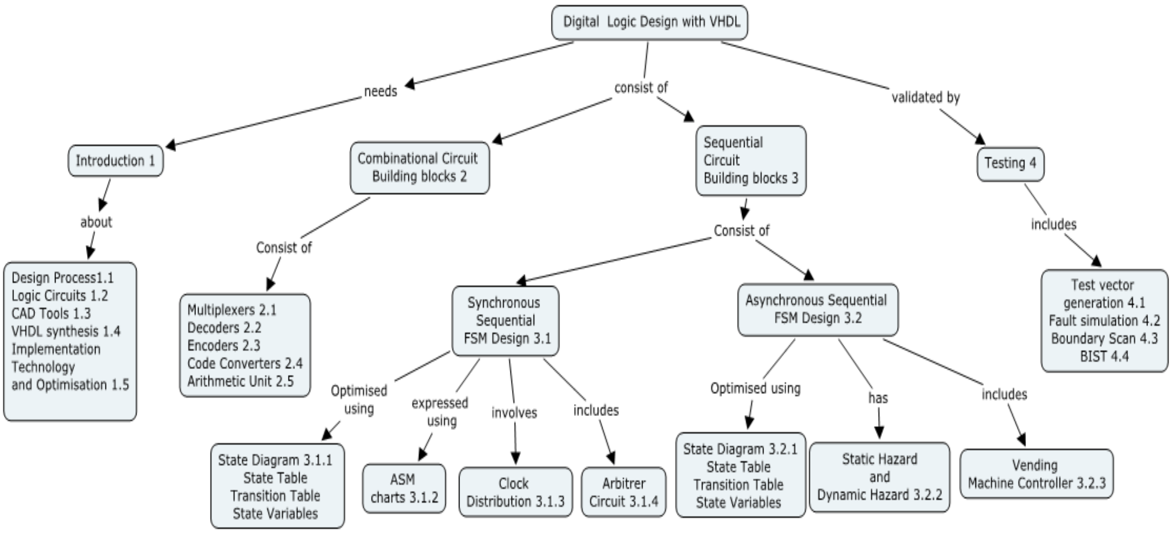
Course Outcome 5 (CO5):

1. Design a control mechanism for Vending machine that accepts nickels and dimes. It dispenses merchandise when 20 cents is deposited; it does not give change if 25 cents is deposited.
2. Design a system controller for the pop machine that will direct the control of the coin receiver, coin changer and pop drop mechanics while dispensing soda pop at 30 Rs

per can and making the proper change retrieval for the following coin sequences of 5 and 10.

3. Design and evaluate a full adder circuit expressed having inputs A, B, C by introducing stuck at fault 0 at "B" signal using signature analysis.
4. Design a flow diagram that describes the sequential behavior of the system which will load a register and then will sequentially replace the contents of that register with its 2's complement.
5. Design and evaluate a circuit expressed by F = AB+BC+CA by introducing stuck at fault 1 at "A" signal using signature analysis.

Concept Map



Syllabus

Introduction: Design Process, Logic Circuits, CAD Tools, VHDL synthesis, Implementation Technology and Optimisation, **Combinational Building Blocks:** Multiplexers, Decoders, Encoders, Code Converters, Arithmetic Units, **Sequential Building Blocks:** Synchronous Sequential FSM Design, Optimization of Synchronous Sequential FSM Design, ASM charts, Clock Distribution, Case Study: Arbitrer Circuit, Asynchronous Sequential FSM Design, Optimization of Asynchronous Sequential FSM Design, Static and Dynamic Hazard, Case study: Vending Machine Controller, **Testing:** Test Vector Generation, Fault Simulation, Boundary Scan, ATPG, BIST.

Reference Books

1. Stephen Brown and Zvonko Vranesic, "Fundamentals of Digital Logic Design with VHDL design", Tata McGraw hill, second edition, 2005
2. M. Morris Mano and Michael D. Ciletti, "Digital Design", PHI, fourth edition, 2008
3. Michael John Sebastian Smith, " Application Specific Integrated Circuits", Addison Wesley, Ninth Indian Reprint, 2004
4. William I. Fletcher, "An Engineering Approach to Digital Design", EEE, Fourth Indian Reprint, 1996
5. Kwang-ting Cheng, Vishwani D. Agarwal and Cheng Kwang Ting Cheng, "Unified Methods for VLSI Simulation and Test generation" Springer, 1989

Course Contents and Lecture Schedule

No.	Topic	No. of Lectures
1	**Introduction**	
1.1	Design Process	1
1.2	Logic Circuits	1
1.3	CAD Tools	1
1.4	VHDL synthesis	2
1.5	Implementation Technology and Optimisation	2
2	**Combinational Circuit Building Blocks**	
2.1	Multiplexers	2
2.2	Decoders	2
2.3	Encoders	2
2.4	Code Converters	2
2.5	Arithmetic Unit	2
3.	**Sequential Circuit Building Blocks**	
3.1	Synchronous Sequential FSM Design	1
3.1.1	Optimization of Synchronous Sequential FSM Design	4
3.1.2	ASM charts	1
3.1.3	Clock Distribution	1
3.1.4	Case Study: Arbitrer Circuit	1
3.2	Asynchronous Sequential FSM Design	1
3.2.1	Optimization of Asynchronous Sequential FSM Design	4
3.2.2	Static and Dynamic Hazard	1
3.2.3	Case study: Vending Machine Controller	1
4	**Testing**	
4.1	Test Vector Generation	1
4.2	Fault Simulation	1
4.3	Boundary Scan	2
4.4	BIST	2

Course Designers:

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14WT170	COMMUNICATION NETWORK LAB

Category	L	T	P	Credit
PC	0	0	1	1

Preamble

The main aim of this course is to supplement the theory course on 14WT130: Wireless ad hoc and Sensor Networks and to assist the students in obtaining a better understanding of the characteristics of wireless networks using computer simulations.

Prerequisite

Nil

Course Outcomes

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

CO1	Analyze the performance of Different LAN scenarios	Analyze
CO2	Implementation of Error control protocols	Apply
CO3	Compare the throughput performance of MAC protocols	Analyze
CO4	Implementation of wireless Routing protocols	Apply
CO5	Implementation of error control – channel codes and spread spectrum techniques	Apply

Mapping with Programme Outcomes

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

S- Strong; M-Medium; L-Low

List of Experiments

1. Performance analysis of Different LANs
2. Implementation of
   i) Stop and Wait ARQ protocol
   ii) Go back-N ARQ protocol
   iii) Selective Repeat ARQ protocols.
3. Simulation of wireless LAN 802.11 – MAC protocol.
4. Simulation of Ad hoc network using AODV protocol.
5. Simulation of Ad hoc network using DSDV protocol.
6. Simulation of Ad hoc network using DSR protocol
7. (7,4) Cyclic Code generation and Syndrome calculation
8. PN Sequence generation and verification of its properties
9. Direct Sequence Spread Spectrum
   i) DSSS
   ii) FHSS

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14WT210	SPACE TIME WIRELESS COMMUNICATIONS

Category	L	T	P	Credit
PC	3	1	0	4

Preamble

Space-time processing for MIMO wireless communications is a broad area, owing in part to the underlying convergence of information theory, communications, and signal processing that brought it to fruition. This includes MIMO wireless channel characterization, modelling and validation, model-based performance analysis, spatial multiplexing and joint transceiver design using channel state information (CSI). The use of multiple antennas at the transmitter and /or the receiver in a wireless system, popularly known as Multiple Input Multiple Output (MIMO) wireless systems has become as a matured and promising technology for dealing with the fading and interference. Multiple-input multiple-output (MIMO) technology constitutes a breakthrough in the design of wireless communication systems, and is already at the core of several wireless standards. Exploiting multi-path scattering, Space Time MIMO techniques deliver significant performance enhancements in terms of data transmission rate and interference reduction. The objective of this course is to present the techniques in the physical layer aspects of Space Time wireless communications and determine the performance of Wireless systems in terms of fundamental capacity limits, coding for wireless channels, diversity concepts, transmitter design, including pre-coding and space time coding and equalization and multi carrier modulation (OFDM).

Prerequisite

14WT120 Baseband Wireless Communications

Course Outcomes

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

CO1. Describe the Space Time MIMO concept of wireless communication systems.	Understand
CO2. Determine the capacity and bit error rate for a given digital modulation scheme of SIMO, MISO and MIMO wireless communication system in Rayleigh frequency flat and frequency selective fading environment.	Apply
CO3. Apply OFDM and spread spectrum modulation techniques in space time wireless communications	Apply
CO4. Analyze the space time coding and optimal pre-filter design in the absence of CSIT and presence of CSIT	Analyze
CO5. Design a space time MIMO wireless communication receiver architecture as per given specifications	Apply

Mapping with Programme Outcomes

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

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	20	20
Apply	60	60	60	60
Analyse	0	0	20	20
Evaluate	0	0	0	0
Create	0	0	0	0

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Give the sampled signal models of SIMO and MISO systems, assuming that the channel is slow and flat frequency fading.
2. Consider a SIMO system with L receive antennas. Independent complex Gaussian noise with variance N_0 corrupts the signal at receive antenna. The transmit signal has a power constraint of P. Compute the capacity of this system, assuming that the gain between the transmit antenna and each of the receive antenna is 1.
3. State true or false : Justify your answer
   a. Channel knowledge at the transmitter is not required in MIMO channels to extract multiplexing gain.
   b. Channel knowledge at the transmitter is required in MIMO channels to extract diversity gain.

Course Outcome 2 (CO2):

1. Derive an expression for the capacity of the following systems
   a. SIMO system assuming that the channel is known at Receiver
   b. MISO system assuming that the channel is known at transmitter
   c. MISO system assuming that channel is unknown at the transmitter
2. Derive expressions for the following
   a. MIMO Channel Capacity, assuming that CSI known at Tx
   b. MIMO Channel Capacity, assuming that CSI unknown at Tx
3. Assume uncoded 4-QAM transmission over an i.i.d. Rayleigh flat fading MISO channel with $M_T = 4$.
   a. Derive a closed form BER expression over the channel assuming transmit-MRC.
   b. What is the corresponding upper-bound on symbol error rate for a SIMO channel with $M_R = 4$? Which channel (SIMO or MISO) performs better, why?

Course Outcome 3 (CO3):

1. Prove that the OFDM system converts the delay spread channel into a set of parallel fading channels, using the concept of cyclic prefix.
2. Show that the capacity of a time-invariant MIMO channel with n_t transmit, nr receive antennas and channel matrix **H** is the same as that of the channel with nr transmit, nt receive antennas, matrix **H***, and same total power constraint.
3. Consider the two-user fast fading MIMO uplink under i.i.d. Rayleigh fading. Show that the input covariance achieves the maximal value of every linear functional $a_1R_1+a_2R_2$ over the capacity region. Thus the capacity region in this case is simply a pentagon.

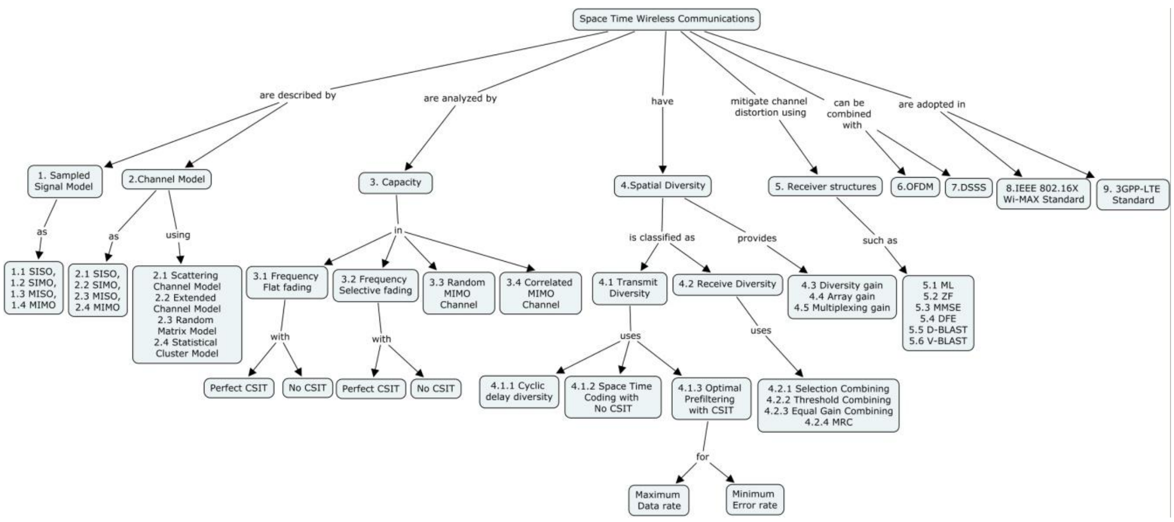
Course Outcome 4 (CO4):

1. 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.
2. Consider the L-parallel channel with i.i.d. Rayleigh coefficients. Show that the optimal diversity gain at a multiplexing rate of r per sub-channel is L −Lr.
3. Prove that 2 x 2 MIMO system (without channel state information) at the transmitter provides the diversity gain of 4 and array gain of 2 using Alamouti Scheme.

Course Outcome 5 (CO5):

1. Generalize the staggered stream structure 2×nr MIMO channel of the D-BLAST architecture to a MIMO channel with nt > 2 transmit antennas.
2. Consider a block length N D-BLAST architecture on a MIMO channel with n_t transmit antennas. Determine the rate loss due to the initialization phase as a function of N and n_t.

Concept Map



Syllabus

Space Time Signal Model: SISO, SIMO, MISO and MIMO Signal Models, **Space Time Channel Model:** SISO, SIMO, MISO and MIMO Channel Models, Scattering channel Model, Extended Channel Model, Random Matrix Model, Statistical Cluster Model, **Capacity Of Space Time Wireless Channels:** Frequency Flat Fading channel with Perfect CSIT and in the absence of CSIT, Frequency Selective Fading channel with Perfect CSIT and in the absence of CSIT, Random MIMO channel, Correlated MIMO channel, **Spatial Diversity:** Transmit Diversity: Cyclic Delay Diversity, Space Time coding in the absence of CSIT, Optimal Pre filtering with CSIT for Maximum data rate and minimum error rate, Receive diversity: Selection Combining, Threshold Combining, Equal Gain Combining, Maximal Ratio Combining, Diversity gain, Array gain, Multiplexing gain, **Receiver structures:** Maximum Likelihood Receiver, Zero forcing Receiver, MMSE,DFE, D-BLAST, V-BLAST, **Space Time OFDM and Spread spectrum Modulation:** Orthogonal Frequency Division Multiplexing (OFDM), Direct Sequence Spread Spectrum Modulation, **Space Time Wireless Standards:** IEEE 802.16X – Wi-MAX Standard, 3GPP – LTE Standard.

Reference Books

1. Paulraj, R. Nabar and D Gore, “Introduction to Space-Time Wireless Communications”, Cambridge University Press, 2003.
2. Andrea Goldsmith, “ Wireless Communications”, Cambridge University Press, 2005.
3. David Tse and Pramod Viswanath, “Fundamentals of Wireless Communications”, Cambridge University Press, 2005 (First Asian Edition, 2006)
4. A.B.Gershman, N.D.Sidiropoulos, “Space Time Processing for MIMO Communications”, John Wiley and sons Limited, 2005.
5. Erik. G. Larsson, “ Space Time Block Coding for Wireless Communications”, Cambridge University Press, 2003

Course Contents and Lecture Schedule

S.No	Topic	No of lectures
1	**Space Time Signal Model**	
1.1	SISO Signal Model, SIMO Signal Model	1
1.2	MISO Signal Model, MIMO Signal Model	1
2	**Space Time Channel Model**	
2.1	SISO Channel Model, SIMO Channel Model	1
2.2	MISO Channel Model, MIMO Channel Model	1
2.3	Scattering channel Model, Extended Channel Model	1
2.4	Random Matrix Model, Statistical Cluster Model	1
3	**Capacity Of Space Time Wireless Channels**	
3.1	Frequency Flat Fading channel with Perfect CSIT	2
3.2	Frequency Flat Fading channel in the absence of CSIT	2
3.3	Frequency Selective Fading channel with Perfect CSIT	2
3.4	Frequency Selective Fading channel in the absence of CSIT	2
3.5	Random MIMO channel	1
3.6	Correlated MIMO channel	1
4	**Spatial Diversity**	
4.1	Transmit Diversity: Cyclic Delay Diversity	2
4.2	Space Time coding in the absence of CSIT	2
4.3	Optimal Pre filtering with CSIT for Maximum data rate	1
4.4	Optimal Pre filtering with CSIT for Minimum error rate	1
4.5	Receive diversity: Selection Combining	2
4.6	Threshold Combining, Equal Gain Combining	1
4.7	Maximal Ratio Combining	2
4.8	Diversity gain, Array gain, Multiplexing gain	2
5	**Receiver structures**	
5.1	Maximum Likelihood Receiver, Zero forcing Receiver	2
5.2	MMSE,DFE	2
5.3	D-BLAST	2
5.4	V-BLAST	2
6	**Space Time OFDM and Spread spectrum Modulation**	
6.1	Orthogonal Frequency Division Multiplexing (OFDM)	2
6.2	Direct Sequence Spread Spectrum Modulation	2
7	**Space Time Wireless Standards**	
7.1	IEEE 802.16X – Wi-MAX Standard	2
7.2	3GPP – LTE Standard	2

Course Designers:

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14WT220	WIRELESS NETWORK SECURITY	Category	L	T	P	Credit
		PC	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	Apply
CO3. Assess wireless security model and to setup a secure wireless system.	Analyze
CO4. Apply security in point to point and end to end in wireless applications	Apply
CO5. Analyse the integrity of the Wireless system using cryptographic algorithms	Analyse

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
CO5	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	0	0	0	0
Understand	40	40	40	40
Apply	40	40	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):

1. In what ways the temporal attack is different from content attack
2. Enlist the taxonomy of communication systems related to the various models of communication devices
3. State the importance of elliptic curve encryption algorithm

Course Outcome 3 (CO3):

4. 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.
5. Write the principle behind Host based security
6. Mention the principal requirements for providing E2E security in wireless applications. Give suitable examples

Course Outcome 4 (CO4):

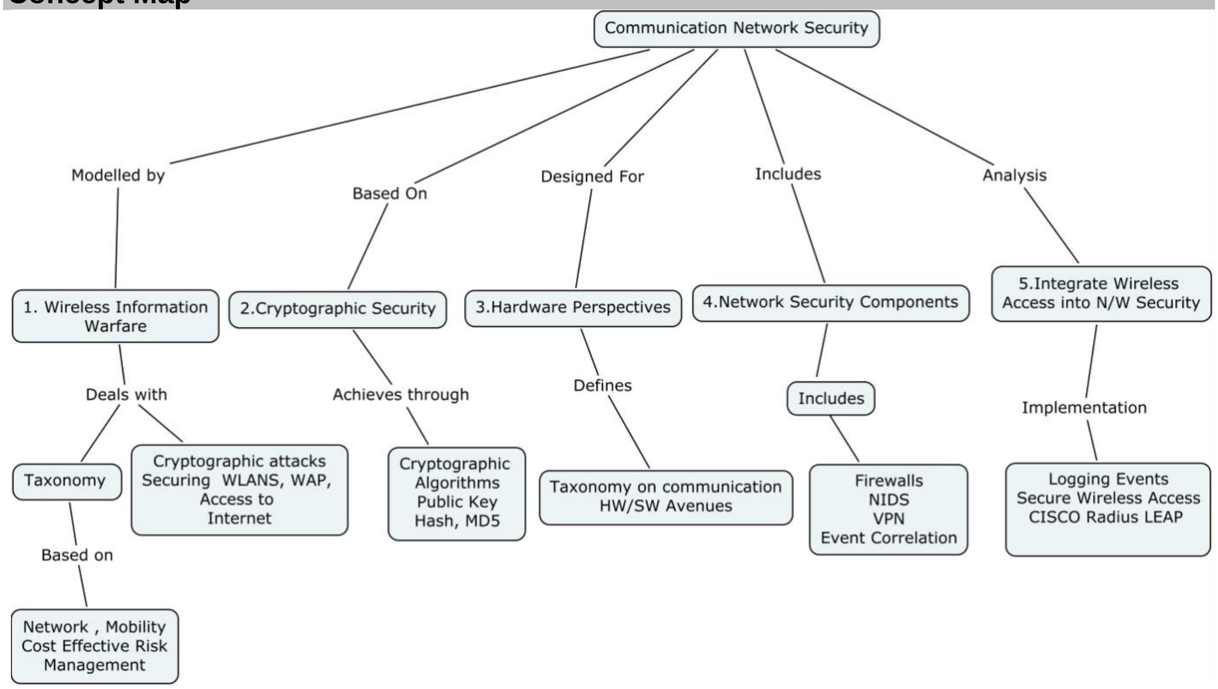
1. Perform encryption and decryption using RSA algorithm for the following
   p=3, q=11, e=7 and message m=5.
2. Consider Diffie- Hellman algorithm with a common prime q=11, primitive root a=2.
   a) If user A has public key Y_A=9, what is A's private key.
   b) If user B has public key Y_B=3, what is 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 5 (CO5):

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:

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14WT230	RF ACTIVE CIRCUITS FOR WIRELESS SYSTEMS

Category	L	T	P	Credit
PC	3	0	0	3

Preamble

Linear RF amplifiers provide the foundation for active circuit design. From the fundamental concepts of amplifier design, students can develop an increasingly detailed understanding of active circuits. Linear techniques will lead us to nonlinear principles, which, in turn, will enable an understanding of Power amplifiers, RF oscillators and Mixers. Modeling of active devices provides insight view on their characteristics at microwave frequencies. This course aims to provide detailed understanding on the analysis and design aspects of LNA, Power amplifier, oscillators and mixers.

Prerequisite

NIL

Course Outcomes

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

CO1. Basic concepts and general considerations of Linear RF amplifier design	Understand
CO2. Design and working principles of LNA and PA	Understand
CO3. Behaviour of RF active devices and their modelling at microwave frequencies	Analyze
CO4. Design principles of High-Power RF transistor amplifiers	Apply
CO5. Operating and design principles of oscillators and mixers	Apply

Mapping with Programme Outcomes

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

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	60	40	40	40
Apply	30	50	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: unilateral figure of merit.
2. What is meant by mismatch loss?

3. State the necessary conditions for oscillation in a one-port network.
4. What is meant by Mismatch uncertainty?
5. Define: Noise Figure.

Course Outcome 2 (CO2):

1. How neutralization can be done in bipolar transistors?
2. Mention the design steps involved in designing low noise amplifiers.
3. What are the drawbacks of cascading impedance-matched stages?
4. Mention the design steps involved in designing power amplifiers.

Course Outcome 3 (CO3):

1. Distinguish between bilateral and unilateral transducer gain.
2. How can you determine the stability given RF transistor?
3. Write the difference between Transducer gain and Maximum Stable Gain?
4. How can you cascade two LNA using balanced amplifier?
5. Distinguish between HBT and HEMT.

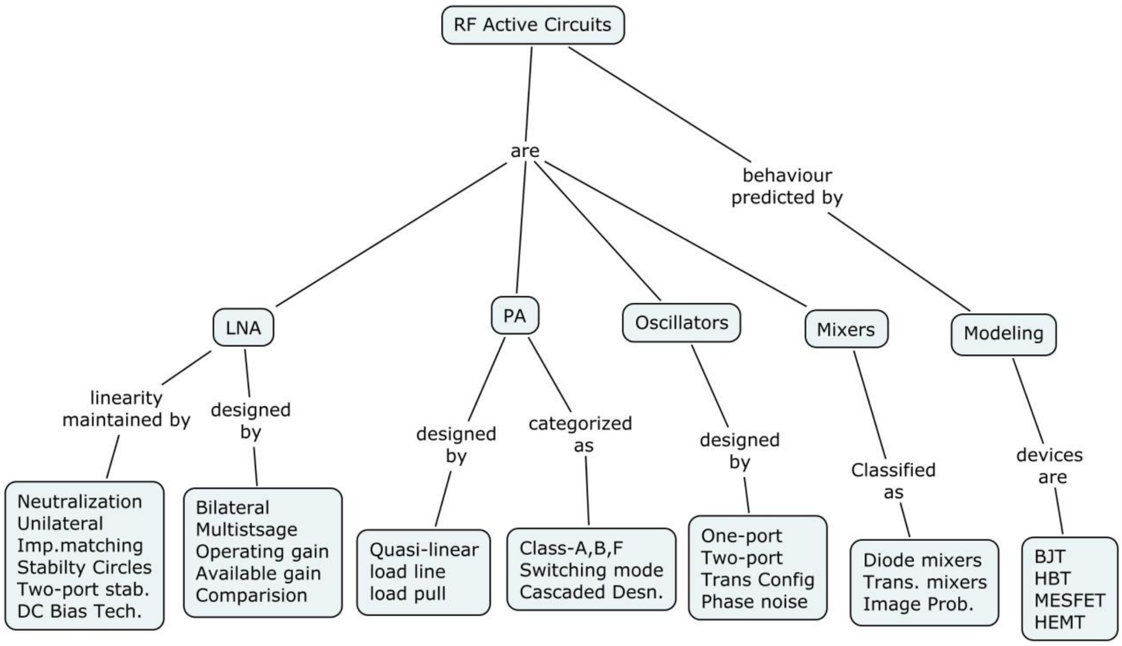
Course Outcome 4 (CO4):

1. Compute the highest and lowest gains by using the unilateral assumption for an Infineon BFP640 bipolar device. Measured S-parameters (2v, 20mA) at 900 MHz are given as: S11=0.4, S21=20.7, S12=0.029, S22=0.54.
2. Design an amplifier stage for GUMAX with the BFP 405 device at 880 MHz, without any added stabilization, using ideal lumped matching elements. What are the gain, input and output reflection coefficient magnitudes of the amplifier with (a) |S12|set to zero and (b) using the actual S12 of the device? How does the value of GUMAX compare with the computed MSG of the device?
3. Find the required terminations for maximum linear output power at 1.95 GHz, using the NEC6500379A GaAs power MESFET, operating at 3V, 800-mA dc bias, into 50-Ω RF source and load terminations.
4. Consider a 50-Ω cable, LNA and another amplifier are cascaded together. Their gain and Noise figures are G1=-3dB, NF1=3dB; G2=-20dB, NF2=1.5dB; G3=13dB, NF3=4dB. Compute the overall noise figure.

Course Outcome 5 (CO5):

1. A bipolar transistor at room temperature requires 0.7V at its base to set the collector current equal to 1mA. What is the value for IS of the device, neglecting reverse leakage current? What would IS be if the collector current were instead 100mA for this base voltage? What would IS be if the base voltage needed to be 0.75V to set the current to 1mA?
2. One oscillator has a Q of 5, another a Q of 50. Which oscillator reaches steady-state conditions first? Which oscillator can be quenched more quickly? Are these results intuitive? Can you think of a mechanical system that behaves the same way?
3. Derive the open-loop gain expression for the Colpitts topology. What are the conditions for startup of oscillation? At steady state, what must the load impedance equal?
4. The dc forward voltage for the BAT17 mixer diode is 340 mV when the current is 1 mA and 425 mV when the current is 10 mA. Calculate the sinusoidal LO power levels in dBm required to achieve these two levels of dc current and voltage. What are the corresponding LO impedances at each power level?

Concept Map



Syllabus

Linear RF Amplifier Design – Power Gain Definition – Neutralization – Unilateral Transducer Gain - RF Circuit Stability Considerations: RF Oscillation, stability Analysis with arbitrary source and local terminations, Two port stability considerations, Stability Circles – Stabilizing an active two port - Stabilization of a bipolar Transistor – The dc bias techniques: Passive DC bias networks, Active dc bias circuits, Feeding dc bias into RF Circuit. **Linear and Low Noise RF Amplifiers -** Bilateral RF Amplifier Design for Maximum Small-Signal Gain, Multistage Amplifiers – Operating Gain Design for Maximum Linear output power – Noise in RF Circuits - Available Gain Design Techniques: Gain Design Outline, Low Noise Amplifier Design Consideration, Design of Single Ended 1.9 GHz LNA, Comparison of Various Amplifier Design and Smith Chart Based Graphical Design aids. **Active RF Devices and Modeling -** The Diode Model – Two Port Design Model: The output terminals of a two port RF Device, The bipolar Transistor, The heterojunction bipolar transistor, The GaAS MESFET, The High Electron Mobility Transistor. **High Power RF Transistor Amplifier Design -** Nonlinear Concepts – Quasi-linear power amplifier design - Categories of Amplifiers: Class A, Class B, Class F Amplifiers, Switching Mode Amplifiers - Power Amplifier Design Examples: Transistor Selection, Transistor Characterization, Matching the input and output of the Device - Bias Considerations: Bias Changes at the input, Bias Changes at the output. **Oscillators -** Principles of Oscillator Design: Two Port Oscillator Design Approach, One Port Oscillator Design Approach, Transistor Oscillator Configurations, Characterizing Oscillator Phase Noise – Design examples. **Mixers** - Applications of Mixers in Systems – Diode Mixers - Single Ended Mixer, Single Balanced Mixer, Double Balanced Mixer, Image Problem in Mixers, Harmonic Components in Mixers - Transistor Mixers – Active transistor mixer.

Reference Books

1. Les Besser and Rowan Gilmore, "Practical RF Circuit Design for Modern Wireless Systems – Active Circuits and Systems", Vol.II, Artech House Publishers, Boston, London 2003.
2. D.M.Pozar, "Microwave Engineering", John Wiley & Sons, Singapore 2004.
3. R.E.Collin, "Foundations of Microwave Engineering", McGraw Hill, 1995.

4. Les Besser and Rowan Gilmore, "Practical RF Circuit Design for Modern Wireless Systems – Passive Circuits and Systems", Vol 1, Artech House Publishers, Boston, London 2003.

Course Contents and Lecture Schedule

No.	Topics	No of Lectures
1	**Linear RF Amplifier Design**	
1.1	Power Gain Definition – Neutralization – Unilateral Transducer Gain	2
1.2	RF Circuit Stability Considerations: RF Oscillation, stability Analysis with arbitrary source and local terminations	2
1.3	Two port stability considerations, Stability Circles – Stabilizing an active two port	2
1.4	Stabilization of a bipolar Transistor – The dc bias techniques: Passive DC bias networks, Active dc bias circuits, Feeding dc bias into RF Circuit	3
2	**Linear and Low Noise RF Amplifiers**	
2.1	Bilateral RF Amplifier Design for Maximum Small-Signal Gain	2
2.2	Multistage Amplifiers – Noise in RF Circuits - Operating Gain Design for Maximum Linear output power	2
2.3	Available Gain Design Techniques: Gain Design Outline, Low Noise Amplifier Design Consideration	2
2.4	Design of Single Ended 1.9 GHz LNA, Comparison of Various Amplifier Design and Smith Chart Based Graphical Design aids	3
3	**Active RF Devices and Modeling**	
3.1	The Diode Model – Two Port Design Model: The output terminals of a two port RF Device, The bipolar Transistor	2
3.2	The heterojunction bipolar transistor, The GaAS MESFET, The High Electron Mobility Transistor	3
4	**High Power RF Transistor Amplifier Design**	
4.1	Nonlinear Concepts – Quasi-linear power amplifier design	2
4.2	Categories of Amplifiers: Class A, Class B, Class F Amplifiers, Switching Mode Amplifiers	2
4.3	Power Amplifier Design Examples: Transistor Selection, Transistor Characterization, Matching the input and output of the Device	3
4.4	Bias Considerations: Bias Changes at the input, Bias Changes at the output	3
5	**Oscillators**	
5.1	Principles of Oscillator Design: Two Port Oscillator Design Approach, One Port Oscillator Design Approach, Transistor Oscillator Configurations	3
5.2	Characterizing Oscillator Phase Noise – Design examples	2
6	**Mixers**	
6.1	Applications of Mixers in Systems – Diode Mixers - Single Ended Mixer – Single Balanced Mixer, Double Balanced Mixer	3
6.2	Image Problem in Mixers – Harmonic Components in Mixers	2
6.3	Transistor Mixers – Active transistor mixer	2

Course Designers:

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14WT270	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

14WT140 RF Passive Circuits for Wireless 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:

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14WT310	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	PO12
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	10	10	0	0
Understand	30	10	20	20
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. 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

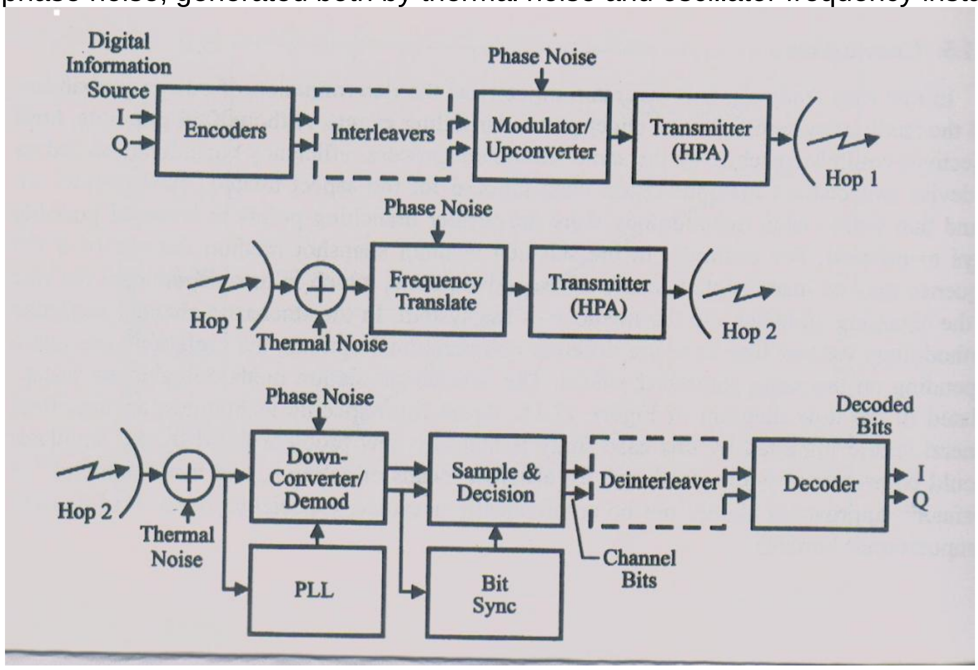
Course Outcome 3 (CO3):

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.



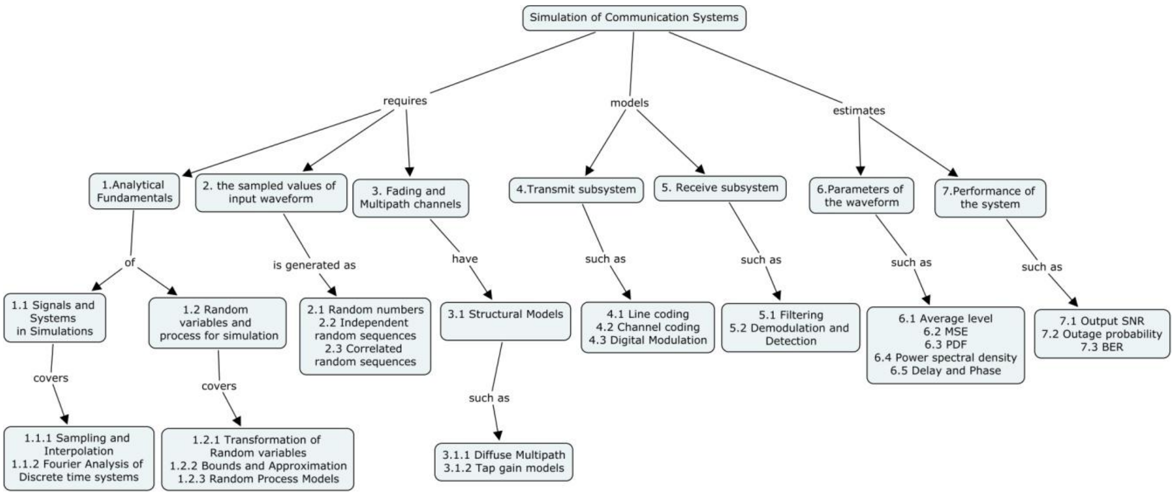
2. Simulate the IS-95 CDMA downlink system and analyze the BER performance.
3. Simulate the Physical downlink control format indicator channel in LTE downlink system assuming that the bandwidth is 10MHz. Analyze the error performance of it in the SISO and MISO transmit diversity schemes.
4. Simulate 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:

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14WTPA0	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	Apply

Mapping with Programme Outcomes

S- Strong; M-Medium; L-Low

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
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	-	-	-

Assessment Pattern

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	10	10	0	0
Understand	20	20	20	20
Apply	50	50	40	40
Analyse	20	20	40	40
Evaluate	0	0	0	0
Create	0	0	0	0

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):

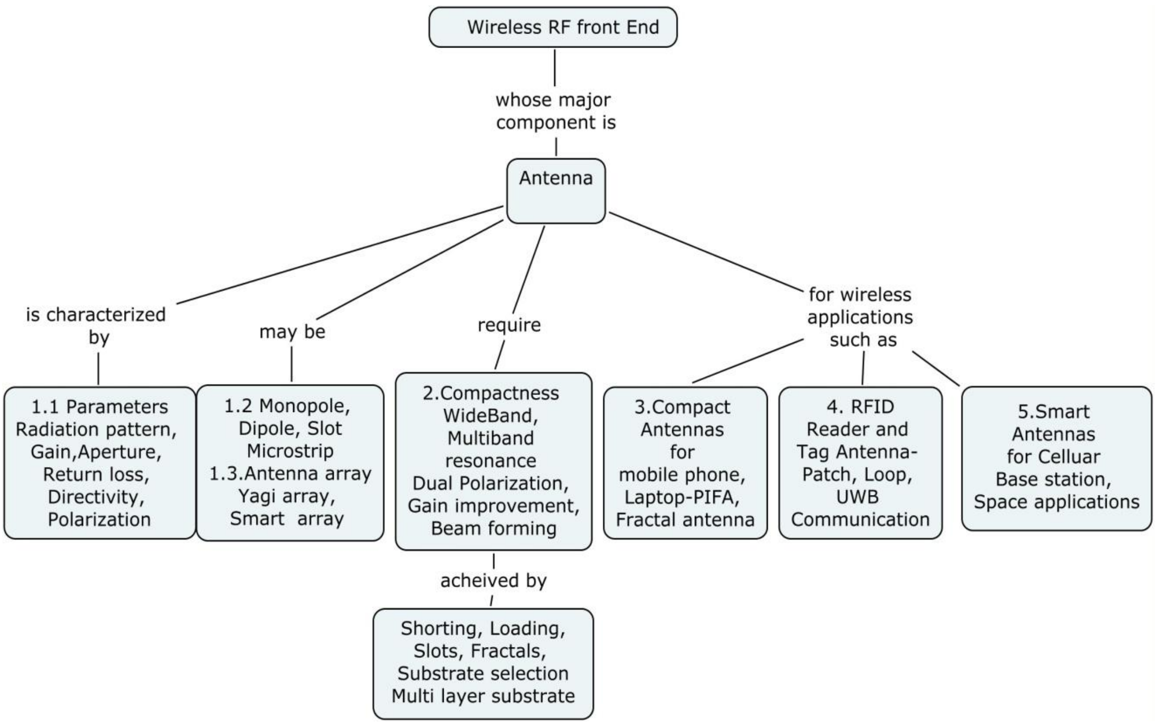
1. A two element end-fire array in free space consists of 2 vertical side by side λ/2 elements with equal out of phase currents. At what angles in the horizontal plane is the field intensity is maximum: (a) when the spacing is λ/2?
2. What spacing of two in phase side by side λ/2 antenna produces maximum 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) β=0° (b) β=-90° (c) β=+90° the and propose the phase condition for making the array as broadside array.

Course Outcome 5 (CO5):

1. Design a mini wireless antenna for Laptop WLAN applications.
2. 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.
3. Design a compact microstrip antenna resonating at the frequency of 2.4GHz
4. Design a planar inverted F antenna operating in Cellular GSM lower band.
5. 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
6. 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:

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14WTPB0	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.Apply signal models in designing and analyzing RADAR signal processor.	Apply
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.	Apply

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	10	10	0	0
Understand	30	30	20	20
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):

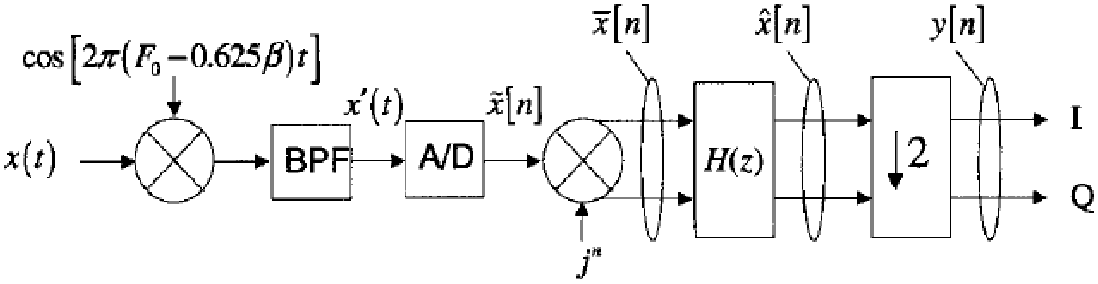
1. Mention the basic RADAR functions.
2. What is clutter?
3. Define ambiguity function.

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

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

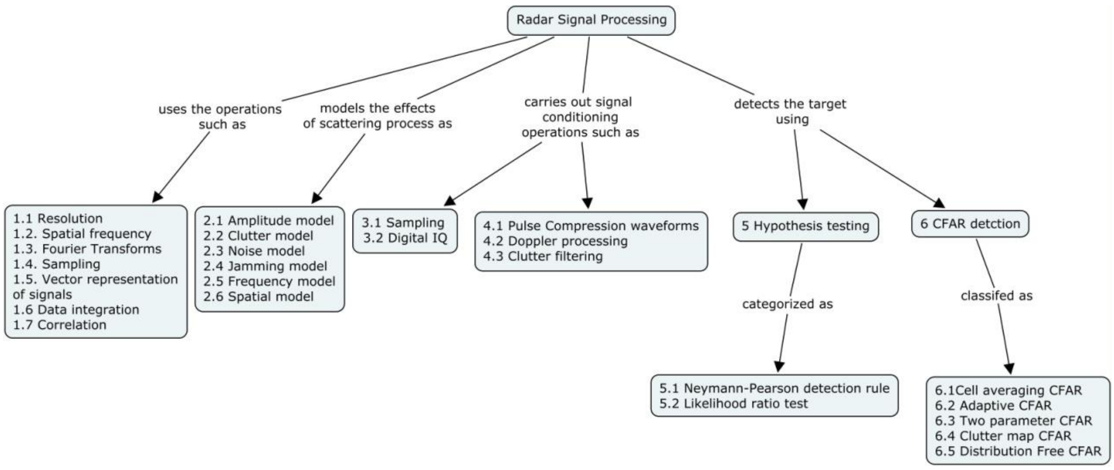
$$H_1 : p(x[0]) = \frac{1}{\sqrt{2\pi}}\exp\left(-\frac{1}{2}x^2[0]\right)$$

2. Determine the matched filter output for P3 codes of length 4 and 5.
3. Consider the detection problem $\begin{matrix} H_o : \mathbf{y}_i = \mathbf{w}_i & \textit{for } i = 0,1...N-1 \\ H_1 : \mathbf{y}_i = m + \mathbf{w}_i & \textit{for } i = 0,1...N-1 \end{matrix}$ 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 $\begin{matrix} H_0 : x[0] \sim N(0,1) \\ H_1 : x[0] \sim N(0,2) \end{matrix}$ 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

Module No.	Topic	No. of Lectures
5	**Hypothesis testing**	
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:

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14WTPC0	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.Apply different data representations such as text, image audio and video for multimedia applications	Apply
CO2.Apply various audio compression and image compression schemes for different applications.	Apply
CO3.Examine the ideas behind MPEG standards such as MPEG 1, 2, 4,7 and MPEG 21.	Apply
CO4.Examine multimedia communication through multimedia networks and transmission.	Apply
CO5.Apply various multimedia retrieval algorithms for different applications.	Apply

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	-	-
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	10	10	0	0
Understand	40	40	40	40
Apply	50	50	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)

Course Outcome 2 (CO2):

1. Explain the concept of dithering to print images
2. Discuss about MPEG 4 video coding with neat sketch?
3. Explain the following terms: a) ATM b) ISDN
4. Explain different multiplexing technologies with neat sketch.

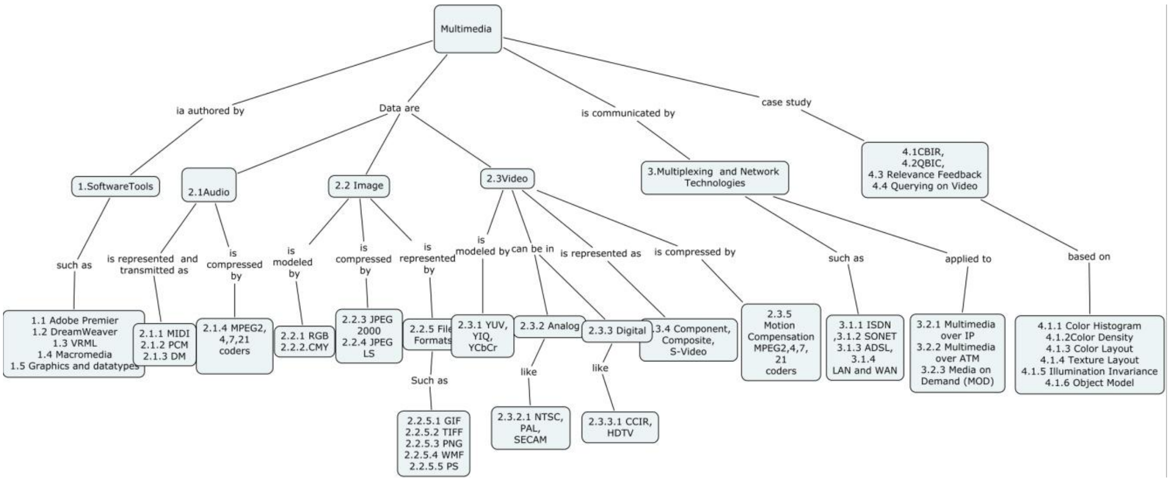
Course Outcome 4 (CO4):

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 5 (CO5):

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:

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14WTPD0	HIGH PERFORMANCE WIRELESS NETWORKS	Category	L	T	P	Credit
		PE	3	1	0	4

Preamble

The course “14WTPD0: High performance wireless networks” is offered in the Second semester in continuation with the course on “14WT130: Adhoc and Sensor Networks”. This course aims to understand Wireless LAN and Wireless ATM technologies and their performance along with implementation issues and their standards.

Prerequisite

NIL

Course Outcomes

CO1	Identify the requirements of high speed networks such as WLAN, WPAN and WATM	Understand
CO2	Classify the wireless LAN standards with its PHY and MAC functions	Analyze
CO3	Design and Implement issues of the WLAN and WPAN systems	Apply
CO4	Implementing WLAN systems for Multimedia applications	Apply
CO5	Compare the capabilities of ATM and WATM systems	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	M	L	-	-	-	--	-	-	-	-
CO2.	S	S	M	M	-	-	-	-	-	-	-
CO3.	S	M	M	L	L	L	L	L	-	-	-
CO4.	S	M	M	M	L	L	L	L	-	-	-
CO5.	S	M	L	L	-	L	-	L	-	-	-

S- Strong; M-Medium; L-Low

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Specify the application of different classes in ATM network
2. List out the different types of fading in multipath environment.
3. Mention the unresolved issues in WLAN.
4. Identify the need of WATM
5. Mention the application of WATM

Course Outcome 2 (CO2):

1. Describe the operation of CSMA/CA protocol in WLAN along with its frame formats.
2. Discuss about ATM cell transmission including operation, administration and maintenance operation.
3. Explain in detail about Link management protocol, LLC and Adaptation protocol
4. Draw ISDN protocol Architecture and explain its operation in detail
5. Compare the merits and demerits in FHSS and DSSS for WLAN
6. Discuss the performance evolution method in WLAN with case studies

Course Outcome 3 (CO3):

1. Calculate the total delay experienced by a packet generated by a source travels over one link, gets buffered at a switch, is then routed to another link, and so on, until it arrives at its destination with example.

2. Consider the HIPERLAN-2 standard that uses BPSK and r=3/4 codes for 9 Mbits/sec information transmission and 16 QAM with the same coding for the actual payload data transmission rate of 36 Mbits/sec.
   a. Calculate the coded symbol transmission rate per subscriber for each of the two nodes. What is the bit transmission rate per subscriber for each of the two nodes?
   b. If one switches from 32 Mbps mode to 9 Mbps mode, how much mode in DB of the path loss can it afford?
3. Determine the applications of code division multiple access along with its principle of operation.

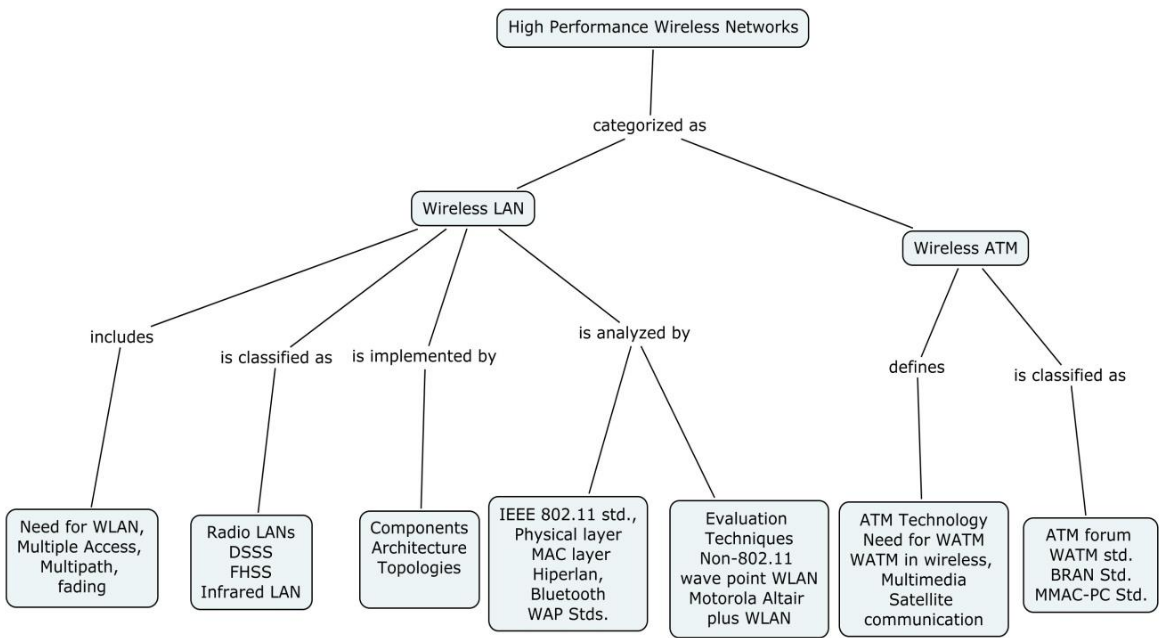
Course Outcome 4 (CO4):

1. Determine the methods used to mitigate Intersymbol interference in wireless networks
2. Relate the applications and operations of cellular systems and cordless phone.
3. Calculate the packetization delay for 1)53 byte ATM cells ii) a thousand byte packet transfer service for a)voice samples that are sampled 8000 times per sec and encoded into a 64 bits per sec stream and b)MPEG1 which takes 30 video frames per sec and encodes them into a 1Mbps stream.(The packetization delay depends on the speed of information transfer).

Course Outcome 5 (CO5):

1. Analyze why packet switching is more efficient than circuit switching for bursty traffic?
2. Identify the propagation delay of a link from an earth station to a geostationary satellite and also identify the end-to-end delay of a voice conversation that is relayed via such a satellite?
3. Identify the major challenges in implementing WATM that did not exist for data oriented Ethernet like IEEE 802.11.
4. Distinguish error-correction schemes (instead of error detection followed by retransmission) in data storage applications(such as audio CDs and magnetic disks) and in real-time applications(e.g., controlling a satellite)

Concept Map



Syllabus

Wireless Local Area Network - Need for WLAN, Indoor Wireless Communication, Radio Spectrum, Path loss, Multiple Access, Multipath, fading. **Classification of WLAN** Radio LANs, DSSS, FHSS, Comparison of DSSS and FHSS, Infrared WLAN **WLAN Implementation** WLAN Components, Architecture and Topologies, Deployment Considerations, WLAN enhancement techniques **WLAN Standards** IEEE 802.11 WLAN standard, Physical and MAC layer, Unresolved issues in 802.11, Current and commercial 802.11 Deployment, HIPERLAN, Bluetooth and WAP standards **Performance evaluation of WLAN:** Evaluation Techniques, Non 802.11 Wave point WLAN, Case studies- Motorola Altair plus WLAN **Wireless ATM Networks:** ATM Technology, Need for WATM, WATM for Wireless, Multimedia and Satellite Communication, WATM prototypes, Commercial WATM systems for Local loop **WATM Standards:** ATM Forum, WATM Standard, BRAN standard, MMAC-PC standard.

Reference Books

1. Benny Bing, "High-speed Wireless ATM and LANs" Artech House Publishers, 2009.
2. William Stallings, "High Speed Networks and Internet", 2nd Edition, Pearson Education, 2002.
3. Kaveh Pahalavan and P. Krishnamurthy." Principles of Wireless Networks- A Unified approach", Pearson Education,2009.
4. Larry L. Peterson and Bruce S. Davie, "Computer networks-A system Approach", Third Edition, McGrawHill, 2010.
5. Mani Subramanian, "Network Management: principles and practice " Addision – Wesley Publisher 2007.
6. Peter T. Davis, Craig R. McGuffin, "Wireless Local Area Networks- Technologies, issues and strategies", McGraw Hill 2003.
7. David E. McDysan,Darren L. Spohn, McDysan," ATM Theory and applications", McGraw Hill, 2004.

Course Contents and Lecture Schedule

Module No.	Topics	No of Lectures
1	**Wireless Local Area Network**	
1.1	Need for WLAN	1
1.2	Indoor Wireless Communication	1
1.3	Radio Spectrum	1
1.4	Path loss	1
1.5	Multiple Access, Multipath, fading	1
2	**Classification of WLAN**	
2.1	Radio LANs	1
2.2	DSSS	1
2.3	FHSS	1
2.4	Comparison of DSSS and FHSS	1
2.5	Infrared WLAN	2
3	**WLAN Implementation**	
3.1	WLAN Components	2
3.2	Architecture and Topologies	1
3.3	Deployment Considerations	2
3.4	WLAN enhancement techniques	2
4	**WLAN Standards**	

4.1	IEEE 802.11 WLAN standard	2
4.2	Physical and MAC layer	1
4.3	Unresolved issues in 802.11	1
4.4	Current and commercial 802.11 Deployment	1
4.5	HIPERLAN	1
4.6	Bluetooth and WAP standards	1
5	**Performance evaluation of WLAN**	
5.1	Evaluation Techniques	2
5.2	Non 802.11 Wave point WLAN	1
5.3	Case studies- Motorola Altair plus WLAN	1
6	**Wireless ATM Networks**	
6.1	ATM Technology	2
6.2	Need for WATM	2
6.3	WATM for Wireless and Multimedia Communication	2
6.4	WATM for Satellite Communication	2
6.5	WATM prototypes	1
6.6	Commercial WATM systems for Local loop	1
7	**WATM Standards**	
7.1	ATM Forum, WATM Standard	2
7.2	BRAN standard	2
7.3	MMAC-PC standard	2

Course Designers:

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

14WTPE0	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.	Analyze

Mapping with Programme Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
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	10	10	0	0
Understand	40	40	20	20
Apply	50	50	30	30
Analyse	0	0	50	50
Evaluate	0	0	0	0
Create	0	0	0	0

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.

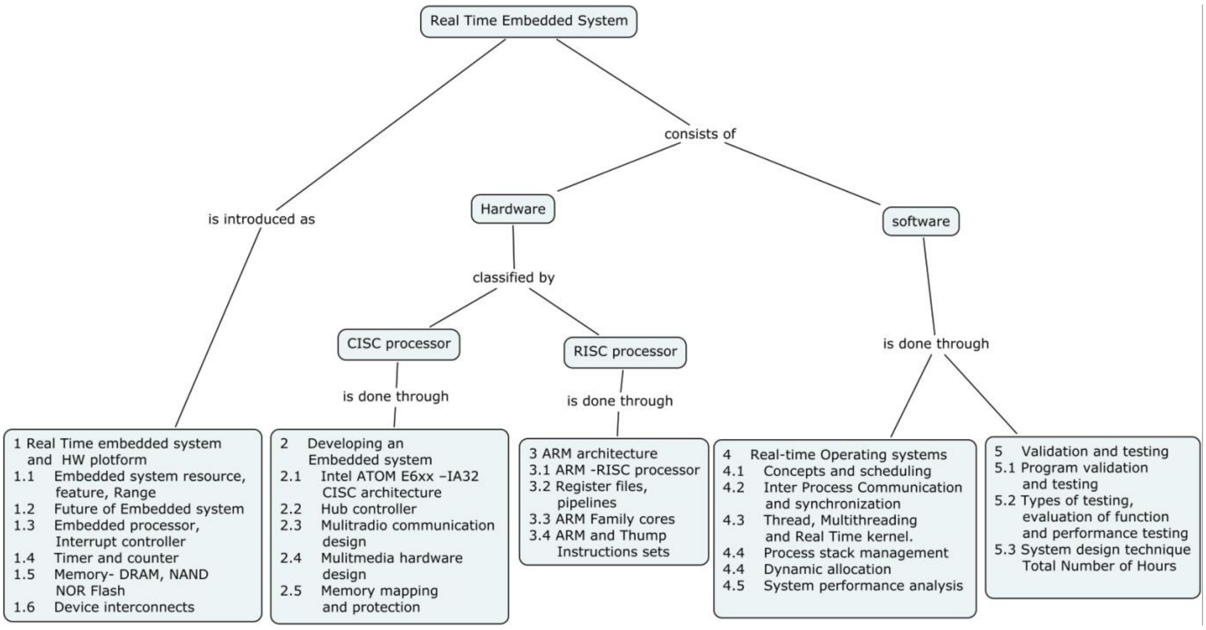
Course Outcome 4 (CO4):

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:

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2. Dr.L.R. Karl Marx lrkarlmarx@tce.edu

14WTPF0	CMOS ASIC DESIGN	Category	L	T	P	Credit
		PE	3	1	0	4

Preamble

The proposed course is offered as an elective in the second semester. This course WT2F: CMOS ASIC DESIGN is preceded by a three credit course "Digital Logic Design with VHDL" offered in first semester. 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	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	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	10	20	0	0
Understand	30	20	20	20
Apply	40	40	40	40
Analyse	20	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):

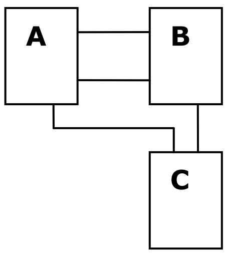
1 Draw the ASIC design flow
2 Explain different types of I/O requirements with example?
3 Illustrate channel definition in floor planning with suitable examples.
4 Compare the different types of Gate Array semi custom ASIC.
5 Explain in detail about routing algorithms.
6 Illustrate I/O and power planning 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):

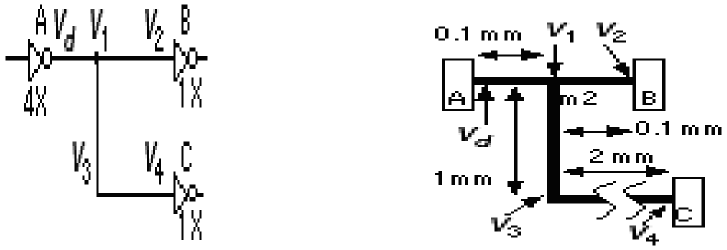
1. Identify the procedure to partition the network using iterative improvement algorithm
2. Distinguish the difference between Global routing inside flexible blocks and between blocks
3. Identify the steps involved to place logic cells of a network in two dimensional structures.

Course Outcome 5 (CO5):

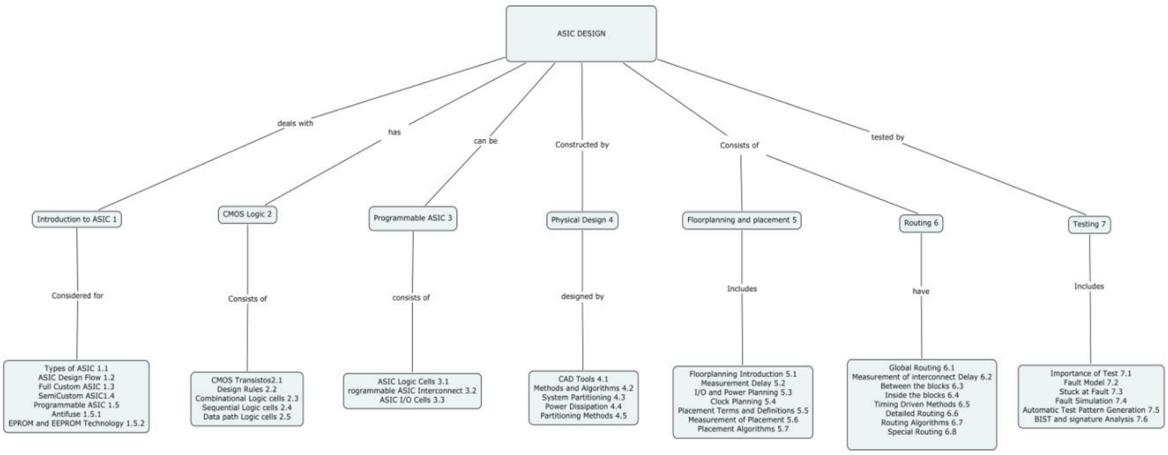
1. Calculate the total chip power dissipation for following ACTEL 1020B FPGA. Consider an ACTEL with a 20 MHz clock. We shall initially assume 100 percent utilization of the 547 logic modules and assume that each switches at an average

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:

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2. Dr.D.Gracia Nirmala Rani gracia@tce.edu

14WTPG0	ADAPTIVE SIGNAL PROCESSING	Category	L	T	P	Credit
		PE	3	1	0	4

Preamble

The course ": Adaptive Signal Processing" is offered as elective subject. This course describes the adaptive signal processing algorithms to extract the desired signal from observed noisy signal. The objective is to present the adaptive implementation of Wiener filter. The adaptive algorithms considered are Steepest decent method, LMS, RLS and QR-RLS. These algorithms are used for applications such as signal enhancement, signal prediction, system identification, channel equalization, beam forming and echo cancellation.

Prerequisite

Nil

Course Outcomes

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

CO1.	Characterize the stationary and non-stationary stochastic process.	Apply
CO2.	Determine the Wiener filter coefficients from the auto correlation and cross correlation of random sequences.	Apply
CO3.	Determine the filter coefficients and minimum error of an LMS and RLS adaptive filters	Analyze
CO4.	Apply the concept of Wiener filter for channel equalization and echo cancellation in an adaptive manner.	Apply
CO5.	Analyze the performance of adaptive signal processing algorithms for a given application/specification and designing of subband adaptive filter banks for given specifications	Analyze

Mapping with Programme Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
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	10	0	0
Understand	20	10	20	20
Apply	60	60	60	60
Analyse	0	20	20	20
Evaluate	0	0	0	0
Create	0	0	0	0

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Define Markov process
2. State the principle of orthogonality.
3. Define bias and consistency.

4. Give the update equation of LMS algorithm.
5. What is multi rate system?
6. What is delay less subband adaptive filters?

Course Outcome 2 (CO2):

1. Compare the performance of LMS and RLS algorithm.
2. What is the difference between LS and RLS algorithm and what is the difference between recursive RLS and lattice based RLS?
3. What is the relationship between least squares and Wiener solution?
4. Relate the coefficient-error vector-covariance matrix $\text{cov}[\Delta w(k)]$ with σ_n^2 in RLS algorithm.
5. What is the difference between a priori error and a posteriori error? What is the relationship between the two errors in forward and backward prediction filters?
6. Differentiate decimation and interpolation.

Course Outcome 3 (CO3):

1. The autocorrelation sequence of a discrete time stochastic process is $\phi(k) = (0.5)^{|k|}$. Determine its power density spectrum.
2. A stationary random signal has autocorrelation function $r_{xx}(k) = 0.25^{|k|}$, for all 'k'. The observation signal is $y_n = x_n + v_n$, where v_n is zero mean, white noise sequence of variance 1, uncorrelated from x_n. Determine the optimal FIR Wiener filter of order M=1, for estimating x_n from y_n
3. Let $x(n)$ be a zero mean white noise sequence of unit variance. Compute the output correlation $R_{yy}(k)$, for all k of the system. $y(n) = 0.25y(n-1) + x(n)$.
4. Let $y_n = A_1 \exp(j(\omega_1 n + \phi_1))$ be a complex sinusoid with amplitude A_1 and frequency ω_1. The randomness y_n arises only from the phase ϕ_1 which is assumed to be a random variable uniformly distributed over the interval $0 \le \phi_1 \le 2\pi$. Compute the autocorrelation function of y_n.
5. Suppose in an adaptive filtering environment, the input signal consists of $x(k) = \cos(w_o k)$. The desired signal is given by $d(k) = \sin(w_o k)$, where $w_o = \frac{2\pi}{7}$. In this case M=7. Compute the optimal solution for a first order adaptive filter.
6. Prove the orthogonality principle for the least square problem in which $\lambda = 1,\ d(1) = \begin{bmatrix} 0.5 \\ 1.5 \end{bmatrix} and\ X[1] = [1 \ \ -2]$

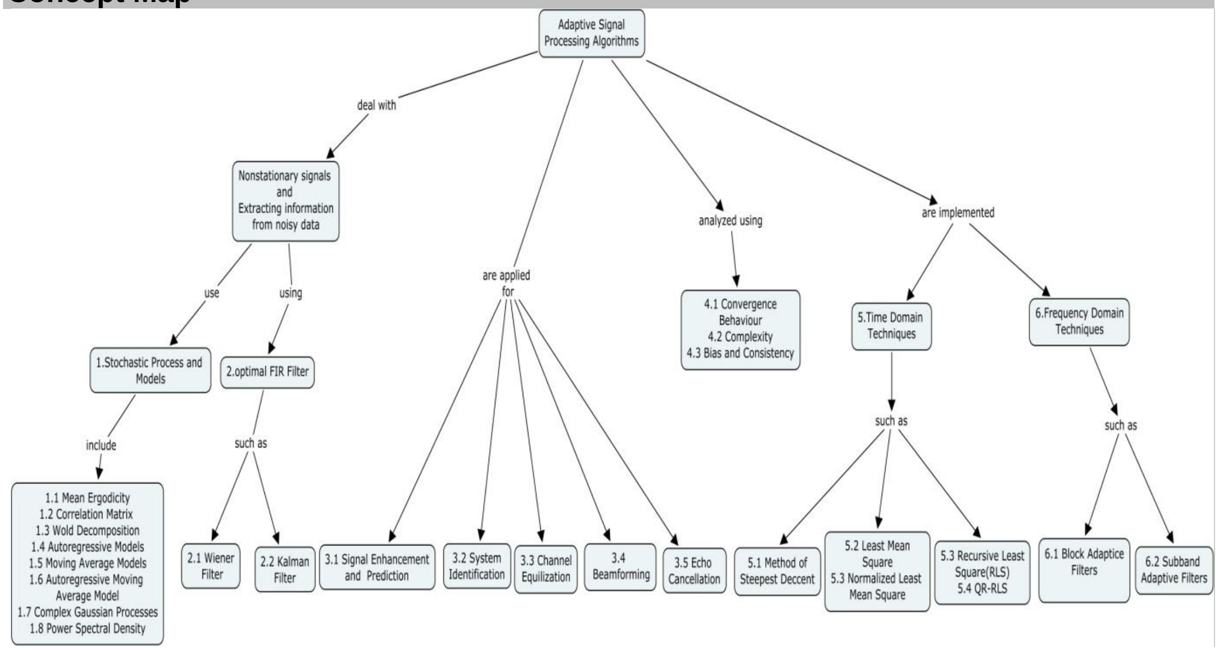
Course Outcome 4 (CO4):

1. The LMS algorithm is an O(M) algorithm, where M is the length of the transversal filter component. Confirm the validity of this statement.
2. The steepest decent algorithm becomes unstable when the step size parameter μ is assigned a negative value. Justify the validity of this statement.
3. The RLS filter differs from the LMS filter in a fundamental respect. The step size parameter μ in the LMS filter is replaced by the inverse correlation matrix $\boldsymbol{\varphi}^{-1}(n)$. This replacement has a self orthogonalizing effect in the RLS filter, which is expressed by $E[\varepsilon(n)] \approx \left(1 - \frac{1}{n}\right) E[\varepsilon(n-1)]$ for large n, where $\varepsilon(n) = \mathbf{w}_o - \hat{\mathbf{w}}(n)$. Distinguish between the RLS filter and the self orthogonalizing adaptive filter.

Course Outcome 5 (CO5):

1. The process equation $\mathbf{x}(n+1) = \lambda^{-1/2}\mathbf{x}(n), \quad 0 < \lambda \le 1,$ for an RLS filter describes the evolution of the state as $\mathbf{x}(n+1) = \lambda^{-1/2}\mathbf{x}(n)$ With the exponential weighting factor λ in the interval $0 < \lambda \le 1,$ the Euclidean norm of the state $\mathbf{x}(n)$ grows unboundedly with time n for $\lambda < 1.$ Yet the RLS filter operates satisfactorily despite this seemingly abnormal behaviour. Why?
2. We consider the general case of a time-varying real-valued ARMA process $y(n)$ described by the difference equation $y(n) + \sum_{k=1}^{M} a_k(n) y(n-k) = \sum_{k=1}^{N} a_{M+k}(n) v(n-k) + v(n),$ where $a_1(n), a_2(n), ...a_M(n), a_{M+1}(n).......a_{M+N}(n)$ are the ARMA coefficients, the process $v(n)$ is the input, and the process $y(n)$ is the output. The process $v(n)$ is a white Gaussian noise process of zero mean and variance σ^2. The ARMA coefficients are subject to random fluctuations.
   a) Formulate the state-space equations for the ARMA process.
   b) Find an algorithm for computing the predicted value of the state vector $\mathbf{x}(n+1)$, given the observation $y(n)$.
   c) How would you initialize the algorithm in the above question?
   d) The Kalman filter used in this problem is not optimal. Why?
3. The inverse QR-RLS algorithm is a natural extension of the standard RLS filter, and it may therefore be referred to as the square-root RLS algorithm. Justify the validity of this statement.

Concept Map



Syllabus

Stochastic Process and Models: Discrete-Time Stochastic Process**,** Mean Ergodicity, Correlation Matrix, Wold Decomposition, Autoregressive Models, Moving Average Models, Autoregressive Moving Average Models, Complex Gaussian Processes, Power Spectral Density **Optimal FIR Filter:** Wiener Filter- Principle of orthogonality, Minimum mean square error, Wiener-Hopf Equations, Error-Performance Surface, Kalman Filter-The Innovation Process, Estimation of state using Innovation Process, Filtering. **Applications:** Signal Enhancement and Prediction, System Identification, Channel Equalization, Beamforming, Echo Cancellation. **Properties of Adaptive Algorithms**: Convergence Behavior, Complexity, Bias and Consistency**. Time Domain Techniques:** Method of Steepest Decent**,** Least Mean Square (LMS) algorithm, Normalized Least Mean Square (NLMS) algorithm, Recursive Least Square (RLS) algorithm, QR decomposition based RLS (QR-RLS) algorithm. Gradient Adaptive Lattice Filters, **Frequency Domain Techniques:** Block Adaptive Filters, Subband Adaptive Filters.

Reference Books

1. Simon Haykin, ‘Adaptive Filter Theory’, Pearson Education, 4th edition 2009.
2. Paulo S.R.Diniz, Adaptive Filtering: Algorithms and Practical Implementation, Kluwer Academic Publishers, 3rd edition, 2008.
3. Ali H.Sayed , ’Adaptive Filters’, John Wiley and Sons, 2008.
   Kong-Aik Lee, Woon-Seng Gan, Sen M., ‘Subband Adaptive Filtering: Theory and Implementation’ John Wiley and Sons, 2009.
4. B.Widrow and S.D. Stearns, “ Adaptive Signal Processing”, Prentice Hall, Englewood Cliffs, NJ, 1985

Course Contents and Lecture Schedule

No.	Topic	No. of Lectures
1.	**Stochastic Process and Models :**	
1.1	Discrete-Time Stochastic Process, Mean Ergodicity	1
1.2	Correlation matrix	1
1.3	Wold Decomposition, Autoregressive Models	1
1.4	Moving Average Models, Autoregressive Moving Average Models	1
1.5	Complex Gaussian Processes, Power Spectral Density	1
2	**Filtering**	
2.1	Wiener filter- Principle of orthogonality	2
2.2	Minimum mean square error, Wiener-Hopf Equations	2
2.3	Error-Performance Surface	1
2.4	Kalman Filter- Statement of Kalman Filter Problem	2
2.5	The Innovation Process,	2
2.6	Estimation of state using Innovation Process	2
2.7	Filtering	2
3	**Applications**	
3.1	Signal Enhancement and Prediction	1
3.2	System Identification	1
3.3	Channel Equalization	2
3.3	Beamforming	2
3.4	Echo Cancellation	1
4	**Properties of Adaptive Algorithms**	
4.1	Convergence Behavior	2
4.2	Complexity	1

4.3	Bias and Consistency	1
5	**Time Domain Techniques**	
5.1	Method of Steepest Decent	2
5.2	Least Mean Square (LMS) algorithm	2
5.3	Normalized Least Mean Square (NLMS) algorithm	2
5.4	Recursive Least Square (RLS) algorithm	2
5.5	QR decomposition based RLS (QR-RLS) algorithm	2
6	**Frequency Domain Techniques**	
6.1	Block Adaptive Filters	3
6.2	Subband Adaptive Filters	3
	Total	45

Course Designers:

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14WTPH0	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	PO12
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	0	0
Understand	20	10	20	20
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,

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

   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.

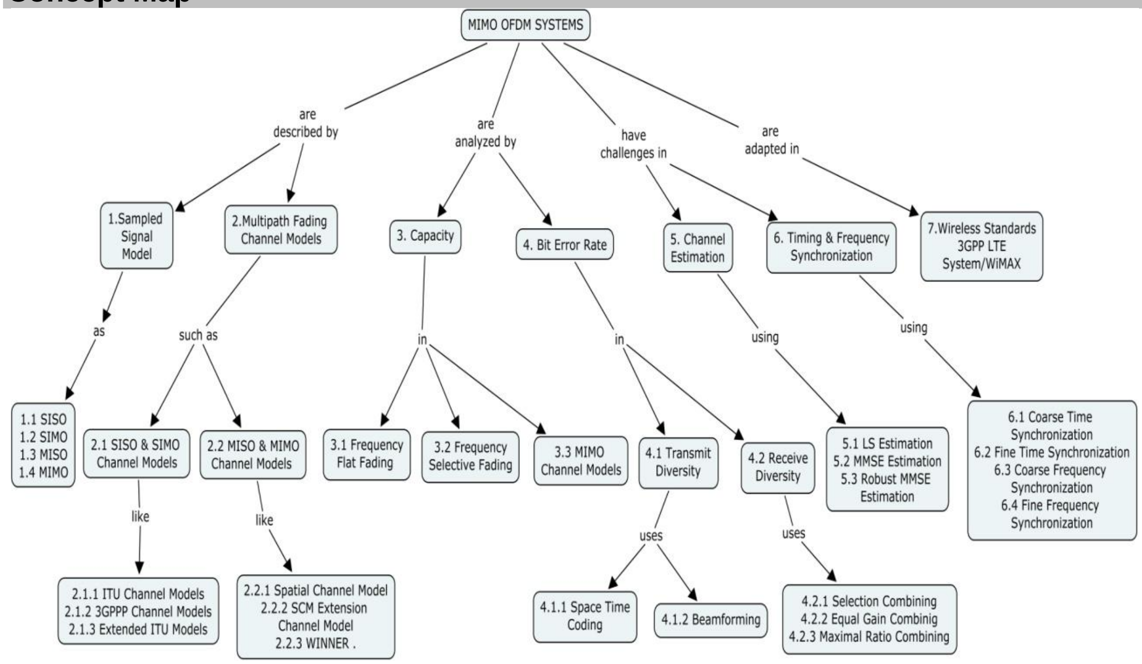
Course Outcome 4 (CO4):

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:

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2. Mrs.K.Rajeswari rajeswari@tce.edu

14WTPI0	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	PO12
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	0	0
Understand	20	20	40	40
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.

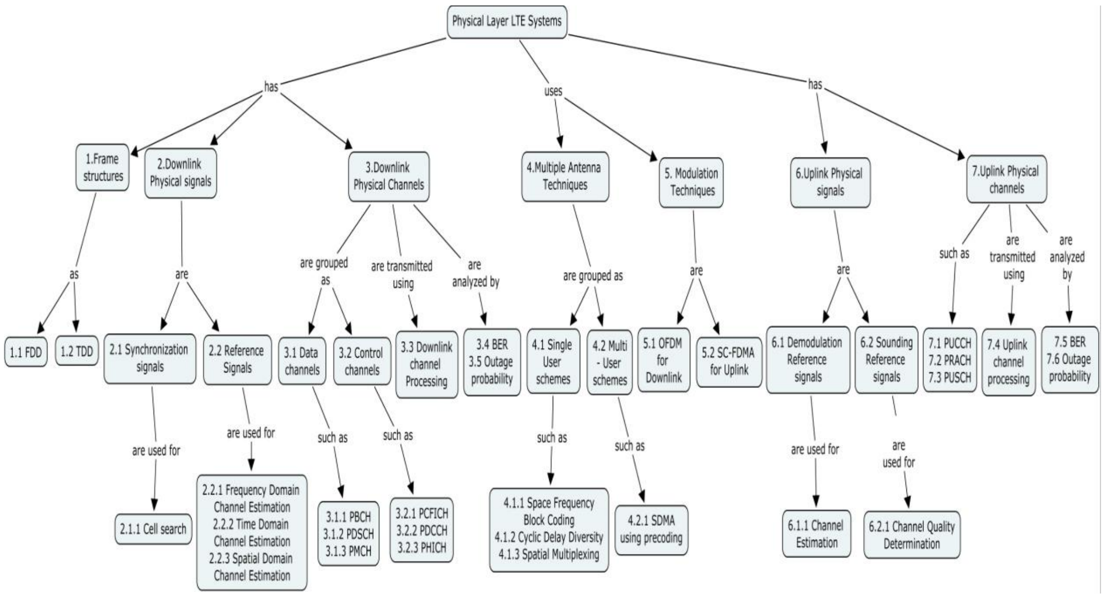
Course Outcome 4 (CO4):

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:

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14WTPJ0	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. Summarize the Concept of miniaturization, need for MEMS in various applications and also the need for packaging.	Understand
CO2. Explain the concepts of various actuation mechanisms of MEMS.	Understand
CO3. Design and analyze RF MEMS components such as switches, capacitors, phase shifters and antennas.	Apply
CO4. Generalize Micro fabrication techniques.	Apply
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	M	L	M	-	M	L	L	M	-	-
CO2.	S	M	M	M	M	M	-	-	-	-	-
CO3.	S	S	S	S	S	S	S	S	M	-	-
CO4.	S	M	M	S	M	L	L	L	L	-	-
CO5.	S	S	S	M	S	S	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	0	0
Understand	20	20	30	30
Apply	60	60	50	50
Analyse	0	0	20	20
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):

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

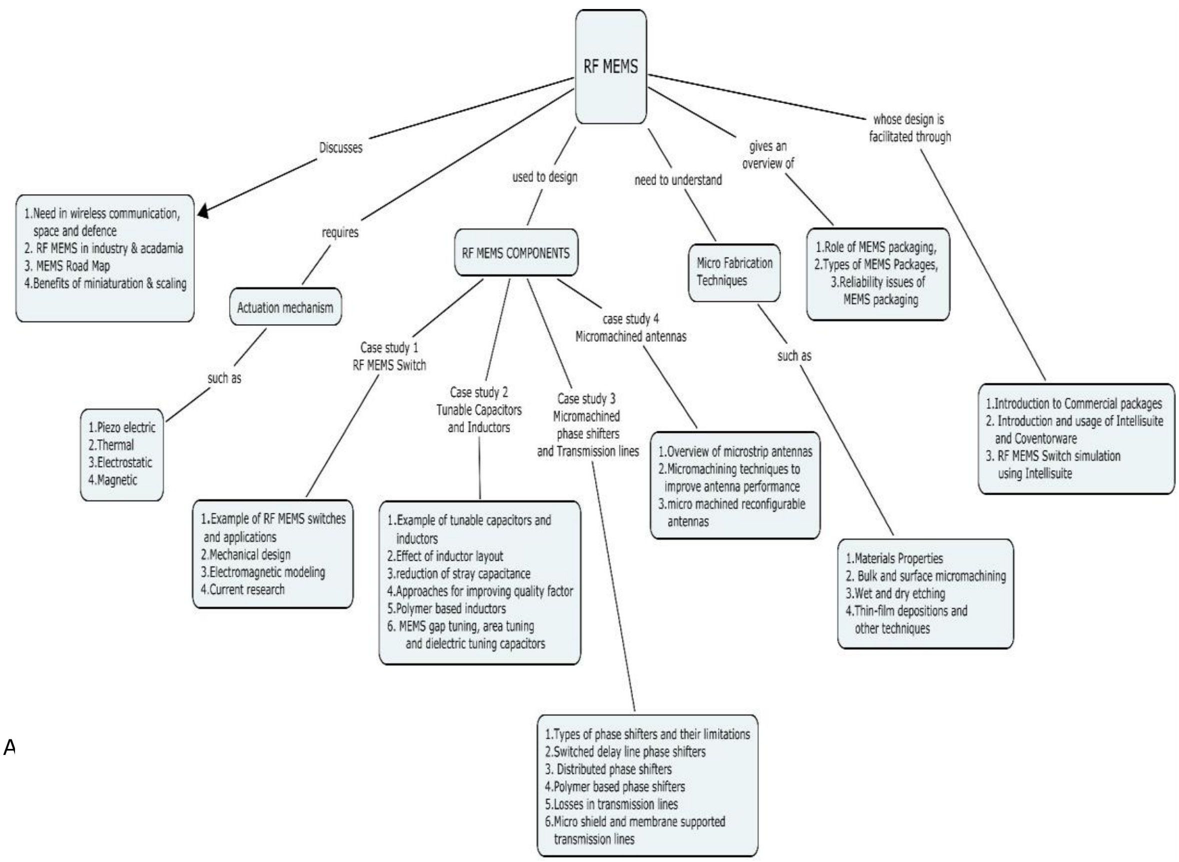
Course Outcome 4 (CO4):

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



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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:

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

14WTPK0	**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	0	0
Understand	40	40	20	20
Apply	40	40	40	40
Analyse	0	0	40	40
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):

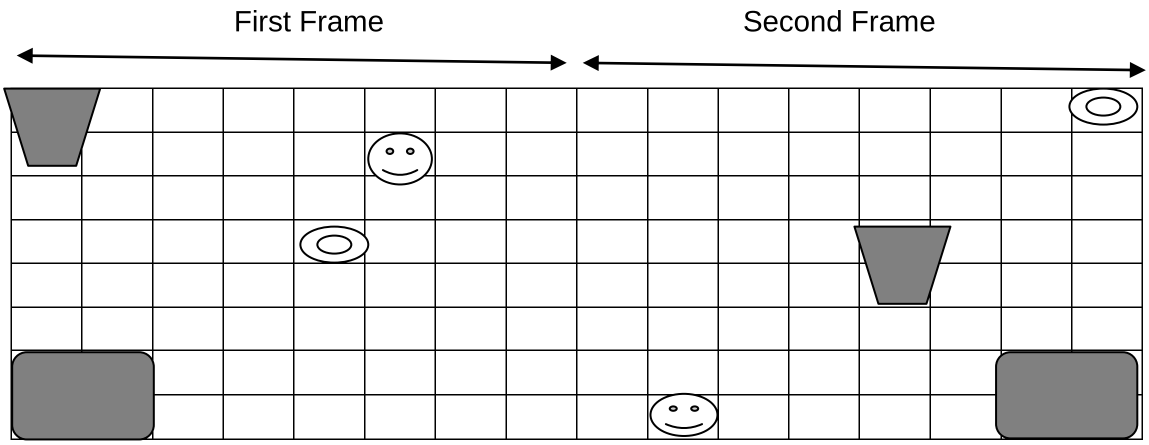
1. For the following colors in the RGB coordinate, determine their values in the YIQ and YUV coordinates, respectively.
   a. (1,1,1); (b) (0,1,0); (c) (1,1,0); (d) (0, 1,1).
2. How is video tracker applied to medical applications?
3. State different approaches for background subtraction
4. Design and 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.

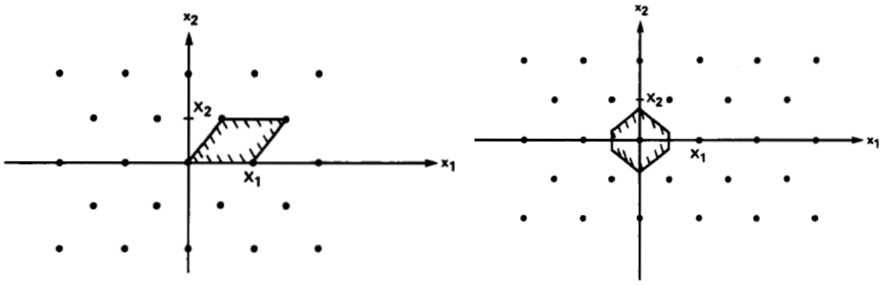
   ii) For the following frames, obtain the motion vector for the motion compensated prediction. Obtain the motion vector for the following four objects. Consider First 8X8 as Frame I and second 8X8 as Frame II.



Course Outcome 5 (CO5):

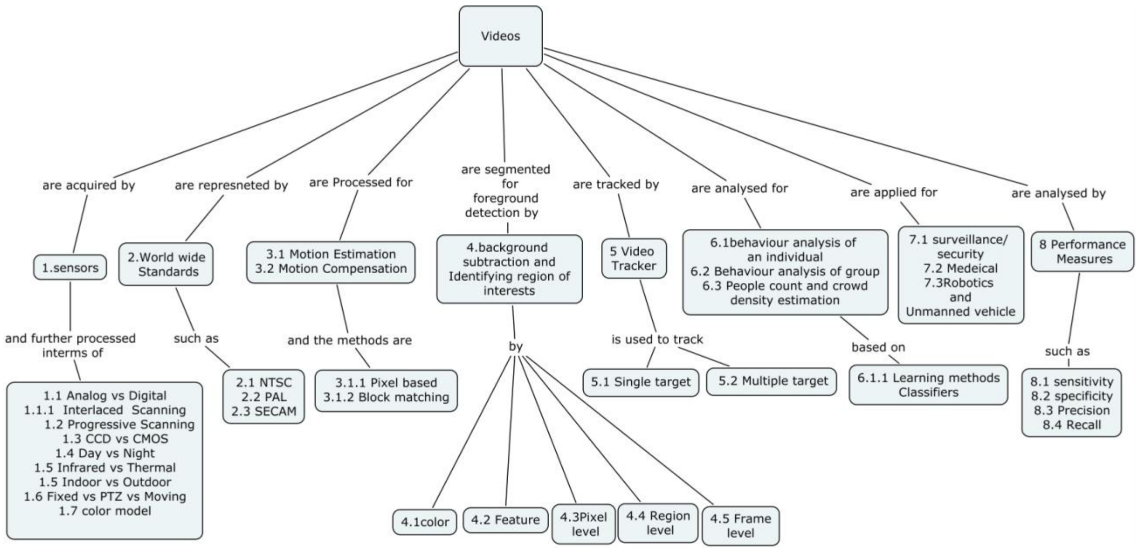
1. Design a video tracker for single target tracking and multiple target tracking. How will you overcome the challenges of a tracker?

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

14WTPL0	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	Analyze
CO2	Analyze the operation of the different version of SNMP protocol	Analyze
CO3	Implement the SNMP protocol through Remote Monitoring(RMON)	Apply
CO4	Manage the broadband network such as ATM and ADSL technologies	Evaluate
CO5	Configure different network management applications with NMS tools	Apply

Mapping with Programme Outcomes

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

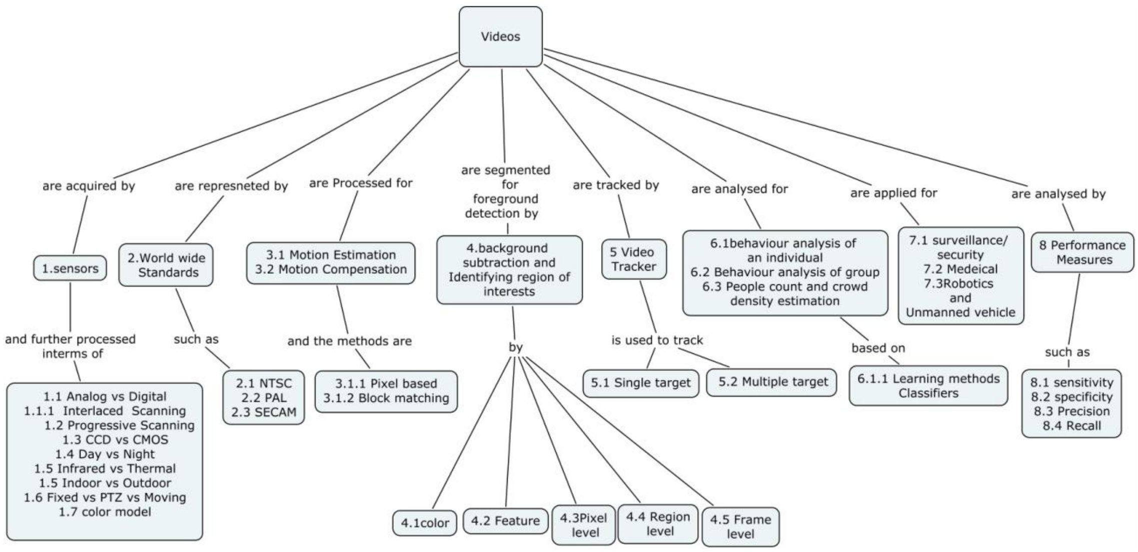
- Draw a two-tier management network that performs configuration and fault management.
- Explain the rational for your configuration.
- Compare the requirements if configuration is a three-tier configuration.

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

14WTPM0	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. Illustrate a VHDL/Verilog HDL program for FIR Filter using distributed arithmetic	Apply
CO3. Implement filter with pipelining and/or parallel processing.	Apply
CO4. Examine the different types of FFT algorithms including Cooley-Tukey, Winograd and Good-Thomas .	Analyze
CO5. Investigate FFT algorithms using Hardware Description languages	Analyze

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	10	10	0	0
Understand	40	20	30	20
Apply	50	50	50	50
Analyse	0	20	20	30
Evaluate	0	0	0	0
Create	0	0	0	0

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

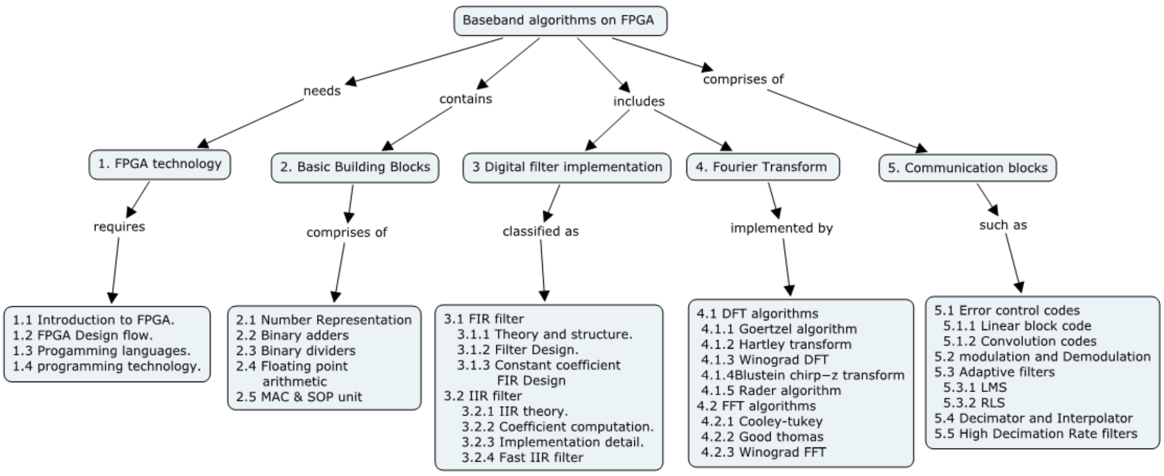
Course Outcome 2 (CO2):
1 Draw the design flow of FPGA
2 Convert the given decimal number 15 into equivalent optimal CSD
3 Explain the function of pipelined adder with neat diagram
4 Illustrate DA algorithm in VHDL coding
5 Explain in detail about the designing of FIR filter
6 Predict equivalent CSD 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 ≡ 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:

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14WTPN0	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. Apply the basic RF measurement procedure for transmission line, RF components and EMI/EMC	Apply
CO2. Apply the different measurement techniques and procedure	Apply
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. 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	20	10	0	0
Understand	40	30	40	40
Apply	40	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. 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.

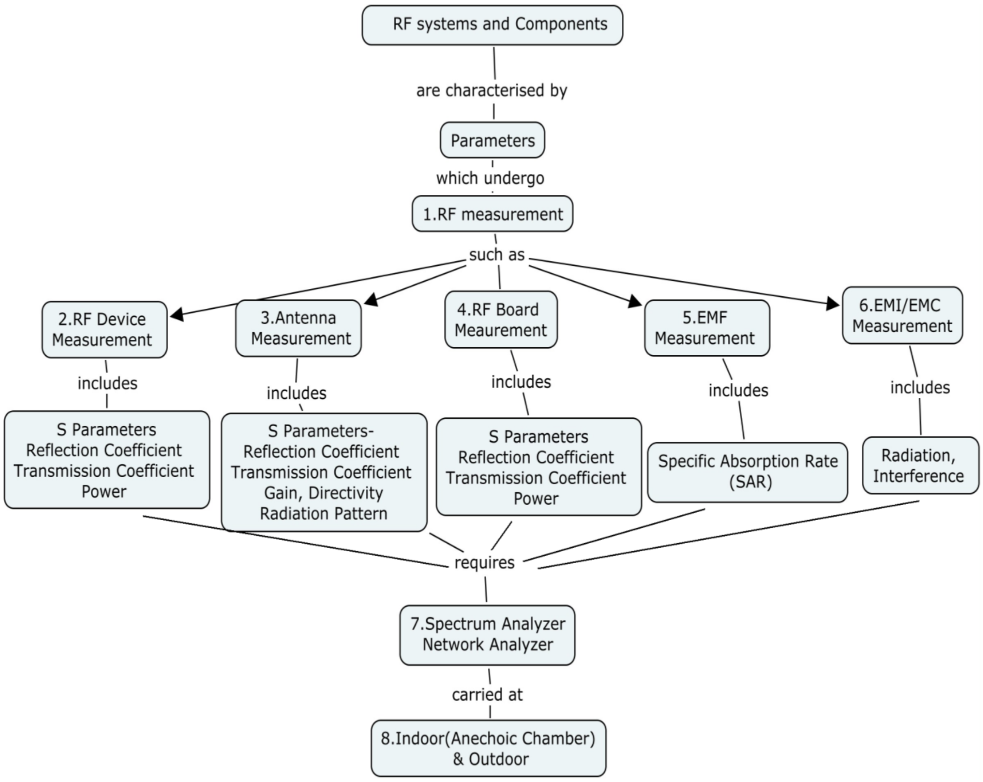
Course Outcome 3 (CO3):

1. What are the mandatory requirements for measuring far field pattern of an antenna?
2. What are the effects of electromagnetic interference?
3. Explain the working principle of Spectrum analyze.

Course Outcome 4 (CO4):

1. 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.
2. 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
3. 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.
4. 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.
5. 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:

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14WTPO0	CRYPTOGRAPHY WITH CODING THEORY

Category	L	T	P	Credit
PE	3	1	0	4

Preamble

Cryptography With Coding Theory is the discipline which studies the theoretical, practical and managerial aspects of cryptography from a mathematical point of view. The course will enable the students to familiarize the various aspects of cryptography: Overview of cryptography and its application; Basic number theory; Data Encryption Standard; Public key algorithm; Hash functions.

Prerequisite

Nil

Course Outcomes

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

CO1	Implement hash function for authentication	Apply
CO2	Use data encryption standards and advanced encryption standards	Apply
CO3	Analyse the public key algorithm	Analyze
CO4	Implement the security protocols	Apply
CO5	Configure different cryptographic application	Apply

Mapping with Programme Outcomes

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

S- Strong; M-Medium; L-Low

Assessment Pattern

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

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. What is meant by the term Hash function?
2. Define Diffie- Hellmen key exchange
3. List four general categories of schemes for the distribution of public keys
4. Differentiate IPsec and Websec
5. Define the term Non repudiation
6. What is the purpose of Dual signature?

Course Outcome 2 (CO2):

1. The ciphertext *UCR* was encrypted using the affine function 9x+2 mod 26.Find the plaintext
2. Encrypt *howareyou* using the affine function 5x+6 (mode 26).What is the decryption function? Check that it works.
3. The following ciphertext was encrypted by an affine cipher mod 26:*CRWWZ.* The plaintext starts *ha*. Decrypt the message.
4. Discuss about the web security threats and the methods used to overcome the threats
5. Discuss about firewall Design principles and its characteristics
6. Discuss in detail about different types of malicious programs

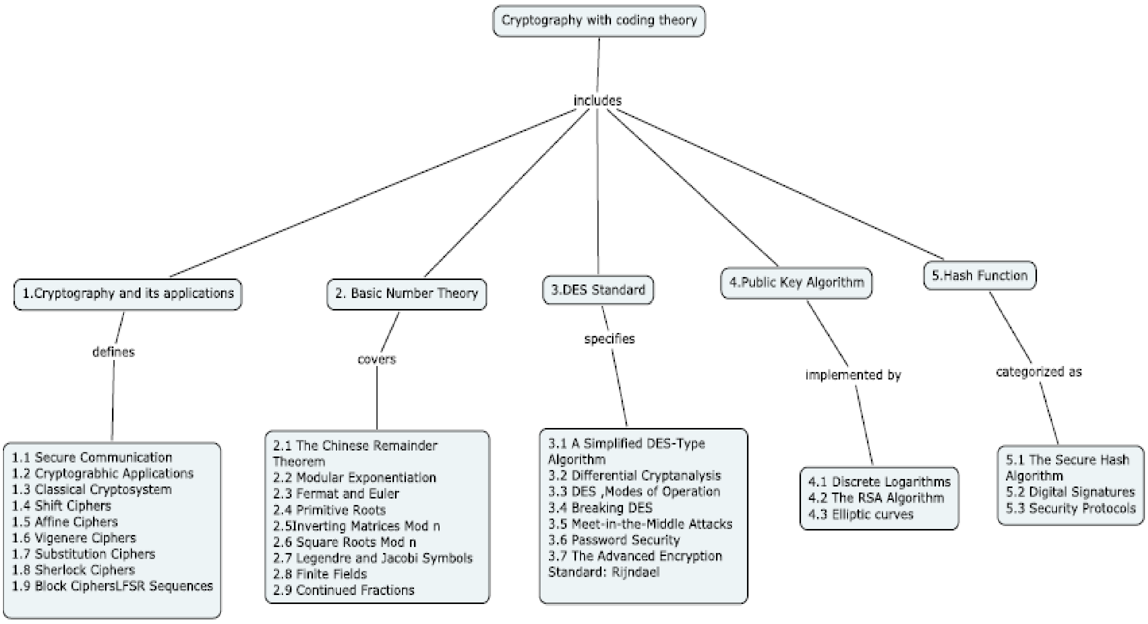
Course Outcome 3 (CO3):

1. Suppose you encrypt using an affine cipher, then encrypt the encryption using another affine cipher (both are working mod 26).Is there any advantage to doing this, rather than using a single affine cipher? Why or why not?
2. Suppose we work mod 27 instead of mod 26 for affine ciphers. How many keys are possible? What if we work mod 29?
    a. Find integers x and y such that 17x + 101y=1
    b. Find 17^{-1} (mod 101)
3. Use Euclidean algorithm to compute gcd (30030, 257). Using this result and the fact that 30030=2.3.5.7.11.13, show that 257 is prime. (Remark: This method of computing one gcd, rather than doing several trial divisions (by 2, 3, 5 ...), is often faster for checking whether small primes divide a number.)
4. Suppose x≡2 (mod 7) and x≡3 (mod 10).What is x congruent to mod 70?
5. The exponents e = 1 and e= 2 should not be used in RSA. Why?

Course Outcomes 4 and 5 (CO4 and CO5):

1. The cipher block chaining (CBC) mode has the property that it recovers from errors in ciphertext blocks. Show that if an error occurs in the transmission of a block C_j, but all the other blocks are transmitted correctly, then this affects only two blocks for decryption. Which two blocks?
2. Suppose the key for round 0 in AES consists of 128 bits, each of which is 0.
3. Why is gcd(*n, n+1*) for two consecutive integers *n* and *n + 1*?
4. The ciphertext 5859 was obtained from the RSA algorithm using *n* =11413 and *e* = 7467. Using the factorization 11413 = 101.113.find the plaintext.
5. Suppose you encrypt messages m by computing $c \equiv m^3$ (mod 101).How do you decrypt? (That is, you want a decryption exponent d such that $c^d \equiv m$ (mod 101); note that 101 is prime).
6. Suppose that there are two users on a network. Let their RSA moduli be n_1 and n_2, with n_1 not equal to n_2.If you are told that n1 and n_2 are not relatively prime, how would you break their system?

Concept Map



Syllabus

Overview of Cryptography And Its Applications –Secure Communications, Cryptographic Applications. **Classical Cryptosystems**: Shift Ciphers, Affine Ciphers , The Vigen`ere Cipher , Substitution Ciphers ,Sherlock Holmes ,The Play air and ADFGX Ciphers ,Block Ciphers , Binary Numbers and ASCII , One-Time Pads , Pseudo-random Bit Generation, LFSR Sequences. **Basic Number Theory -**Basic Notions ,Solving ax + by = d, Congruence's ,The Chinese Remainder Theorem, Modular Exponentiation, Fermat and Euler ,Primitive Roots ,Inverting Matrices Mod n , Square Roots Mod n , Legendre and Jacobi Symbols , Finite Fields ,Continued Fractions. **The Data Encryption Standard –** Introduction, A simplified DES –Type algorithm , Differential Cryptanalysis , DES Modes of Operation, Breaking DES, Meet-in-the-Middle Attacks ,Password Security, The Advanced Encryption Standard: Rijndael ,The Basic Algorithm ,The Layers , Decryption, Design Considerations. **Public Key Algorithm Discrete Logarithms-**Discrete Logarithms, Computing Discrete Logs, Bit Commitment Diffie-Hellman Key Exchange, The ElGamal Public Key Cryptosystem, The RSA Algorithm, Attacks on RSA, Primality Testing, Factoring, The RSA Challenge, An Application to Treaty Verification, The Public Key Concept, **Elliptic curves:** The addition law, Elliptic curves mod *p*, Factoring with elliptic curves, Elliptic curves in characteristic 2, Elliptic curve cryptosystems. **Hash Functions**-Hash Functions ,A Simple Hash Example ,The Secure Hash Algorithm , Birthday Attacks, Multicollisions ,The Random Oracle Model, Using Hash Functions to Encrypt , Computer Problems. **Digital Signatures**: RSA Signatures, The El Gamal Signature Scheme, Hashing and Signing, Birthday Attacks on Signatures, The Digital Signature Algorithm. Security Protocols: Intruders-in-the-Middle and Impostors, Key Distribution, Kerberos, Public Key Infrastructures (PKI), X.509 Certificates, Pretty Good Privacy, SSL and TLS, Secure Electronic Transaction.

Reference Books

1. Wade Trappe, Lawrence C. Washington, “Introduction to Cryptography with Coding Theory”, Pearson Education, Second Edition, 2006.
2. William Stallings, “Cryptography and Network Security”, Pearson Education, Second Edition, 2006.

Course Contents and Lecture Schedule

Module No.	Topics	No of Lectures
1	**Overview Of Cryptography And Its Applications**	
1.1	Secure Communications	1
1.2	Cryptographic Applications	1
1.3	Shift Ciphers,	1
1.4	Affine Ciphers	1
1.5	The Vigen`ere Cipher, Substitution Ciphers	1
1.6	Sherlock Holmes	1
1.7	The Play air and ADFGX Ciphers, Block Ciphers	1
1.8	Binary Numbers and ASCII	1
1.9	Pseudo-random Bit Generation and LFSR Sequences	1
2	**Basic Number Theory**	
2.1	Basic Notions ,Solving ax + by = d	1
2.2	The Chinese Remainder Theorem	1
2.3	Modular Exponentiation	1
2.4	Fermat and Euler	1
2.5	Primitive Roots	1
2.6	Inverting Matrices Mod n	1
2.7	Square Roots Mod n	1
2.8	Legendre and Jacobi Symbols	1
2.9	Finite Fields ,Continued Fractions	1
3	**The Data Encryption Standard**	
3.1	Introduction, A simplified DES-Type Algorithm	1
3.2	Modes of Operation	1
3.3	Breaking DES	1
3.4	Password Security	1
3.5	The Advanced Encryption Standard: Rijndael ,The Basic	1
3.6	The Layers , Decryption, Design Considerations	1
4	**Public Key Algorithm Discrete Logarithms**	
4.1	Discrete Logarithms, Computing Discrete Logs	1
4.1.1	Bit Commitment Diffie-Hellman Key Exchange	1
4.1.2	The ElGamal Public Key Cryptosystem	1
4.2	The RSA Algorithm-	1
4.2.1	An Application to Treaty Verification	1
4.3	Elliptic curves: The addition law	1
5	**Hash Functions**	
5.1	A Simple Hash Example ,The Secure Hash Algorithm	1
5.1.1	Birthday Attacks	1
5.1.2	Multicollisions	1
5.1.3	The Random Oracle Model	1

5.1.4	Using Hash Functions to Encrypt	1
5.2	**Digital Signatures**: RSA Signatures	1
5.2.1	The ElGamal Signature Scheme	1
5.2.2	Hashing and Signing	1
5.2.3	Birthday Attacks on Signatures	1
5.3	**Security Protocols**: Intruders-in-the-Middle and	1
5.3.1	Key Distribution	2
5.3.2	Pretty Good Privacy	2
5.3.3	Secure Electronic Transaction	1

Course Designers:

1. Dr.M.S.K. Manikandan manimsk@tce.edu

14WTPP0	APPLIED CRYPTOGRAPHY

Category	L	T	P	Credit
PE	3	1	0	4

Preamble

Applied Cryptography is the discipline which studies the theoretical, practical and managerial aspects of cryptography. The course will enable the students to familiarize the various aspects of cryptography: Overview of Cryptography; Key Parameters; Ciphers; Cryptographic Protocols; Implementation

Prerequisite

NIL

Course Outcomes

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

CO1	Describe the cipher concept	Understand
CO2	Configure different cryptographic protocol	Apply
CO3	Implement the different cryptographic schemes	Apply
CO4	Determine the role of secure routing protocols for different applications	Apply
CO5	Design a secure data communication network	Analyze

Mapping with Programme Outcomes

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

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	40	40	20	20
Apply	50	50	60	60
Analyse	0	0	20	20
Evaluate	0	0	0	0
Create	0	0	0	0

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. What are the principle elements of public key cryptosystem?
2. What is meant by the term Hash function?
3. What is the purpose of S-box in DES?
4. What is a primitive root of a function?
5. List SSL Record protocol services
6. What is digital immune system?

Course Outcome 2 (CO2):

1. Discuss the merits and Demerits of Double DES and Triple DES with its operation.
2. Explain in detail about MAC and Hash function
3. Elaborate key management operation in IPsec
4. Describe about the cryptographic protocols.
5. Discuss the various ciphers applied in cryptography
6. Elaborate the prime number generation.

Course Outcome 3 (CO3):

1. Let p be a prime and let α be an integer with $p \nmid \alpha$. Let h(x)= α^x (mod p).Explain why h(x) is not a good cryptographic hash function.
2. Show that if someone discovers the value of k used in the ElGamal signature scheme, then a can also be determined.
3. Compute the bits number 1,16,33, and 48 at the output of the first round of the DES encryption, assuming that the cipher text block is composed of all ones and external key is composed of all ones
4. Let K=111...111 be the DES key consisting of all 1s.Show that if E_K (P)=C, then $E_K(C)=P$, so encryption twice with this key returns the plaintext. Find another key with the same property as K in part (a).
5. Discuss Zero knowledge protocols with its properties.
6. Let p be a prime and let α be an integer with $p \nmid \alpha$. Let h(x)= α^x (mod p). Explain why h(x) is not a good cryptographic hash function.

Course Outcome 4 and 5(CO4 and CO5):

1. It can be shown that 5 is a primitive root for the prime 1223.You want to solve the discrete logarithm problem $5^x \equiv 3 \pmod{1223}$.Given that $3^{611} \equiv 1 \pmod{1223}$, determine whether *x* is odd or even.
2. Encrypt the given plaint text 1011 0111 using S –DES for IP=[2 6 3 1 4 8 5 7], k1=[10001111], k2=[11110000], $s_0 = \begin{pmatrix} 1 & 0 & 3 & 2 \\ 3 & 2 & 1 & 0 \\ 0 & 2 & 1 & 3 \\ 3 & 1 & 3 & 2 \end{pmatrix}$ $s_1 = \begin{pmatrix} 0 & 1 & 2 & 3 \\ 2 & 0 & 1 & 3 \\ 3 & 0 & 1 & 0 \\ 2 & 1 & 0 & 3 \end{pmatrix}$ and p_4=[2 4 3 1] and verify using decryption.
3. Encrypt the term "Network Security" using the Hill cipher with the key $k = \begin{bmatrix} 0 & 3 & 0 \\ 0 & 0 & 21 \\ 15 & 0 & 0 \end{bmatrix}$ such that $kk^{-1}=I$.
4. Discuss the demerits of S-DES and explain the motivation of feistel block cipher with its neat diagram.
5. It can be shown that 5 is a primitive root for the prime 1223.You want to solve the discrete logarithm problem $5^x \equiv 3 \pmod{1223}$.Given that $3^{611} \equiv 1 \pmod{1223}$, determine whether *x* is odd or even.
6. Consider a Diffie Hellmen scheme with a common prime q=11 and a primitive root alpha=2. Show that 2 is the primitive root of 11.
   a. If user A has public key Y_A=9,what is a A's private key $X_{A.}$
   b. If user B has public key Y_B=3,what is the shared secret key K

Syllabus

Overview Of Cryptography: Introduction – Information security and cryptography – Background on functions – Basic terminology and concepts – Symmetric-key encryption – Digital signatures – Authentication and identification – Public-key cryptography – Hash functions –Protocols and mechanisms – Key establishment, management, and certification – Pseudorandom numbers and sequences – Classes of attacks and security models. **Key Parameters:** Key length – Symmetric key length – Key management – Probabilistic primality tests – (True) Primality tests – Prime number generation – Irreducible polynomials over Zp – Generators and elements of high order. **Ciphers:** Stream ciphers – Feedback shift registers – Stream ciphers based on LFSRs – Other stream ciphers – Block ciphers – Background and general concepts – Classical ciphers and historical development – DES, FEAL, IDEA, SAFER, RC5. **Cryptographic Protocols:** Zero Knowledge Protocols – Basic definitions – Zero knowledge properties – Proof or Argument – Protocols with Two sided error – Round Efficiency – Non interactive Zero knowledge. **Implementation:** SEAL, RC5, IDEA, FEAL,SAFER – using API's.

Reference Books

1. Wenbo Mao, "Modern Cryptography", Pearson Education, 2007.
2. M. Bishop, "Computer Security – Art and Science", First Edition, Pearson Education, 2003.
3. Alfred J. Menezes, Paul C. van Oorschot and Scott A. Vanstone, "Hand book of Applied Cryptography" 5th Edition, 2001.

Course Contents and Lecture Schedule

Module No.	Topics	No of Lectures
1	**Overview of Cryptography**	
1.1	Introduction – Information security and cryptography	2
1.2	Background on functions	1
1.3	Basic terminology and concepts	1
1.4	Symmetric-key encryption	1
1.5	Digital signatures	1
1.6	Authentication and identification	1
1.7	Public-key cryptography	1
1.8	Hash functions	1
1.9	Protocols and mechanisms	1
1.10	Key establishment, management, and certification	2
1.11	Pseudorandom numbers and sequences	1
1.12	Classes of attacks and security models.	1
2	**Key Parameters**	
2.1	Key length	1
2.2	Symmetric key length	1
2.3	Key management	1
2.4	Probabilistic primality tests	1
2.5	(True) Primality tests	1
2.6	Prime number generation	1
2.7	Irreducible polynomials over Zp	1
2.8	Generators and elements of high order	2
3	**Ciphers**	
3.1	Stream ciphers	1

3.2	Feedback shift registers	1
3.3	Stream ciphers based on LFSRs	1
3.4	Other stream ciphers	1
3.5	Block ciphers	2
3.6	Background and general concepts	2
3.7	Classical ciphers and historical development	2
3.8	DES, FEAL, IDEA, SAFER, RC5	2
4	**Cryptographic Protocols**	
4.1	Zero Knowledge Protocols– Basic definitions	1
4.2	Zero knowledge properties	1
4.3	Proof or Argument	2
4.4	Protocols with Two sided error	1
4.5	Round Efficiency	1
4.6	Non interactive Zero knowledge	1
5	**Implementation**	
5.1	SEAL, RC5, IDEA, FEAL,SAFER – using API's	2

Course Designers:

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14WTPQ0	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

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
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	10	0	0	0
2	Understand	30	20	20	20
3	Apply	60	60	60	40
4	Analyze	0	20	20	40
5	Evaluate	0	0	0	0
6	Create	0	0	0	0

Course Level Assessment Questions

Course Outcome (CO1)

1. What is atmospheric window?
2. Define: spectral reflectance of earth surface features.
3. What is meant by geometric correction?
4. Write the law's 2D masks to ridges and waves.

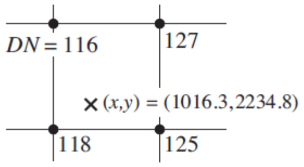
5. What is meant by Scale space fusion?
6. Explain the terms; Fractal dimension, Lacunarity.
7. What are different types of Vegetation Indexes?

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

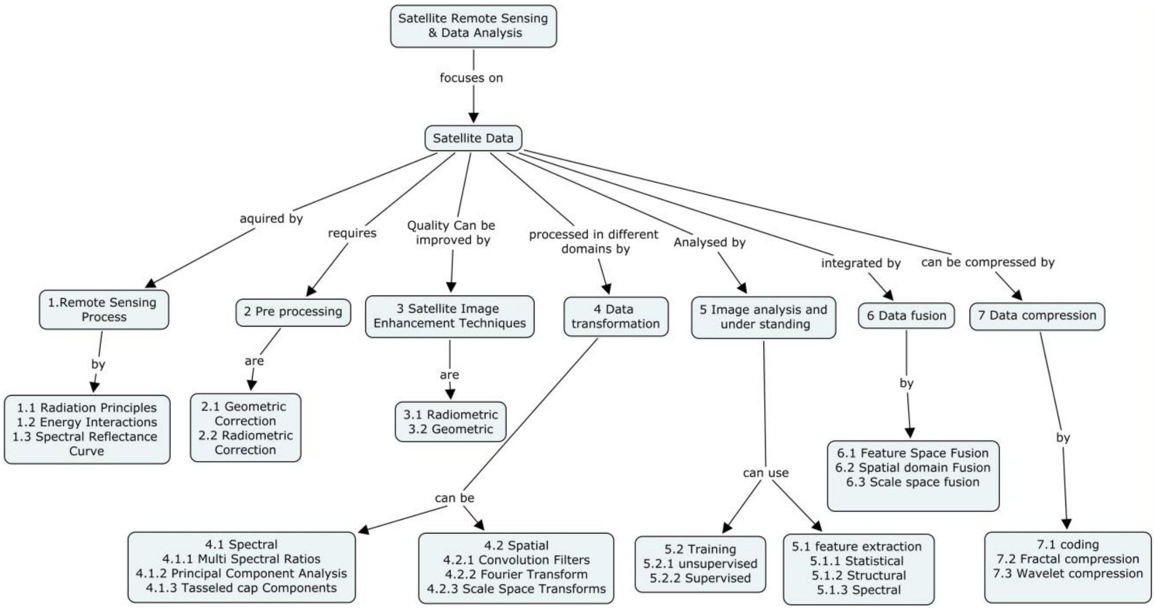
Draw the histogram corresponding to these grey levels, and then perform histogram equalization and draw the resulting histogram.

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

No.	Topic	No. of Lectures
1.3	EMR interactions with-atmosphere-earth surface features	2
2.	**Satellite Data**	
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:

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14WTPR0	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	Analyze
CO2. Design of Analog CMOS Subcircuits including MOS Switch, Current sinks and Sources, Current Mirrors.	Apply
CO3. Design of CMOS Single Stage Amplifiers including Differential Amplifiers, Cascode Amplifiers and Inverters	Apply
CO4. Design of CMOS Operational Amplifiers considering Power Supply rejection ratio and noise.	Analyze
CO5. Design of CMOS Analog circuits including open loop comparator and Digital- Analog Converters.	Analyze

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
1.	S	M	M	M	L	-	-	L	L	L	L
2.	S	S	M	L	L	-	-	L	L	L	L
3.	S	S	M	L	L	-	-	L	L	L	L
4.	S	S	S	M	L	-	-	L	M	M	L
5.	S	M	S	M	L	-	-	M	M	M	L

S- Strong; M-Medium; L-Low

Assessment Pattern

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

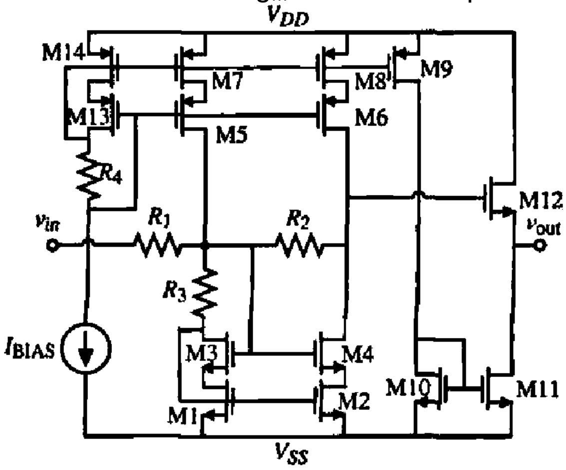
Course Level Assessment Questions

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):

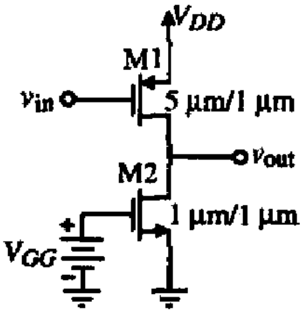
1. If the mobility of an electron is 500cm^2/(V-s) and the mobility of the hole is 200cm^2/(V-s). Compare the performance of an n-channel with a p-channel transistor. In particular, consider the value of the transconductance parameter and speed of the MOS transistor.
2. Using small signal analysis, design the output impedance of a MOS cascode current mirror. Include in your analysis the voltage –dependent current source that models the body effect.
3. Design Analog CMOS subcircuits including MOS Switch, MOS Diode/Active Resistor, Current Sinks and Sources, Current Mirrors, Bandgap Reference, Current and Voltage References.
4. 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.
5. 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.



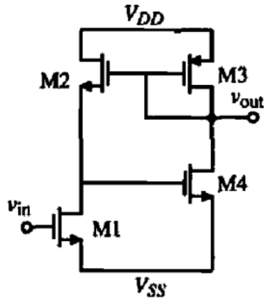
Course Outcome 3 (CO3):

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.

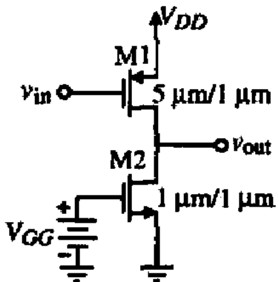
2. A CMOS amplifier is shown in figure. Assume M1 and M2 operate in the saturation region.

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

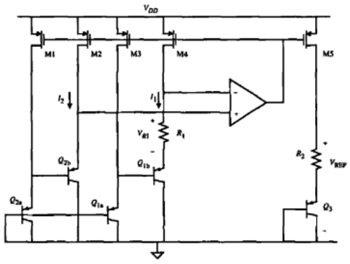
   (b) What is the dc value of V_{IN}?

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

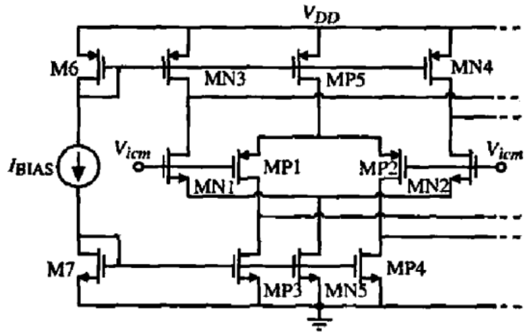
   (d) What is the -3dB frequency in hertz of this amplifier if Cgd1=Cgd2=5fF, Cbd1=Cbd2=30fF and C_L=500fF?



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.



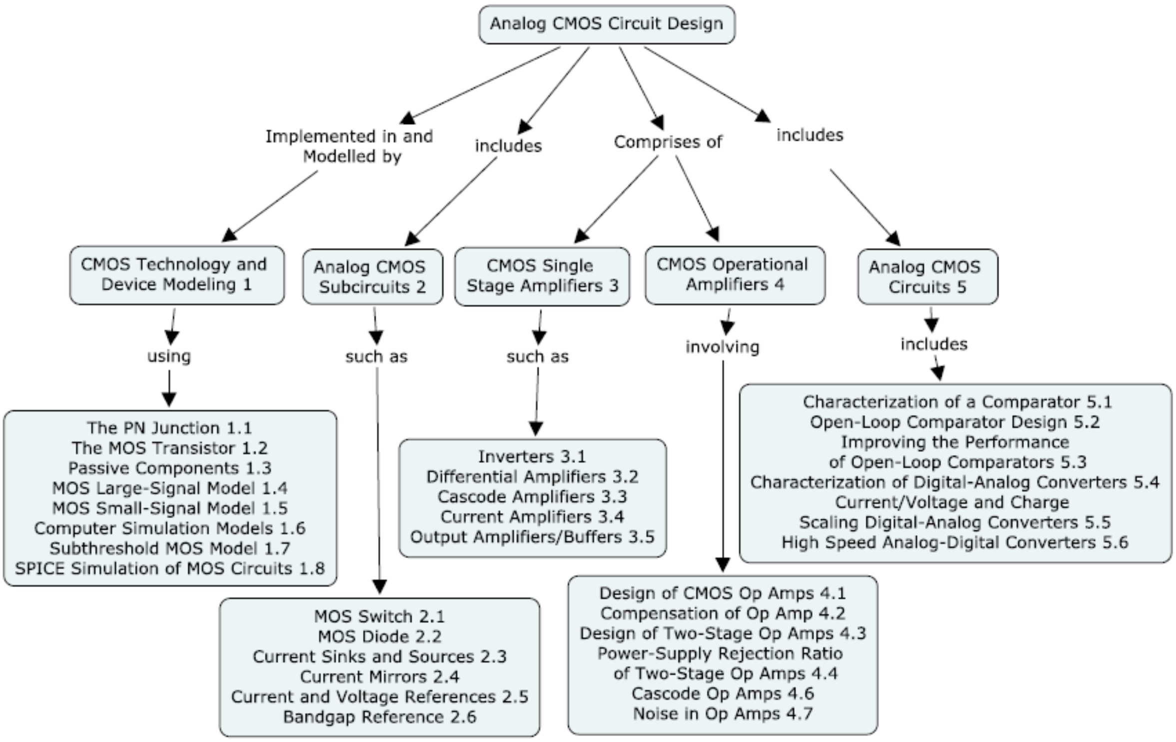
4. Find the value of V_{onn} and V_{onp} of the following figure. If the W and L values of all transistors are 10 µm and 1 µm, respectively, and the bias current in MN5 and MP5 are 100 µA each.



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

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