CURRICULUM AND DETAILED SYLLABI

FOR

M.E. DEGREE (Wireless Technologies) PROGRAM

FOR THE STUDENTS ADMITTED FROM THE

ACADEMIC YEAR 2011-2012 ONWARDS

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

MADURAI – 625 015, TAMILNADU

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

Approved in BoS Meeting 27.08.2011 Approved in 43rd Academic Council Meeting 12.11.2011

Thiagarajar College of Engineering, Madurai-625015

Department of Electronics and Communication Engineering

Scheduling of Courses

Semester	Courses						Laboratory/ Project
4th (12)							WT41 Project 0:12
3rd (16)	WT31 Modeling and Simulation of Wireless Systems 3:1	WT3X Elective IV 3:1	WT3X Elective V 3:1				WT34 Project 0:4
2nd (24)	WT21 Space Time Wireless Communications 3:1	WT22 Wireless Network Security 3:1	WT23 RF Active Circuits for Wireless Systems 3:0	WT2X Elective I 3:1	WT2X Elective II 3:1	WT2X Elective III 3:1	WT27 RF Systems Laboratory 0:1
1st (24)	WT11 Linear Algebra and Optimization 3:1	WT12 Baseband Wireless Communications 3:1	WT13 Wireless Adhoc and Sensor Networks 3:0	WT14 RF Passive Circuits for Wireless Systems 3:1	WT15 Multimedia Compression Techniques 3:1	WT16 Digital Logic Design with HDL 3:1	WT17 Communication Network Laboratory 0:1

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

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015
(An Autonomous Institution Affiliated to Anna University)
CURRICULUM
(For the Students admitted from the academic year 2011- 2012)

Name of the Degree: ME (Wireless Technologies)

SUBJECTS OF STUDY

I SEMESTER

Theory:

Sub. Code	Name of the subject	Regulation			
		L	T	P	C
WT11	Linear Algebra and Optimization	3	1	0	4
WT12	Baseband Wireless Communications	3	1	0	4
WT13	Wireless Adhoc and Sensor Networks	3	0	0	3
WT14	RF Passive Circuits for Wireless Systems	3	1	0	4
WT15	Multimedia Compression Techniques	3	1	0	4
WT16	Digital Logic Design with VHDL	3	1	0	4

Practical

WT17	Communication Network Lab	0	0	3	1

Total Credits 24

II SEMESTER

Theory:

Sub. Code	Name of the subject	Regulation			
		L	T	P	C
WT21	Space Time Wireless Communications	3	1	0	4
WT22	Wireless Network Security	3	1	0	4
WT23	RF Active Circuits for Wireless Systems	3	0	0	3
WT2X	Elective I	3	1	0	4
WT2X	Elective II	3	1	0	4
WT2X	Elective III	3	1	0	4

Practical

WT27	Seminar/Lab	0	0	3	1

Total Credits 24

List of Electives:

WT2A Antennas for Wireless Applications
WT2B Radar Signal Processing
WT2C Multimedia Communication Systems
WT2D High Performance Wireless Networks
WT2E Real Time Embedded Systems
WT2F CMOS ASIC Design
WT2G Adaptive Signal Processing
WT2H Radio Frequency Integrated Circuits
WT2J Analog CMOS Circuit Design
WT2K Estimation and Detection Algorithms
WT2L Satellite Remote Sensing and Data Analysis
WT2M Computer Vision

III SEMESTER

Theory:

Sub. Code	Name of the subject	Regulation			
		L	T	P	C
WT31	Modeling and Simulation of Communication Systems	3	1	0	4
WT3X	Elective – IV	3	1	0	4
WT3X	Elective – V	3	1	0	4

Practical

WT34	Project I	0	0	12	4

Total Credits 16

List of Electives:

WT3A MIMO OFDM Systems
WT3B Physical Layer LTE Systems
WT3C RF MEMS
WT3D Video Surveillance Systems
WT3E Network Management
WT3F Baseband Algorithms on FPGA
WT3G RF Test and Measurement
WT3H Cryptography with Coding Theory
WT3J Applied Cryptography

IV Semester:

Practical:

Sub. Code	Name of the subject	Regulation			
		L	T	P	C
WT41	Project II	0	0	36	12

Total Credits 12

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

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015
M.E Degree (Wireless Technologies) Program
SCHEME OF EXAMINATIONS
(For the candidates admitted from 2011-2012 onwards)

I Semester

S.No	Sub. Code	Name of the subject	Duration of Terminal Exam. in Hrs.	Marks			Minimum Marks for Pass	
				Continuous Assessment	Terminal Exam	Max. Marks	Terminal Exam	Total
THEORY								
1	WT11	Linear Algebra and Optimization	3	50	50	100	25	50
2	WT12	Baseband Wireless Communications	3	50	50	100	25	50
3	WT13	Wireless Adhoc and Sensor Networks	3	50	50	100	25	50
4	WT14	RF Passive Circuits for Wireless Systems	3	50	50	100	25	50
5	WT15	Multimedia Compression Techniques	3	50	50	100	25	50
6	WT16	Digital Logic Design with HDL	3	50	50	100	25	50
PRACTICAL								
7	WT17	Communication Network Lab	3	50	50	100	25	50

II Semester

S.No	Sub. Code	Name of the subject	Duration of Terminal Exam. in Hrs.	Marks			Minimum Marks for Pass	
				Continuous Assessment	Terminal Exam	Max. Marks	Terminal Exam	Total
THEORY								
1	WT21	Space Time Wireless Communications	3	50	50	100	25	50
2	WT22	Wireless Network Security	3	50	50	100	25	50
3	WT23	RF Active Circuits for Wireless Systems	3	50	50	100	25	50
4	WT2X	Elective I	3	50	50	100	25	50
5	WT2X	Elective II	3	50	50	100	25	50
6	WT2X	Elective III	3	50	50	100	25	50
PRACTICAL								
7	WT27	Seminar/Lab	3	50	50	100	25	50

III Semester

S.No	Sub. Code	Name of the subject	Duration of Terminal Exam. in Hrs.	Marks			Minimum Marks for Pass	
				Continuous Assessment	Terminal Exam	Max. Marks	Terminal Exam	Total
THEORY								
1	WT31	Modeling and Simulation of Communication Systems	3	50	50	100	25	50
2	WT3X	Elective – V	3	50	50	100	25	50
3	WT3X	Elective – VI	3	50	50	100	25	50
PRACTICAL								
4	WT34	Project I	-	150	150	300	75	150

IV Semester

S.No	Sub. Code	Name of the subject	Duration of Terminal Exam. in Hrs.	Marks			Minimum Marks for Pass	
				Continuous Assessment	Terminal Exam*	Max. Marks	Terminal Exam	Total
PRACTICAL								
1	WT41	Project II	-	150	150	300	75	150

CURRICULUM AND DETAILED SYLLABI

FOR

M.E. DEGREE (Wireless Technologies) PROGRAM

FIRST SEMESTER

FOR THE STUDENTS ADMITTED FROM THE

ACADEMIC YEAR 2011-2012 ONWARDS

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Sub code	Lectures	Tutorial	Practical	Credit
WT11	3	1	-	4

WT11 Linear Algebra and Optimization 3:1

(Common with N11 Linear Algebra and Optimization)

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.

Competencies

At the end of the course the student should be able to

1. Determine the dimension of vector space.
2. Predict orthonormal basis.
3. Perform diagonalization of a given matrix. .
4. Apply linear programming techniques to optimize problems arising in communication engineering.
5. Determine the optimum values of non-linear programming problems using Kuhn tucker conditions, elimination method.
6. Determine the optimum values of non-linear programming problems using search methods.

Assessment Pattern

	Bloom's category	Test 1	Test 2	Test 3 / End Semester Examinations
1	Remember	10	10	0
2	Understand	30	30	30
3	Apply	60	60	70
4	Analyze	0	0	0
5	Evaluate	0	0	0
6	Create	0	0	0

Course level learning objectives:

Remember

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

Understand

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

Apply

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

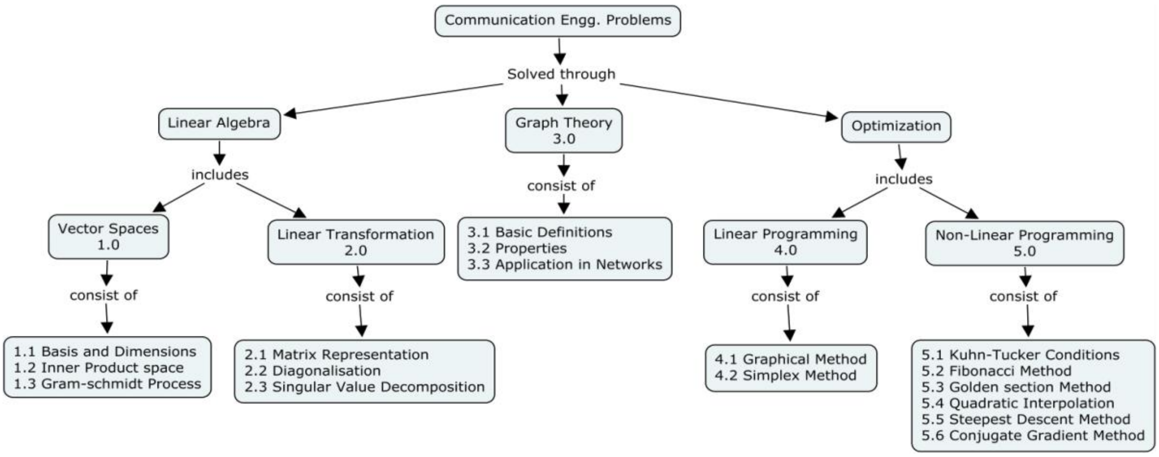
x	-1	0	1	2
y	0	1	3	9

3. Consider the vector space $C[-1,\ 1]$ with inner product defined by $< f, g >= \int_{-1}^{1} f(x)g(x)dx$ Calculate ortho normal 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.

5. Calculate the minimum of $f = \lambda^5 - 5\lambda^3 - 20\lambda + 5$, using Quadratic interpolation 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. **Nonliear 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 content and Lecture Schedule:

Sl No	Topics	No. of Periods
	UNIT-I	
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
	Unit-II	
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
	Unit-III	
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
	Unit-IV	
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
	Unit-V	
28	NLP (Unconstrained, multi dimension) Direct search methods:	2
29	Pattern search method	2
30	Steepest descent	3
31	Conjugate gradient method	3

Total number of Hours **50Hours**

Course Designers:

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

Sub Code	Lectures	Tutorial	Practical	Credit
WT12	3	1	-	4

WT12 Baseband Wireless Communications 3:1

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.

Competencies: At the end of the course, a student will be able to

1. Apply the theory of probability and stochastic processes in the design of Baseband wireless communication systems.
2. Describe and determine the performance of different error control coding. schemes for the reliable transmission of digital information over the channel.
3. Describe a mathematical model of digital communication system, to provide a frame work for the bit error rate (BER) analysis.
4. Determine the capacity, and bit error rate for a given digital modulation scheme of wireless communication system in AWGN
5. Characterize the wireless Channel in terms of large scale path loss and fading
6. Characterize the rapid fluctuations of wireless Channel in terms of small scale fading and multipath parameters
7. Determine the capacity, and bit error rate for a given digital modulation scheme of wireless communication system in Reyleigh fading and frequency selective fading environments
8. Architect a wireless communication system as per given specifications.

Assessment Pattern

	Bloom's Category	Test 1	Test 2	End-semester examination
1	Remember	20	20	10
2	Understand	20	20	20
3	Apply	60	60	70
4	Analyze	0	0	0
5	Evaluate	0	0	0
6	Create	0	0	0

Course level Learning Objectives

Remember:

1. Define slow and fast fading.
2. Define coherence bandwidth and delay spread.
3. List the parameters that are used to define the multipath channel?
4. List the different types of small scale fading.
5. Define the term co channel interference and adjacent channel interference.
6. What are the re-use factors for the wireless standards namely AMPS, GSM and IS-95 systems?
7. Define outage capacity.
8. Draw the block diagram of forward CDMA channel modulation process IS-95 system. Describe each block in it.

Understand:

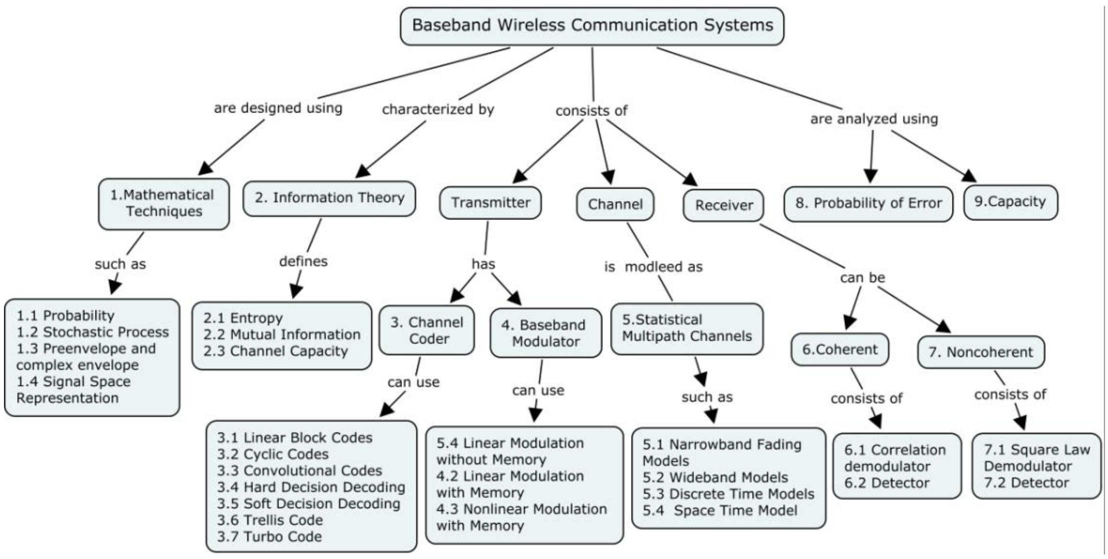
1. Distinguish between flat fading and frequency selective fading.
2. A Wireless channel has a multipath spread of 1msec. The total channel bandwidth at bandpass available for signal transmission is 5KHz. Determine the coherence bandwidth. Is the channel frequency selective? Justify.
3. Differentiate between soft and hard handoffs.
4. Distinguish between the power limited region and bandwidth limited region in the bandwidth Vs capacity curve?
5. When the demand for wireless service increases, how is it possible to provide more channels per unit coverage area?
6. Consider an AWGN Channel with bandwidth 50MHz, received power 10mwatts, and noise power spectral density $N_0 = 2 \times 10^{-9}$ W/Hz.How much does capacity increase by doubling the received power? How much does capacity increase by doubling the channel bandwidth?
7. What is the maximum bit rate that can be sent through the channel with out needing an equalizer, if the RMS delay spread is $0.5\mu s$

8. 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?

Apply:

1. Calculate Brewster angle for a wave impinging on ground having permittivity of $\varepsilon_r = 5$
2. Find the capacity of AWGN Channel has a bandwidth of 1MHz,signal power is 10watts and noise spectral density is 10^{-9}Watts/Hz.
3. 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.
4. Find the far field distance for an antenna with maximum distance of 0.5M and operating frequency of 900MHz.
5. In a digital cellular equalizer if f=800MHz and the mobile velocity V=90Km/Hr determine the maximum number of symbols that could be transmitted without updating the equalizer assuming a symbol rate of 25.3symbols/sec.
6. Assume four branch diversity is used where each branch receives an independent Rayleigh fading signal. If the average SNR is 20 dB determine the probability that it will drop below 5dB. If the receiver is without diversity what will be the case.
7. 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.
8. 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.

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, " Wireless 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

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

No.	Topic	No. of Lectures
3.7	Turbo Code	1
4	**Statistical Multipath Channel Models**	
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
	Total	50

Course Designers

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

Sub Code	Lectures	Tutorial	Practical	Credit
WT13	3	-	--	3

WT13 Wireless Ad-Hoc and Sensor Networks 3:0

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.

Competencies: At the end of the course, the student will be able to

1. Identify the requirements and issues of ad hoc networks
2. Analyze the MAC issues in ad hoc and sensor networks
3. Describe the need and implementation of power control
4. Classify and describe the operation of the routing and localization
5. Design sensor network for indoor applications
6. Describe the QoS Guarantees in wireless sensor networks
7. Analyze Self configuration and Auto configuration in Mesh networks
8. Identify the necessity of heterogeneous and vehicular Mesh networks

Assessment Pattern

	Bloom's Category	Test 1	Test 2	Test 3/End-semester examination
1	Remember	0	0	0
2	Understand	50	40	30
3	Apply	40	40	40
4	Analyze	10	20	30
5	Evaluate	0	0	0
6	Create	0	0	0

Course Level Learning Objectives

Understand

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?
6. Identify the advantages and limitations of routing protocol that uses GPS information for an ad hoc wireless network for search and rescue operations.

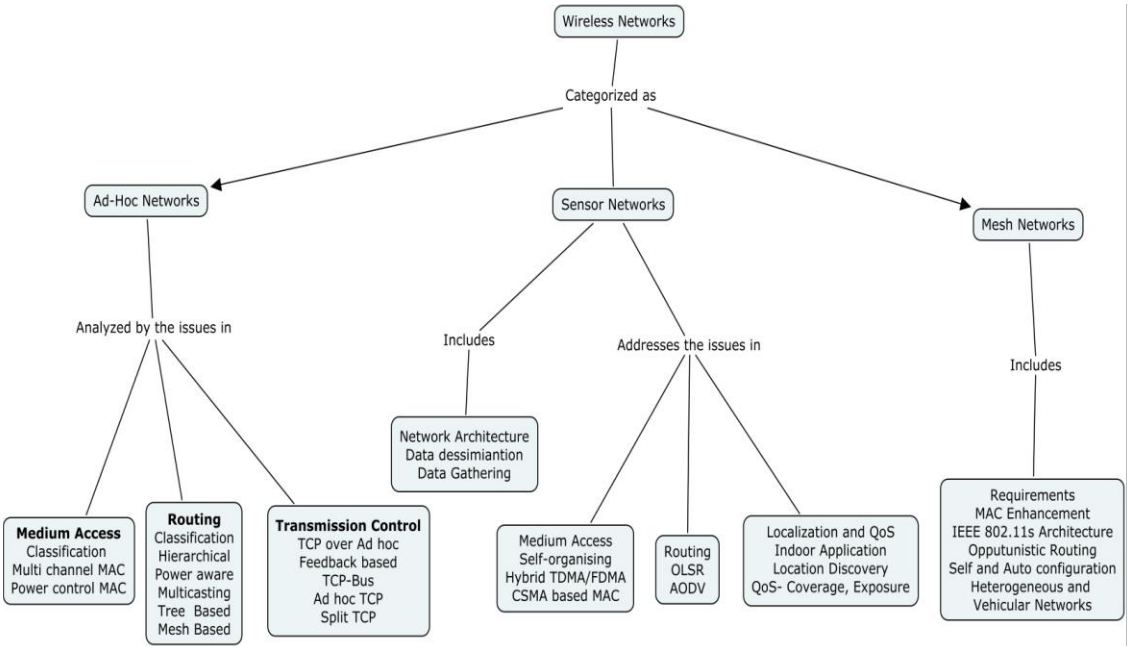
Apply

1. Give application scenarios where contention-based, reservation-based and packet scheduling-based MAC protocols can be used.
2. 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.
3. For the given topology, find the zone link state packets for the various zones marked.
4. 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.
5. Find out the probability of a path break for an eight-hop path, given that the probability of a link break is .2.
6. 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?

Analyze

1. 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.
2. Analyze the effect of the carrier sensing zone of a transmission on the performance of a MAC protocol.
3. Determine the back-off calculation mechanism used in DWOP. Is it guaranteed to be accurate at all times? If not, explain why?
4. Channel quality estimation can be done both at the sender and receiver. Which is more advantageous? Why?
5. 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?
6. 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?

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:

No.	Topics	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:

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

Sub Code	Lectures	Tutorial	Practical	Credit
WT14	3	1	--	4

WT14 RF Passive Circuits for Wireless Systems 3:1

Preamble: The course is aimed at providing knowledge in the fundamentals of RF passive circuits and RF front-end design. 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.

Competencies: At the end of the course, the student should able to

1. Understand the fundamentals of RF passive elements and transmission lines.
2. Understand the basic building blocks of RF transceiver system and how to evaluate its performance.
3. Explain the impedance mismatch effects in RF system and various techniques to circumvent impedance mismatch effects.
4. Obtain the equivalent circuit model of passive components at high frequencies.
5. Design and simulate of microwave filters and different resonator circuits.
6. Synthesize, Analyze and Optimization of RF passive circuits using CAD tools.

Assessment Pattern

	Bloom's Category	Test 1	Test 2	Test3/End-semester Examination
1	Remember	20	20	20
2	Understand	40	20	30
3	Apply	20	40	30
4	Analyze	0	0	0
5	Evaluate	0	0	0
6	Create	20	20	20

Course Level Learning Objectives:

Remember

1. What is the difference between return loss and mismatch loss?
2. Define: Jitter
3. What are the effects of automatic gain control system?
4. Mention the ways to reduce the spurious responses?

5. Define: Skin depth.
6. Write the expression for inductance of solenoidal coils.

Understand

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. State the significance of Eye-Diagram.
3. How can you calculate spurious free dynamic range of RF front end?
4. A signal has an SNR of 20dB. How much can the SNR decrease if the bandwidth is doubled, assuming the same information throughput?
5. How multisection impedance matching is used to reduce the transmission bandwidth?
6. Assume, a transmission line connects a source Zs=Rs+jXs Ω to the load Zl=Rl+jXl. Write the equations for line impedance Ztl and electrical length θ.
7. Find the skin depth of the copper wire at 1GHz. Assume, the conductivity of copper is 5.8e7 s/m.
8. Compute the self-inductance and inductive reactance of 1cm copper wire, whose diameter is 0.0406cm.

Apply

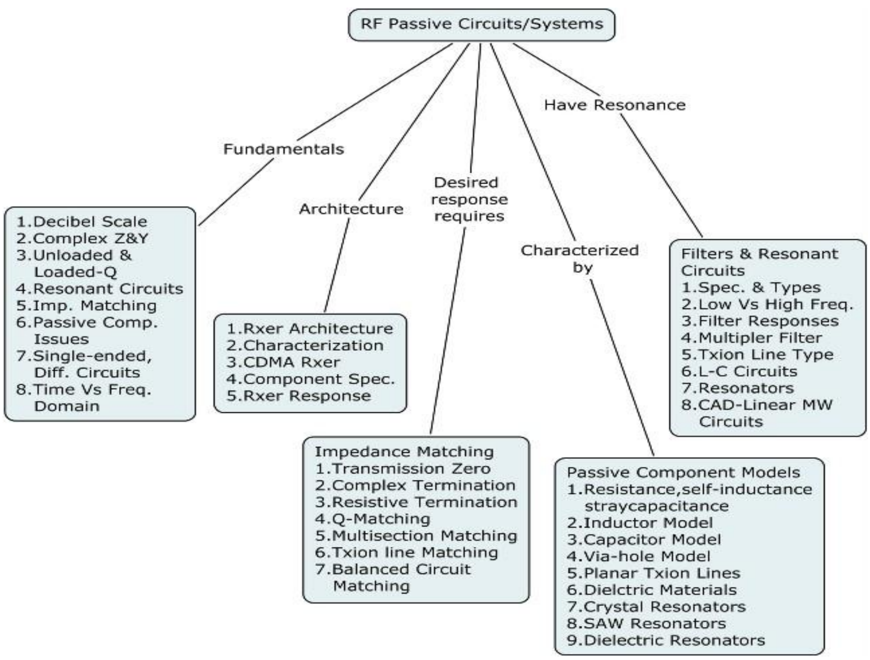
1. The power output (Pt) transmitted from a cellular phone is +30DBm. At the receiver the signal power (Pr) is down to 5pW. What is the attenuation A(dB) of the signal path between the transmitter and receiver?
2. How can you determine the dynamic range of the receiver?
3. Distinguish the differences 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.
6. How can you convert a lowpass prototype to highpass and bandpass filters?
7. Distinguish between impedance mapping and component tuning.
8. When will you apply analysis/synthesis method to specific RF circuit design?

Create

1. When measuring the output power of a high power amplifier, we have a 36dB attenuator connected between the amplifier and the power meter. When the power meter's reading is 0.5W, what is the actual power at the output of the amplifier?

2. The two ideal lumped elements of a resonant circuit are C=3.16pF & L=2nH. Find their electrical equivalent open and shorted stubs at 2GHz, using characteristic impedances of Zos=Zss=50 Ω for both stubs.
3. What is the theoretical maximum transmission capacity down a down a plain old telephone system line, for which the signal to noise ratio is 30 dB? Such a line has its bandwidth restricted to 3.4 kHz.
4. 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.
5. 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.
6. 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.
7. 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.
8. 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.

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 Lectures schedule

No.	Topics	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, Multiplexer filters	3
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
	Total	45

Course Designers:

1. S.Raju hodece@tce.edu
2. K.Vasudevan kvasudevan@tce.edu

Sub. Code	Lecture	Tutorial	Practice	Credit
WT15	3	1	-	4

WT15 Multimedia Compression Techniques 3:1

Preamble:

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

Prerequisite: 1D, 2D Signal Processing and transforms.

Competencies: At the end of the course, the student will be able to

1. Describe and determine the performance of different coding techniques for the generation of a digital representation of the multimedia data.
2. Describe and determine the performance of different coding Schemes for the reliable transmission of digital multimedia data.
3. Describe and determine the performance of various dictionary techniques on File compression
4. Describe a mathematical model of Vocoder, to provide a frame work speech compression.
5. Characterize the influence of transform coding techniques on image and audio compression.
6. Determine the performance of different video compression schemes.

Tools

MATLAB.

Assessment Pattern

	Bloom's Category	Test 1	Test 2	Test3/End Semester Examination
1	Remember	10	0	0
2	Understand	30	20	20
3	Apply	60	60	60
4	Analysis	0	10	10
5	Evaluate	0	10	10
6	Create	0	0	0

Course level learning Objectives

Remember

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.

Understand

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. 3. Write a program for encoding image using rice code with all options split sample = 5, j = 16. For prediction (previous value).

Apply

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

Analysis

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.
4. Provide comparison of facsimile coding algorithms.

Evaluate

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

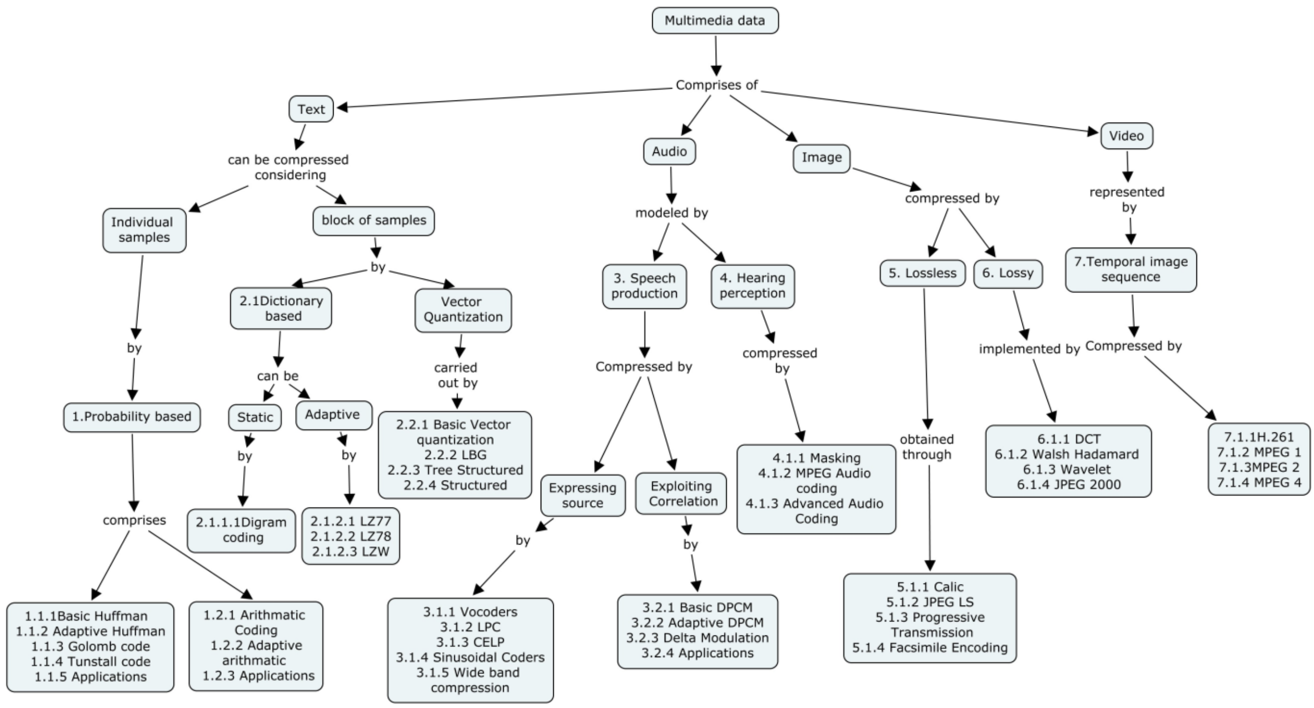
   P (a1) = 0.1, P (a2) = 0.3, P (a3) = 0.25, P (a4) = 0.35

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

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

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

No.	Topic	No. of Lectures
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
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
	Total Hours	**42**

Course Designers

1. S.Md.Mansoor roomi, smmroomi@tce.edu
2. B.Sathya Bama sbece@tce.edu

Sub code	Lectures	Tutorial	Practical	Credit
WT16	3	1	-	4

WT16 Digital Logic Design with VHDL 3:1

Preamble:

The course 'WT16: 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.

Competencies:

At the end of the course, the student should be able to

1. Describe the Combinational and sequential building blocks with VHDL.
2. Understand the need for testing and the strategies to generate test vectors.
3. Design combinational logic circuits for a given specification
4. Design optimal synchronous/asynchronous sequential logic circuits for a given requirements.
5. Validate the digital systems, designed for given specifications, by generating test vectors.

Assessment Pattern:

	Bloom's Category	Test 1	Test 2	End-semester examination
1	Remember	20	10	10
2	Understand	30	10	10
3	Apply	30	50	40
4	Analyze	0	0	0
5	Evaluate	0	0	0
6	Create	20	30	40

Course Level Learning Objectives

Remember

1. Differentiate between truth table and excitation table.
2. Differentiate between combinational circuit and sequential circuit
3. Draw the logic diagram of carry look ahead generator.
4. Define static hazard and dynamic hazard.

5. Define D-calculus

Understand

1. Distinguish between concurrent and sequential VHDL statements
2. Summarize the various steps for the design of synchronous sequential circuits.
3. Explain hazards with a suitable timing diagram.
4. Distinguish between mealy and Moore type Finite state machine.
5. Distinguish between FSM and ASM charts.

Apply

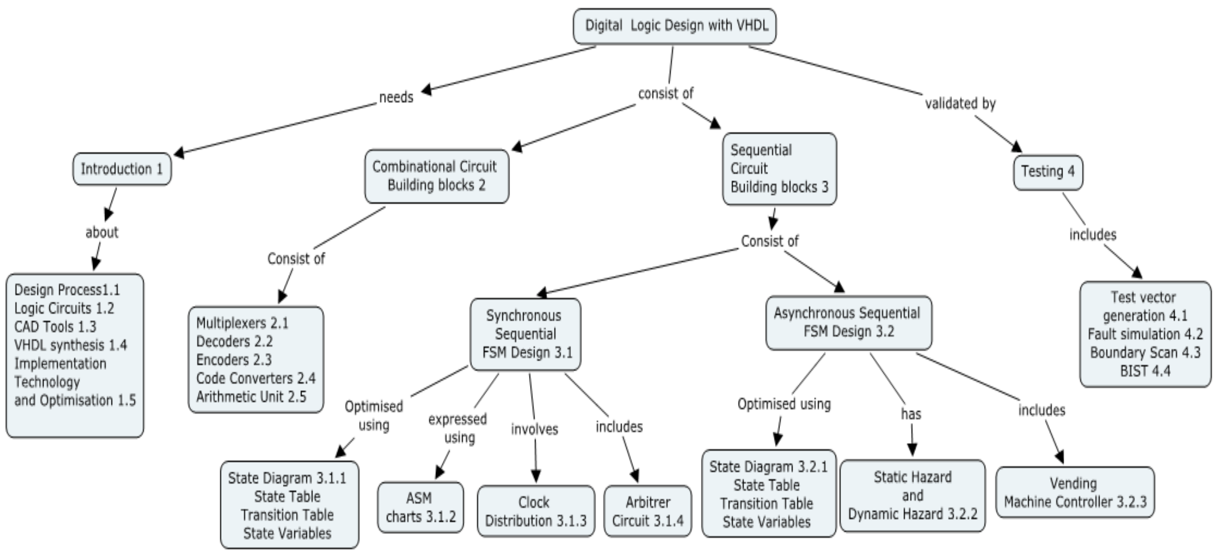
1. Implement the logic expression Y= AB+CD+CE using the Resistor Transistor Level logic IC.
2. Assume that the exclusive –OR gate has propagation delay of 10ns and that the AND or OR gates have a propagation delay of 5ns. Calculate the total propagation delay time of a four-bit carry look ahead adder?
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. Determine the optimal test vectors to detect the stuck at faults for the given logic expression Y=AB+C.
5. Find a hazard free minimum cost implementation of the function F(x1,...x4)=m(0,4,11,13)+D(2,3,5,10)

Create

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. 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.
4. 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.

5. 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.
6. 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.

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

1. S. Rajaram rajaram_siva@tce.edu
2. V. Vinoth thyagarajan vvkece@tce.edu

Sub code	Lectures	Tutorial	Practical	Credit
WT17	-	-	3	1

WT17 Communication Network Lab 0:1

Objective: The main aim of this course is to supplement the theory course on WT13: Wireless adhoc and Sensor Networks and to assist the students in obtaining a better understanding of the characteristics of wireless networks using computer simulations.

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

CURRICULUM AND DETAILED SYLLABI

FOR

M.E. DEGREE (Wireless Technologies) PROGRAM

SECOND SEMESTER

FOR THE STUDENTS ADMITTED FROM THE

ACADEMIC YEAR 2011-2012 ONWARDS

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

MADURAI – 625 015, TAMILNADU

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

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Sub Code	Lectures	Tutorial	Practical	Credit
WT21	3	1	-	4

WT21 Space Time Wireless Communications 3:1

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).

Competencies: At the end of the course, a student will be able to

1. Describe the Space Time MIMO concept of Wireless Communication Systems
2. 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 fading environment.
3. Determine the capacity, and bit error rate for a given digital modulation scheme of SIMO, MISO and MIMO wireless communication system in frequency selective fading environment.
4. Describe the OFDM and Spread Spectrum Modulation Techniques in Space Time Wireless Communications.
5. Describe the Space Time coding and Optimal Pre filter Design in the absence of CSIT and presence of CSIT.
6. Design a Space Time MIMO wireless communication Receiver architectures as per given specifications.

Assessment Pattern

	Bloom's Category	Test 1	Test 2	End-semester examination
1	Remember	20	20	10
2	Understand	20	20	10
3	Apply	60	60	60
4	Analyze	0	0	0
5	Evaluate	0	0	0
6	Create	0	0	20

Course level Learning Objectives prerequisite

Remember:

1. Define Doppler spread.
2. What do you mean by diversity order?
3. Define Spatial Multiplexing gain.
4. State Outage probability and outage capacity.
5. Give the capacity expression for frequency flat MIMO System.
6. Define Water filling power allocation in frequency selective fading channel?

Understand:

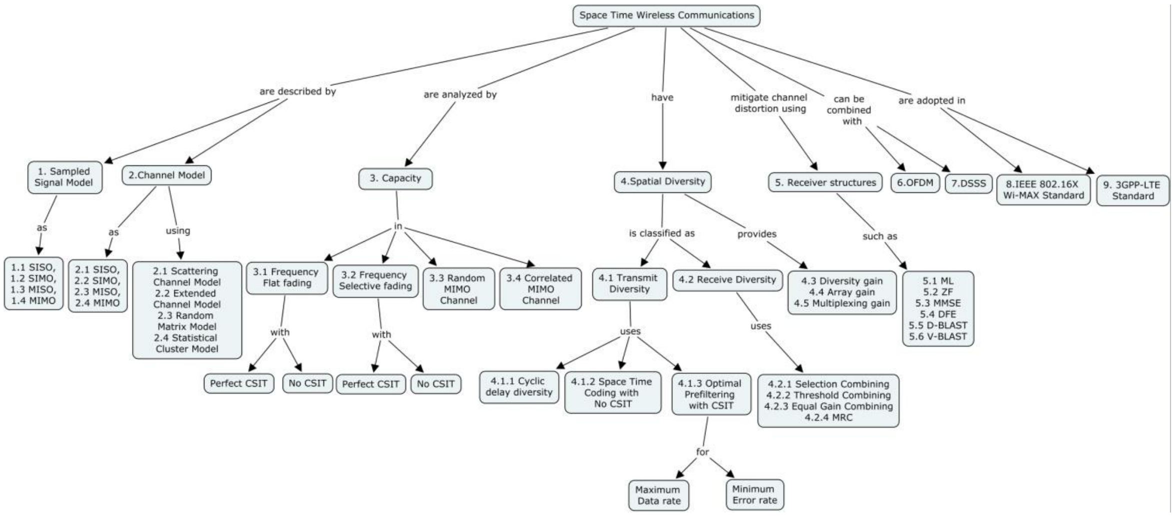
1. Distinguish between flat fading and frequency selective fading.
2. Explain the Singular value Decomposition in Multiplexing channels.
3. Distinguish between V-BLAST and D-BLAST Architectures.
4. Distinguish between Coding gain and diversity gain.
5. What is Lindskog – Paulraj Scheme?
6. What is Sphere decoding?

Apply:

1. 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.
2. 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.
3. Generalize the staggered stream structure 2×nr MIMO channel of the D-BLAST architecture to a MIMO channel with nt > 2 transmit antennas.

4. 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.
5. 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.
6. 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.

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	2

	CSIT	
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
	Total Number of Hours	45

Course Designers

1. S.J. Thiruvengadam sjtece@tce.edu
2. V.N. Senthil Kumaran vnsenthilkumaran@tce.edu

Sub code	Lectures	Tutorial	Practical	Credit
WT22	3	1	-	4

WT22 Wireless Network Security 3:1
(Common with N2H Wireless Network Security)

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.
Objective: To make the students understand the various issues in wireless security and make them aware of what level of security is appropriate for enterprises.

Competencies: At the end of the course the student will be able to

1. Understand why wireless is different from its wired counterpart.
2. Design a secure process and practice the information security model.
3. Assess wireless security model and to setup a secure wireless system.
4. Apply security in point to point and end to end in wireless applications.

Assessment Pattern

	Bloom's Category	Test 1	Test 2	Test3/End Semester Examination
1	Remember	30	30	20
2	Understand	30	30	20
3	Apply	20	20	40
4	Analysis	20	20	20
5	Evaluate	0	0	0
6	Create	0	0	0

Course level learning Objectives

Remember

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

Understand

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
4. Using vigenere scheme with 27 characters in which the 27^{th} 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

Apply

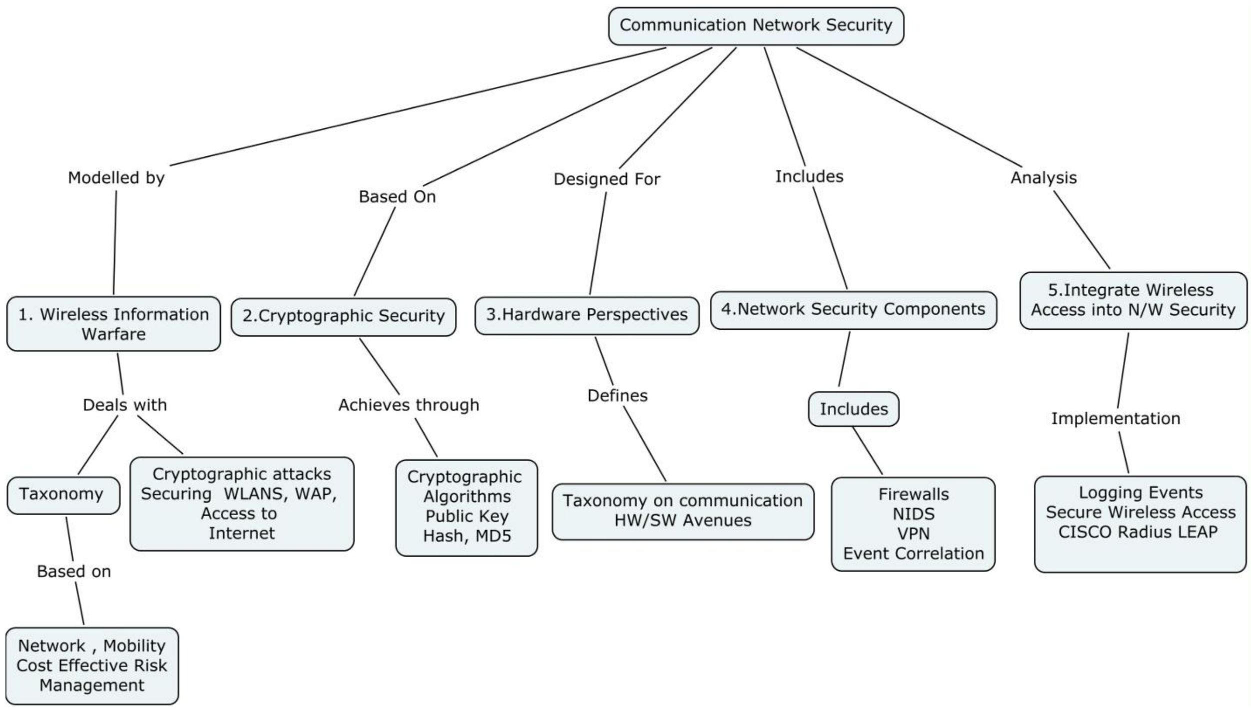
1. Perform encryption and decryption using RSA algorithm for the following
   p=3, q=11, e=7 and message m=5.
2. Consider Diffie- Hellman algorithm with a common prime q=11, primitive root a=2.
   a) If user A has public key Y_A=9, what is A's private key.
   b) If user B has public key Y_B=3, what is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

Analyze

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", CISSPl, 2005.
3. Merrit Maxim, David Pollino, "Wireless Security ", RSA Press, 2005.
4. Cyrus Peikari, Seth Fogie, , "Maximum Wireless Security ", SAMS, 2005.

Course Contents and Lectures schedule

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

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

Course Designers:

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

Sub Code	Lectures	Tutorial	Practical	Credit
WT23	3	--	--	3

WT23 RF Active Circuits for Wireless Systems 3:0

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.

Competencies: At the end of the course, the student will be able to understand

1. Basic concepts and general considerations of Linear RF Amplifier design
2. Design principles for LNA and PA
3. Behavior of RF active devices and their modeling at microwave frequencies
4. Design principles of High-power RF transistor amplifiers
5. Operating and design principles of Oscillators and Mixers

Assessment Pattern

	Bloom's Category	Test 1	Test 2	Test3/End-semester Examination
1	Remember	20	20	20
2	Understand	40	20	30
3	Apply	20	40	30
4	Analyze	0	0	0
5	Evaluate	0	0	0
6	Create	20	20	20

Course Level Learning Objectives:

Remember

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.
6. Draw the small-signal model derived from Gummel Poon model.

7. Draw the MESFET equivalent circuit model.
8. What is meant by switching-mode amplifier?
9. Write short notes on negative resistance oscillator.
10. Define: Conversion gain of an oscillator.

Understand

1. How neutralization can be done in bipolar transistors?
2. What may cause RF oscillations?
3. What are the drawbacks of cascading impedance-matched stages?
4. Mention the types of noise sources in RF systems?
5. Explain in detail about Ebers-Moll model for the bipolar transistor.
6. Mention the factors considered in Gummel-Poon model to improve over Ebers-moll model.
7. Mention the significance of push-pull configuration in class-B amplifiers.
8. State the necessary condition for oscillation to take place in an oscillator.
9. How series resonant circuits behave as an oscillator?
10. How image frequency problem occurs in mixers?

Apply

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.
6. How can you analyze the oscillators using harmonic balance method?
7. Compare the characteristics of class-A and class-B amplifiers.
8. Write any two differences between RC and LC resonant circuits.
9. What will happen if proper isolation is not maintained in the mixer?
10. Compare the performance of single-ended and double-balanced diode mixers.

Create

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.

5. A bipolar transistor at room temperature requires 0.7V at its base to set the collector current equal to 1 mA. What is the value for IS of the device, neglecting reverse leakage current? What would IS be if the collector current were instead 100 mA for this base voltage? What would IS be if the base voltage needed to be 0.75V to set the current to 1 mA?

6. Putting FET cells in parallel is the usual way to obtain higher output current and achieve higher output power. If the gate is modeled as a series R-C circuit and the drain as a parallel R-C circuit, what is the equivalent input and output series resistance at the input and output for two cells in parallel, compared with one? What is the required transformation ratio of the input and output matching networks to 50Ω? What happens to the gain? At what frequency does GMAX drop to 0 dB?

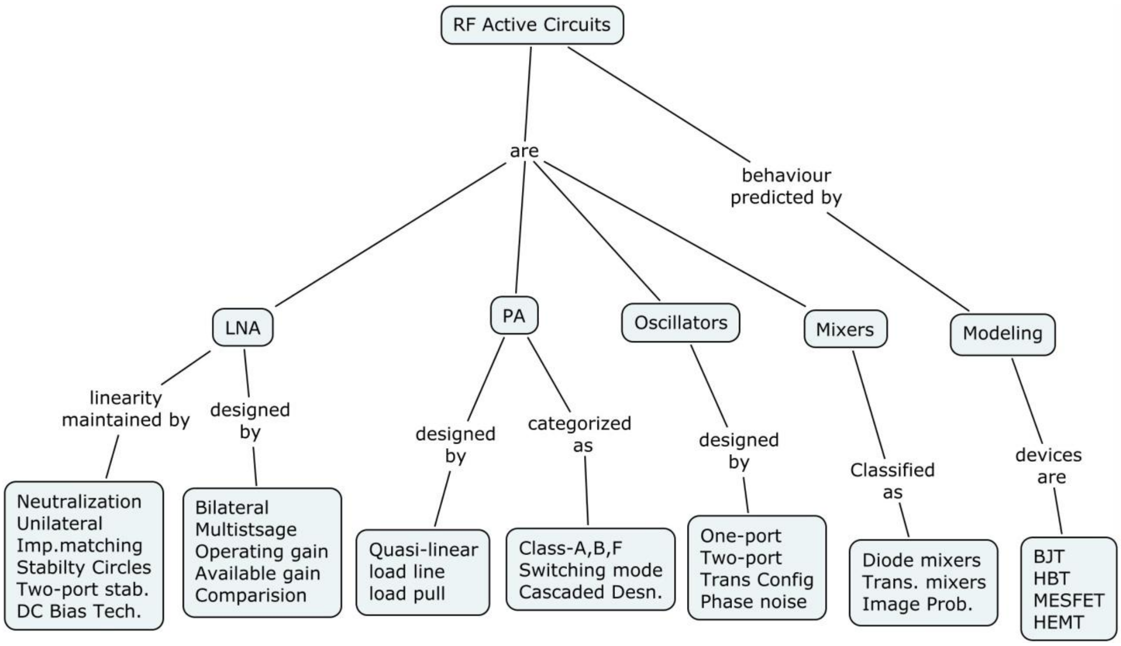
7. One oscillator has a Q of 5, another a Q of 50. Which oscillator reaches steady-state conditions first? Which oscillator can be quenched more quickly? Are these results intuitive? Can you think of a mechanical system that behaves the same way?

8. 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?

9. 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?

10. Using S-parameters for each section of quarter-wave line, show that the input and output impedance of the rat race is 50Ω, assuming each output port is terminated in 50 Ω.

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 Lectures 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	3

	Amplifier Design and Smith Chart Based Graphical Design aids	
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
	Total Number of Hours	45

Course Designers:

1. S.Raju hodece@tce.edu
2. K.Vasudevan kvasudevan@tce.edu

Sub code	Lectures	Tutorial	Practical	Credit
WT2A	3	1	-	4

WT2A Antennas for Wireless Applications 3:1

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 subject 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.

Competencies: At the end of the course the student will be able to

1. Explain the behavior of an antenna in terms its parameters
2. Simulate the radiation pattern of antennas using EM CAD simulator software-ADS
3. Explain the design issues in wireless device including cellular base station, handset and UWB communication
4. Select an antenna for the above mentioned wireless applications
5. Design planar antennas for given specifications
6. Develop prototype of a designed antenna
7. Measure the parameters and radiation pattern of an antenna

Assessment Pattern

	Bloom's Category	Test 1	Test 2	Test 3/End-semester examination
1	Remember	40	20	20
2	Understand	40	20	20
3	Apply	20	20	20
4	Analyze	0	00	00
5	Evaluate	0	20	20
6	Create	0	20	20

Course Level Learning Objectives

Remember

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.

Understand

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?

Apply:

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.
5. Prepare a model chart for developing antenna for wearable devices considering different RF constraints.
6. Explain in detail how conventional planar antenna can be modified to provide wide bandwidth

Analyze:

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.
6. Given the specification, Frequency= 6GHz, Gain =20Db, Find the number of elements and spacing in the smart antenna array. Evaluate the resultant radiation for the phase shifts: (a) $\beta=0^\circ$ (b) $\beta=-90^\circ$ (c) $\beta=+90^\circ$ the and propose the phase condition for making the array as broadside array.

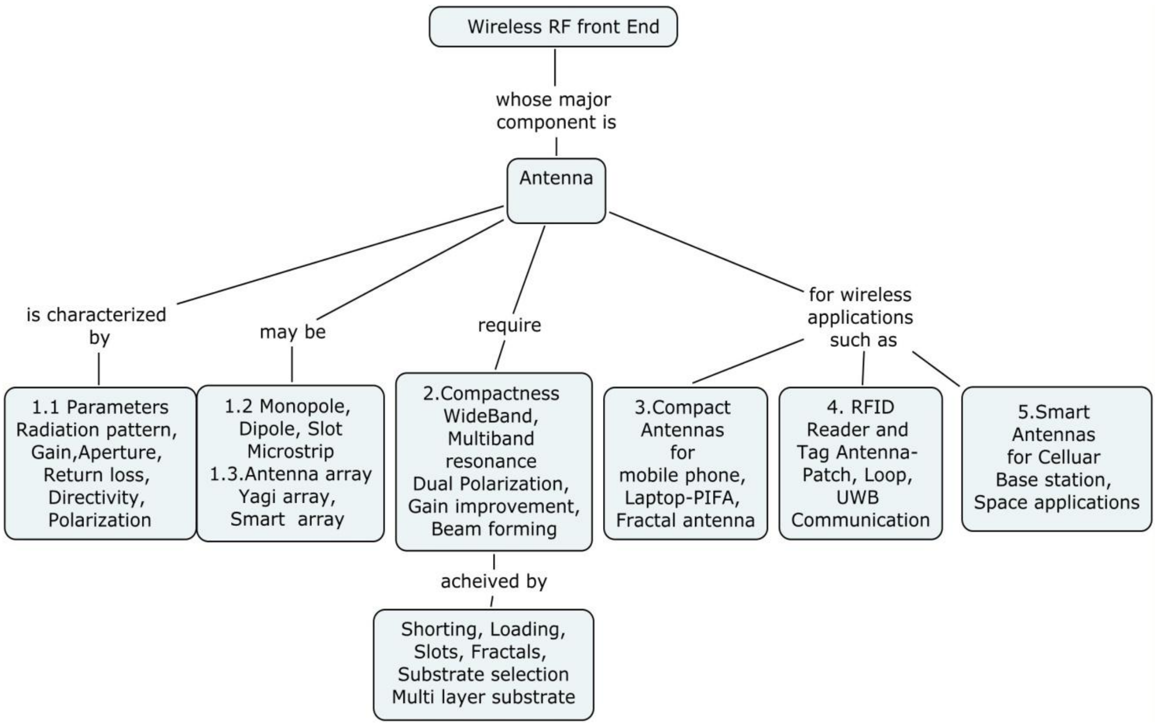
Create:

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
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:

No.	Topic	No. of Lectures
1	**Antenna Parameters & Types**	
1.1	RF Front end in Wireless system,	1
1.2	Antenna fundamentals, Radiation mechanism,	1

1.3	Antenna parameters- Radiation pattern,	2
1.4	power density, radiation intensity, directivity, Gain, polarization, radiation efficiency, effective aperture.	2
1.5	Types of antennas - Monopole, Dipole, Radiation mechanism	1
1.7	Antenna array: Active array- Two element array - broadside, end-fire, phased array	2
1.8	Passive array – Yagi array.	1
2	**Miniaturization and Bandwidth Enhancement**	
2.1	Miniaturization- Shorting and loading of antenna	1
2.2	Use of Slots, Fractal techniques,	1
2.3	Bandwidth Improvement- Multilayer substrate antenna, stacked resonator	1
2.4	Dual & Circular Polarization: Dual feed, Diagonal feed,	1
2.5	Edge shaping of MSA, Circularly Polarized MSAs, MSA with Modified Corners.	1
2.6	Low power antennas	1
3	**Compact Antenna for Mobile Handset and Laptop**	
3.1	Performance Requirements, Electrically Small Antennas,	2
3.2	Classes of Handset Antennas- External, Internal antenna, Microstrip patch antenna,	1
3.3	Planar Inverted F antenna (PIFA), SAR, Practical Design for Mobile application	2
3.4	Wireless in Laptop, Laptop Antenna Issues, Possible Antennas for Laptop Applications,	2
3.5	Mechanical and Industrial design constraints, Link budget model, Antenna Design Methodology.	2
3.6	An INF Antenna, Antennas for WWAN, Integrated Antenna, Dualband antenna.	2

4	**Antennas RFID Tag and UWB Communication**	
4.1	RFID Fundamentals, RFID System Configuration,	2
4.2	Classification of RFID Systems, Principles of Operation, Frequencies,	1
4.3	Regulations and Standardization, Design Considerations for RFID Tag Antennas,	1
4.4	UWB Wireless Systems, Challenges in UWB Antenna Design	1
4.5	Frequency-Independent Designs,	**2**
4.6	Planar Broadband Designs, Planar Printed PCB Designs	2
5	**Antenna array for Cellular applications**	
5.1	Smart Antenna array**-** Benefits of Smart antennas,	1
5.2	Types of Smart antenna, Fixed & switched beam antenna system,	2
5.3	Adaptive array system, design, Analog and Digital Beamforming,	2
5.4	Multiple antenna design, Combining techniques, Diversity, Use of Buttler matrix	2
5.5	Smart antenna for Mobile stations	2

Course Designers

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

Sub code	Lectures	Tutorial	Practical	Credit
WT2B	3	1	-	4

WT2B Radar Signal Processing 3:1

(Common with N2B Radar Signal Processing)

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

Competencies: At the end of the course, a student will be able to

1. Define and explain the basic radar functions and signal operations such as resolution, spatial frequency, which are frequently used in radar
2. Explain the generic radar signal processor flow of operations.
3. Describe the signal models such as Amplitude model, clutter model, noise model, jamming model, frequency model, spatial model used in designing and analyzing radar signal processors.
4. Determine the sampling interval for a pulse radar
5. Design radar waveforms and matched filters for the radar receiver to maximize the received SNR.
6. Differentiate Moving Target Indication and Pulse Doppler Processing.
7. Describe and apply the detection rules/tests such as Neyman-Pearson principle, likelihood ratio test for radar signal processing
8. Design a CFAR detector to improve the detection performance of radar.

Assessment Pattern:

S.No	Bloom's Category	Test 1	Test 2	Test 3/ End-semester examination
1	Remember	20	20	10
2	Understand	20	20	10
3	Apply	60	60	80
4	Analyze	0	0	0
5	Evaluate	0	0	0
6	Create	0	0	0

Course level Learning Objectives

Remember

1. Define effective aperture.
2. Write the relationship between effective aperture and gain.
3. What is clutter?
4. What are the limitations of CA CFAR?
5. Define clutter attenuation.
6. Define ambiguity function.

Understand

1. Consider two signals $x[n]$ and $y[n]$ with DTFTs $X(f)$ and $Y(f)$. Find the deterministic cross correlation between the two signals.
2. Why is CFAR needed in some RADAR? What are the disadvantages of using CFAR?
3. Draw the four pulse MTI canceller.
4. Mention the advantages of Pulse Pair Processing over Doppler processing and MTI processing.
5. Suppose radar has a pulse length of 100 ns. What is the null-to-null bandwidth of the pulse spectrum? If the fast-time (range) signal is sampled at this rate, what will be the spacing in meters of the range samples in meters?
6. In terms of *Dz* and λ, what is the peak-to-first null beam-width of the antenna pattern for an aperture antenna with constant illumination?

Apply

1. 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.
2. Consider a simple pulse of duration τ secs $x(t) = \begin{cases} 1; & 0 \leq t \leq \tau \\ 0 & otherwise \end{cases}$ passed in to a matched filter with impulse response $h(t) = \begin{cases} \alpha; & T_{M-\tau} \leq t \leq T_M \\ 0; & otherwise \end{cases}$. Calculate the output of the matched filter $y(t)$.
3. The average time between false alarms is specified as 30 min and the receiver bandwidth 0.4 MHz.
   a. What is the probability of false alarm P_{fa}?
   b. What is the threshold –to – noise power ratio?

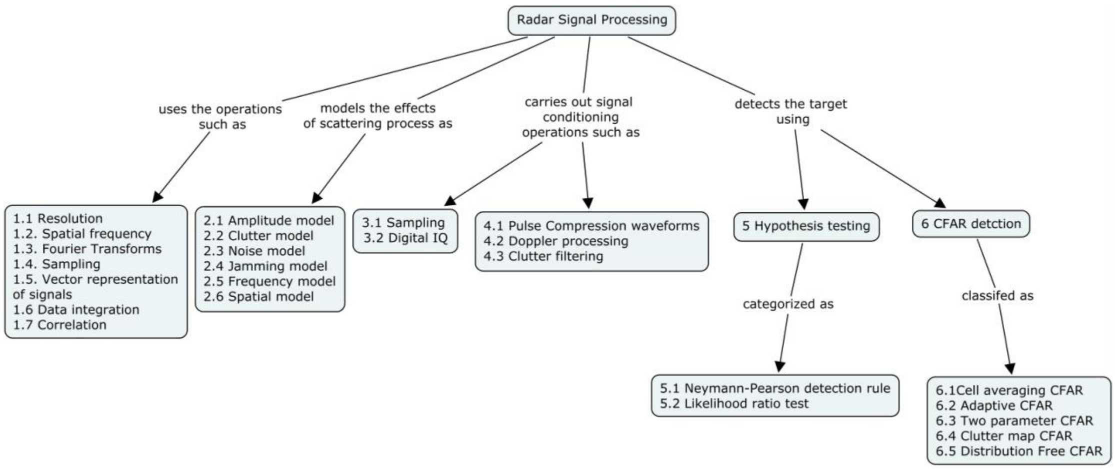
4. Consider a supersonic aircraft traveling at Mach 2 (about 660 m/s) and the RADAR is operating in L-band. Find the Doppler frequency for the given target.
5. Find the NP test to distinguish between the hypotheses that a sample $x[0]$ is observed from the possible PDFs

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

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

   Show the decision regions.
6. 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.

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

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

No.	Topic	No. of Lectures
3.2	Digital I/Q	2
4	**Pulse Compression**	
4.1	Phase Modulated	2
4.2	Frequency Modulated	2
4.3	Clutter filtering	2
4.3.1	Vector formulation of matched filter	1
4.3.2	Matched filters for clutter suppression	1
4.4	Doppler processing	1
4.4.1	Pulse Doppler processing	1
4.4.2	Pulse pair processing	1
5	**Hypothesis testing**	
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
	Total Number of Hours	45

Course Designers

1. S.J. Thiruvengadam sjtece@tce.edu
2. M.PremKumar premkumar@tce.edu
3. P.G.S.Velmurugan pgsvels@tce.edu

Sub Code	Lectures	Tutorial	Practical	Credit
WT2C	3	1	-	4

WT2C Multimedia Communication Systems 3:1
(Common with N2C Multimedia Communication Systems)

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.

Competencies: At the end of the course the student should be able to

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

Assessment Pattern

	Bloom's Category	Test 1	Test 2	Test3/End Semester Examination
1	Remember	20	20	20
2	Understand	40	40	20
3	Apply	40	40	60
4	Analysis	0	0	0
5	Evaluate	0	0	0
6	Create	0	0	0

Course level learning Objectives

Remember

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?

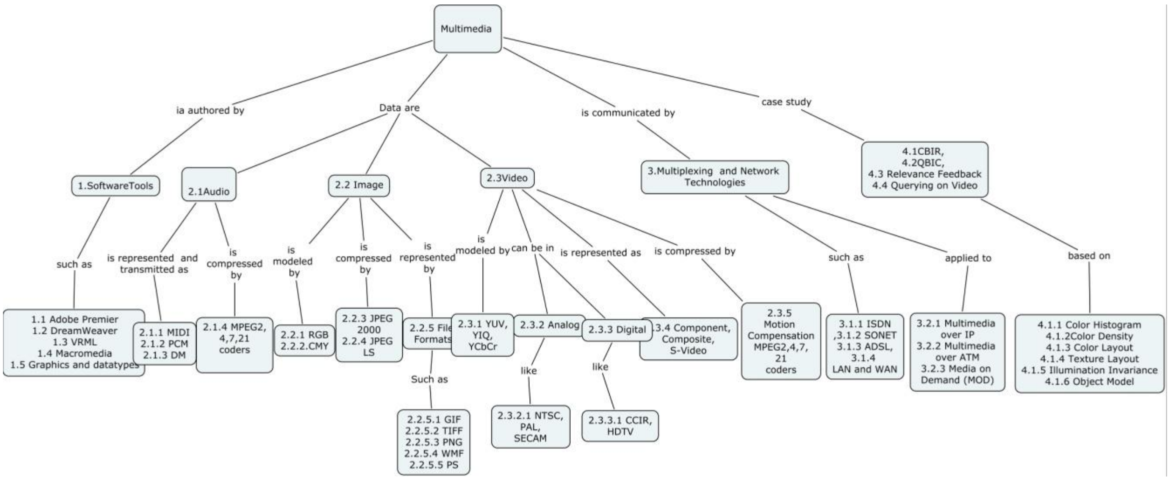
Understand

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

Apply

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?
4. How can we retrieve the images? Explain C-BIRD using a case study?
5. How Relevance feedback is used in CBIR system.
6. 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

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
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

No.	Topic	No. of Lectures
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
	Total Number of hours	45

Course Designers:

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

Sub Code	Lectures	Tutorial	Practical	Credit
WT2D	3	1	--	4

WT2D High Performance Wireless Networks 3:1

Preamble: The course "WT2D: High performance wireless networks" is offered in the Second semester in continuation with the course on "WT13: 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.

Competencies: The student at the end of the course should able to

1. Identify the requirements of high speed networks such as WLAN and WATM.
2. Classify the wireless LAN standards.
3. Design and Implement the WLAN
4. Analyze the performance of WLAN
5. Describe the operation of WATM
6. Analyze WATM standards
7. Identify the role of WATM in wireless communication, Multimedia communication and Satellite communication

Assessment Pattern:

	Bloom's Category	Test 1	Test 2	Test 3/End-semester examination
1	Remember	40	30	20
2	Understand	40	30	40
3	Apply	20	40	30
4	Analyze	0	0	10
5	Evaluate	0	0	0
6	Create	0	0	0

Course Level Learning Objectives:

Remember

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
6. Explain the operation of HIPER LAN.

Understand

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

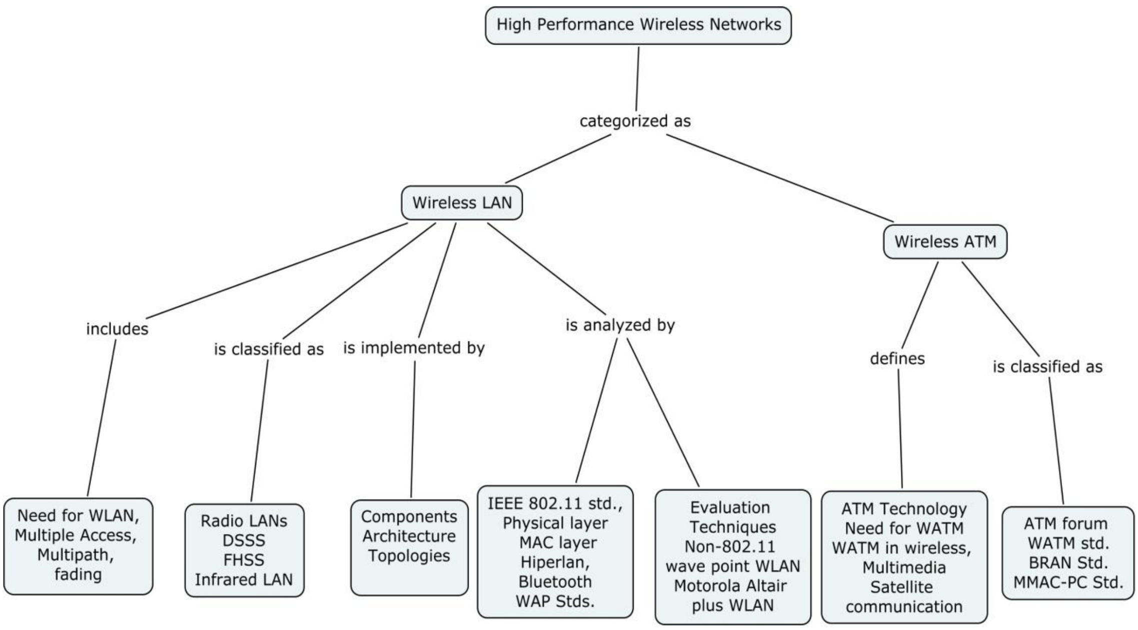
Apply

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.
4. Determine the methods used to mitigate Intersymbol interference in wireless networks
5. Relate the applications and operations of cellular systems and cordless phone.
6. 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).

Analyze

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. Distinguish the methods used to achieve high data rates for different DSL technologies
4. Identify the drawbacks of time division multiplexing of input signals and propose alternative techniques to overcome the drawbacks.
5. Identify the major challenges in implementing WATM that did not exist for data oriented Ethernet like IEEE 802.11
6. 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 Lectures schedule

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
	Total Number of Hours	45

Course Designers:

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

2.E. Murugavalli murugavalli@tce.edu

Sub code	Lectures	Tutorial	Practical	Credit
WT2E	3	1	-	4

WT2E Real Time Embedded Systems 3:1

(Common with N2E Real Time Embedded Systems)

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.

Competencies: At the end of the course, a student will be able to

1. Apply the idea of Real Time Embedded System in Engineering and science.
2. Design and analyze the Real time embedded system for engineering applications.
3. Identify, formulate and solve Real Time System for specific Engineering applications.
4. Design, Apply and analyze the performance parameters of ARM based Hardware for the solution of Real Time Embedded System.
5. Test and validate the performance of the embedded hardware and software.

Assessment Pattern

	Bloom's Category	Test 1	Test 2	End-semester examination
1	Remember	20	20	10
2	Understand	40	40	40
3	Apply	40	40	20
4	Analyze	0	0	20
5	Evaluate	0	0	0
6	Create	0	0	10

Course Level Learning Objectives
Remember

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?

Understand

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.

Apply

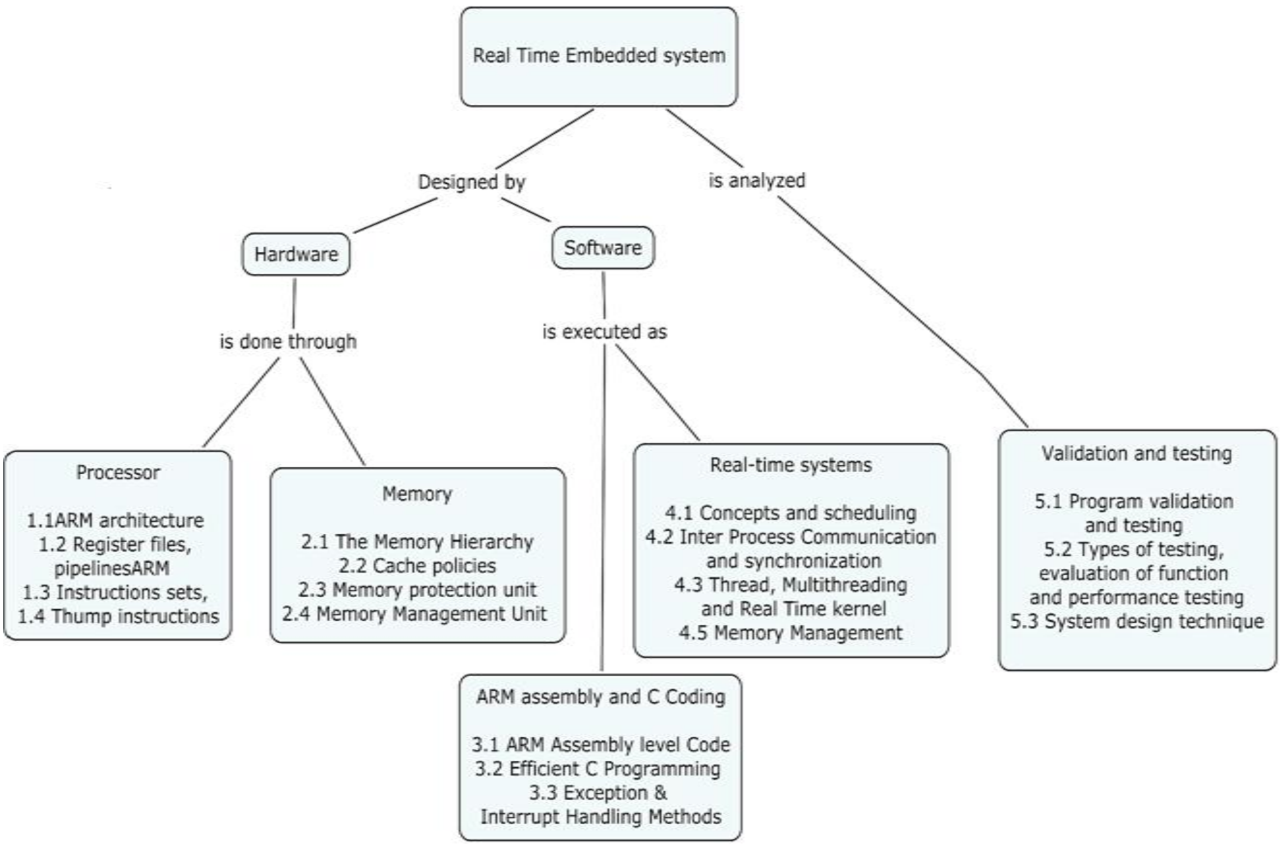
1. Develop an assembly level program for computing Fibonacci function with less memory usage.
2. Develop a C program for ARM processor for accessing an IO using polling method and interrupt driven method.
3. Write an assembly level program for transferring a file from one space to another space using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

5. 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.
6. Develop a pseudo level c code for providing a pipe for two tasks running in multitasking.

Create

1. Design an embedded system which can react for opening and closing the door, upon correct key stroke entry in a security system.
2. Design a digital clock and wake timer using ARM processor with appropriate interrupt handling.
3. Design an embedded system to mange multiple task in real time.
4. Design an Embedded system for a data acquisition system with multi tasking in real time.
5. Design an Embedded system for a vending machine using polled loop kernel method.
6. Design an Embedded system for an Electronic instruments using interrupt driven kernel method.

Concept map



SYLLABUS:

ARM Hw/SW: Introduction to RISC and ARM. Embedded system HW/SW and ARM Processor fundamentals. Introduction to the ARM and its thumb instruction Set. **Memory in ARM:** The Memory Hierarchy and Cache memory. Cache architecture and its policies. Functions of memory protection and memory management units. **ASM and C coding:** Exception and Interrupt Handling. Writing and Optimizing ARM assembly code and efficient C Programming. **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. ARM System Developer's Guide Designing and Optimizing System Software Andrew N. Sloss Dominic Symes Chris Wright. ELSEVIER inc 2007.
2. Philip A. Laplante, "Real time systems Analysis and Design – An Engineer's Handbook", IEEE computer society press PHI, 4th Ed. 2007.
3. Karl Hamcher, Zvonko Vranesic, Safwat Zaky, "Computer Organization", fifth ed. McGraw Hill -2002 , chapter 3,4,9 and 10. (Course material for ARM processor only.)
4. Frank Vahid and Tony Givargis, "Embedded system Design–A unified Hardware/software introduction", John Wiley & sons India 2002

Course Contents and Lecture Schedule:

No.	Topic	No. of Lectures
1	**ARM processor Hw and Sw**	
1.1	ARM architecture	2
1.2	Register files, pipelines	2
1.3	ARM Family cores	2
1.4	ARM Instructions sets,	3
1.5	Thump instructions	3
2	**Memory in ARM**	

2.1	The Memory Hierarchy	2
2.2	Cache policies	2
2.3	Memory protection unit	2
2.4	Memory Management Unit	2
3	**ARM assembly and C Coding**	
3.1	ARM Assembly level Code	2
3.2	Efficient C Programming	4
3.3	Exception and Interrupt Handling Methods	2
4	**Real-time systems**	
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
4.5	Dynamic allocation	1
4.6	System performance analysis	1
5	**Validation and testing**	
5.1	Program validation and testing	1
5.1	Types of testing, evaluation of function and performance testing	1
5.3	System design technique	1
	Total Number of Hours	

Course Designers:

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

Sub code	Lectures	Tutorial	Practical	Credit
WT2F	3	1	-	4

WT2F CMOS ASIC DESIGN 3:1

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.

Competencies: At the end of the course, a student will be able to

1. Provide useful insight into some of the vital issues in deep sub micron design.
2. Explain the different phases of the design flow for digital ASICs
3. Understand capabilities and limitations of CMOS logic and adjust designs to best use CMOS ASIC Technologies
4. Demonstrate an understanding of how to optimize the performance, area, and power of a complex digital functional block, and the tradeoffs between these.
5. Apply techniques to analyze the timing of the final implementation
6. Demonstrate an understanding of issues involved in ASIC design, including technology choice, design management on ASIC design.
7. Demonstrate an understanding of module interfaces ,pipe lining, design for test ,test pattern generation and BIST

Assessment Pattern

	Bloom's Category	Test 1	Test 2	End-semester examination
1	Remember	30	20	10
2	Understand	30	20	10
3	Apply	40	40	40
4	Analyze	0	20	40
5	Evaluate	0	0	0
6	Create	0	0	0

Course Level Learning Objectives

Remember:

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.

Understand:

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

Apply:

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

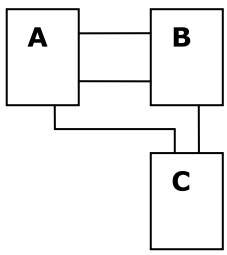
$$C = \begin{Bmatrix} 0 & 1 & 1 \\ 1 & 0 & 1 \end{Bmatrix}$$

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.

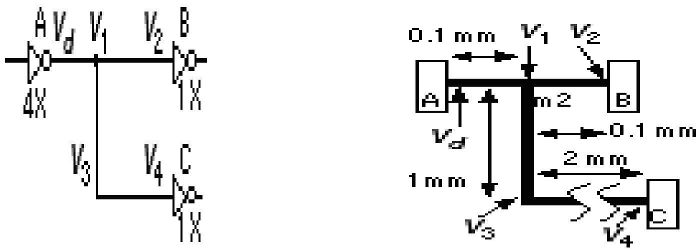
5. Find the Eigen vector for the given network? And also place the cell in two dimensional.



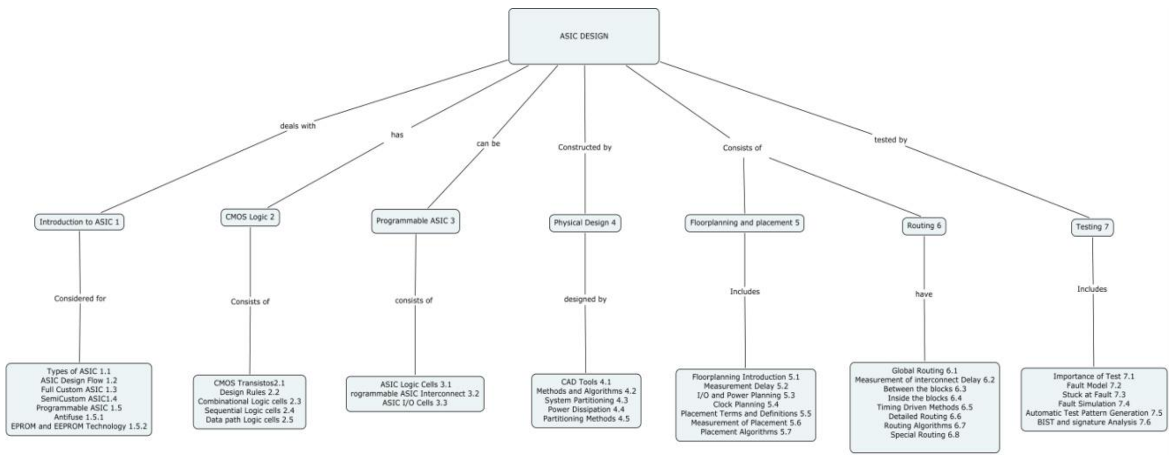
6. Compute the shortest distance between the two nodes using partitioning algorithm.

Analyze

1. Identify the procedure to partition the network using iterative improvement algorithm
2. 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.
3. Distinguish the difference between Global routing inside flexible blocks and between blocks
4. Identify the steps involved to place logic cells of a network in two dimensional structures.
5. 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:

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

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

Course Designers:

1 S.Rajaram rajaram_siva@tce.edu

2 D.Gracia Nirmala Rani gracia@tce.edu

Sub code	Lectures	Tutorial	Practical	Credit
WT2G	3	1	-	4

WT2G Adaptive Signal Processing 3:1

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.

Competencies: At the end of the course, the student will be able to

1. Characterize the stationary and non-stationary stochastic process.
2. Determine the Wiener filter coefficients from the auto correlation and cross correlation of random sequences.
3. Determine the filter coefficients and minimum error of an LMS adaptive filter.
4. Estimate the frequency content and angle of arrival of a sinusoid corrupted with white noise.
5. Apply the concept of Wiener filter for channel equalization and echo cancellation in an adaptive manner.
6. Carry out convergence analysis of the adaptive signal processing algorithms such as LMS and RLS.
7. Analyze the performance of adaptive signal processing algorithms for a given application/specification.
8. Design a subband adaptive filter bank for a given specification.

Assessment Pattern

S.No	Bloom's Category	Test 1	Test 2	Test 3/ End-semester examination
1	Remember	20	10	10
2	Understand	20	10	10
3	Apply	60	60	60
4	Analyze	0	20	20
5	Evaluate	0	0	0
6	Create	0	0	0

Course level Learning Objectives

Remember

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?

Understand

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.

Apply

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 $\lambda = 1,\ d(1) = \begin{bmatrix} 0.5 \\ 1.5 \end{bmatrix} and\ X[1] = [1 \ \ -2]$

Analyze

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.
4. 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?
5. 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 $a_1(n), a_2(n), \ldots . a_M(n), a_{M+1}(n) \ldots\ldots a_{M+N}(n)$ 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.

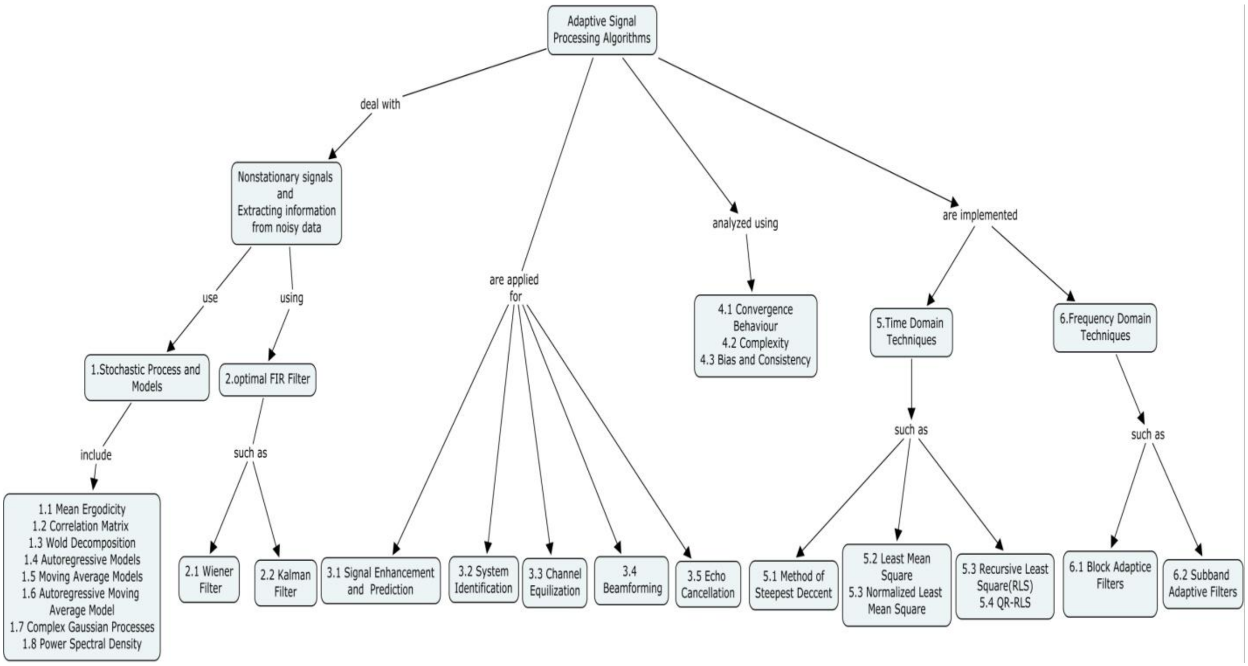
b) Find an algorithm for computing the predicted value of the state vector $\mathbf{x}(n+1)$, given the observation $y(n)$.

c) How would you initialize the algorithm in the above question?

d) The Kalman filter used in this problem is not optimal. Why?

6. 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.
4. Kong-Aik Lee, Woon-Seng Gan, Sen M., 'Subband Adaptive Filtering: Theory and Implementation' John Wiley and Sons, 2009.
5. 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 Number of Hours	45

Course Designers

1 S.J. Thiruvengadam sjtece@tce.edu

2 K.Rajeswari rajeswari@tce.edu

Sub Code	Lectures	Tutorial	Practical	Credit
WT2H	3	1	-	4

WT2H Radio Frequency Integrated Circuits 3:1

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

Competencies: At the end of the course, the student will be able to

- Understand transceiver architectures relevant to current wireless communications standards and their relative advantages and disadvantages
- Discuss active and passive device technologies relevant to RFICs
- Calculate noise ,linearity, and dynamic range performance metrics for RF devices and circuits
- Design of on chip inductors, capacitors and transformers
- Design IC implementations of RF functional blocks (such as low-noise amplifiers, mixers and oscillators) based on foundry models and design rules to meet specifications for a wireless communications system
- Utilization of RF/microwave CAD software

Assessment Pattern

	Bloom's Category	Test 1	Test 2	Test3/End Semester Examination
1	Remember	20	20	10
2	Understand	20	20	10
3	Apply	40	40	60
4	Analysis	0	0	0
5	Evaluate	0	0	0
6	Create	20	20	20

Course Level Learning Objectives

Remember

7. Differentiate low frequency analog design and radio frequency integrated circuit design.
8. Convert 2.5nW power into dBm.
9. Define noise figure
10. Correlate third order intersects point and 1dB compression point.
11. What is metal migration?
12. Define skin depth.

Understand

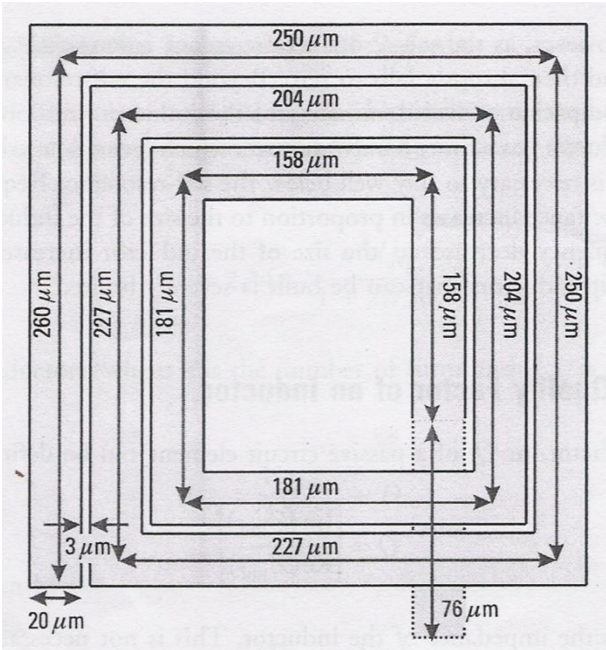
7. Calculate the inductance per unit length for traces with a h/w of 0.5, 1, and 2.
8. Why packaging is essential?
9. Differentiate various packaging techniques.
10. Mention few guidelines for designing bipolar transistor?
11. Compare cadence software with other high frequency simulation tools.
12. What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

Apply

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

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

3. Given a square inductor with the dimensions shown in figure. Determine a model for the structure including all model values. The inductor is made out of 3- μm-thick aluminum metal. The inductor is suspended over 5 μm of oxide above a substrate. The underpass is 1- μm aluminum and is 3 μm above the substrate. Assume the vias are lossless.



Inductor with dimensions

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

Example Transistors

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

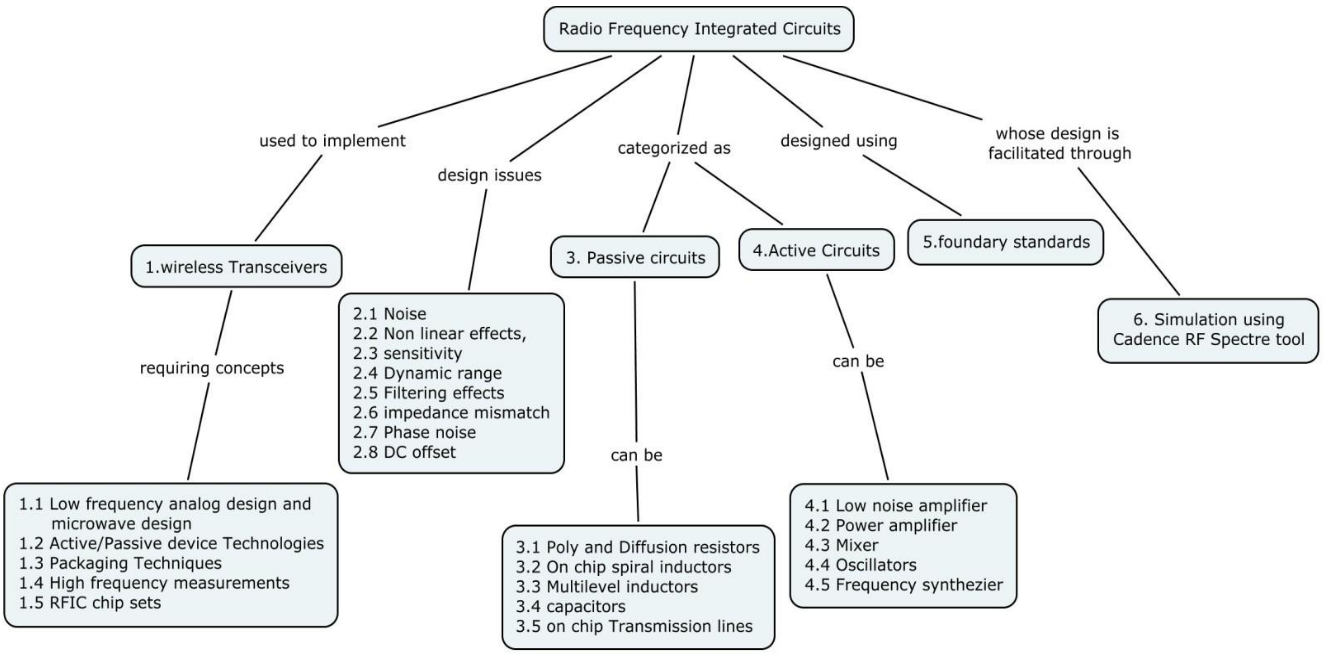
5. Derive the noise figure of the components connected in cascaded sections.

6. Consider a non-linear circuit with 7 and 8 MHz tones applied at the input. Determine all output frequency components, assuming distortion components up to the third order.

Create

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

Concept Map:



Syllabus:

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

Reference Books:

1. John M. W. Rogers, John W. M. Rogers, Calvin Plett, "Radio Frequency Integrated Circuit Design", Second Edition, Artech house 2010.
2. Thomas H. Lee, "The Design of CMOS Radio-Frequency Integrated Circuits", Second Edition, Cambridge University Press, 2004.
3. Behzad Razavi, " Fundamentals of Microelectronics", Prentice Hall, 2008
4. Robert Caverly, "CMOS RFIC Design Principles" Artech House, 2007.
5. Habil. MBA Frank Ellinger, "Radio frequency integrated circuits and technologies", Springer-Varlag Berlin Heidelberg, 2007.
6. http://www.triquint.com.
7. www.vt.edu
8. www.rficsolutions.com
9. web.mit.edu

Course Contents and lecture schedule:

Sl.No:	Topic	No. of Lectures
	Radio frequency Integrated Circuits	
	Introduction	
1	Transceiver architectures-Role of RFICs in Transceiver	1
1.1	Lower frequency design and RFIC design-issues	2
1.2	Active/Passive device technologies for RFIC implementations	1
1.3	Modern RFIC chip sets for current wireless standards	1
1.4	Packaging techniques	1
1.5	High frequency measurement	1
2	**RFIC design issues**	
2.1	Noise	3
2.1	Linearity	2
2.2	Distortion in RF circuits	1

2.3	Dynamic range	1
2.4	Filtering issues, selectivity, and sensitivity	1
2.5	Phase noise	
3	**Design of Passive circuit elements in IC technologies**	
3.1	**Introduction**	1
3.2	Sheet resistance, Poly resistors, diffusion resistors	2
3.3	On chip spiral inductors	2
3.4	Multilevel inductors	3
3.5	On chip capacitors	1
3.6	on chip transmission lines	1
4	**Design of active circuit in IC technologies**	
4.1	Low noise amplifier	4
4.2	Power amplifier	3
4.3	Mixers	3
4.4	Oscillator	2
4.5	Frequency Synthesizers	2
5.	**Foundry standards**	2
6	**Computer aided design of RFICs**	
5.1	Introduction to Commercial packages	1
5.2	Introduction and usage of CADENCE	1
5.3	Spectre RF tool	1
5.4	LNA design and simulation using Spectre RF	2
5.5	Mixer design and simulation using Spectre RF	2
5.6	Oscillator design	2
5.7	Frequency Synthesizer design and simulation	2
	Total Number of Hours	**46**

Course Designers:

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

Sub code	Lectures	Tutorial	Practical	Credit
WT2J	3	1	-	4

WT2J Analog CMOS Circuit Design 3:1

Preamble: The proposed course is offered in the second semester. This course will be followed by elective courses - RFIC Design and System on Package. The prerequisites are undergraduate course on Analog Circuits and Systems, Electrical Circuit Theory and CMOS VLSI Systems. The course aims at understanding the engineering and design principles of Analog CMOS technology for application in analog integrated circuits and subsystems.

Competencies: At the end of the course, the student will be able to

1. Understand Analog CMOS technology.
2. Demonstrate and understanding of MOS device modeling.
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 CMOS Single Stage Amplifiers including Inverters, Differential Amplifiers, Cascode Amplifiers, Current Amplifiers, Output Amplifiers/Buffers.
5. Design of CMOS Op Amps considering Compensation of Op Amp, Power-Supply Rejection Ratio, noise in Op Amps.
6. Characterization and design of CMOS Analog Circuits including Open-Loop Comparator and Digital-Analog Converters.
7. Design to improve the Performance of CMOS Analog Circuits including Open-Loop Comparator and Digital-Analog Converters.

Assessment Pattern

	Bloom's Category	Test 1	Test 2	End-semester examination
1	Remember	20	10	0
2	Understand	30	30	20
3	Apply	30	40	50
4	Analyze	0	0	0
5	Evaluate	0	0	0
6	Create	20	20	30

Course Level Learning Objectives

Remember

1. What is the difference between positive and negative photo resist and how the photo resist used?
2. What is the breakdown voltage of a pn junction with $N_A=N_D=10^{16}/cm^3$?
3. List the sources of error that can make the actual capacitor fabricated using a CMOS process, differ from its designed value.
4. Write the features of cascode amplifier.
5. State the advantages of current mirror circuit.
6. Draw the block diagram of an integrating A/D converter.
7. What is the difference between A/D and D/A converters?
8. List out different sources of errors in DACs?
9. State applications of sample and hold circuits.

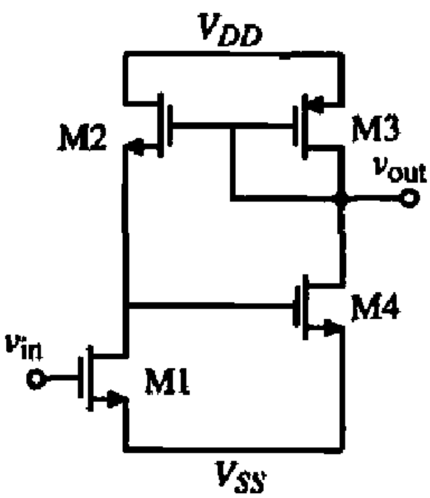
Understand

1. List the five basic MOS fabrication processing steps and give the purpose or function of each step.
2. What change in V_D of a silicon pn diode will cause an increase of 10 (an order of magnitude) in the forward diode current?
3. Assume for a 0.8 μm technology that A_o = 20, n = 3, V_{eff} =0.5 V, and $\mu_n = 0.05M^2/V\cdot$s. What is the maximum clocking frequency of the comparator?
4. 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?
5. An 8 bit D/A converter has V_{ref} = 5 V. What is the output voltage when B_{in} =10100100? Also find V_{LSB}.
6. Explain how an opamp can be used as comparator.
7. Discuss the important characteristics of comparators.
8. What is the necessity of a sample and hold circuit.

9. How does the slew rate affect the behaviour of op-amp in high frequency circuits?

Apply

1. If the mobility of an electron is $500cm^2/(V\text{-}s)$ and the mobility of the hole is $200cm^2/(V\text{-}s)$. Compare the performance of an n-channel with a p-channel transistor. In particular, consider the value of the trans conductance parameter and speed of the MOS transistor.
2. Calculate the value for V_{ON} for an NMOS transistor in weak inversion assuming that fs and fn can be approximated by its unity (1.0).
3. Develop an expression for the small signal trans conductance of a MOS device operating in weak inversion using the large signal model.
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. 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.



6. Assume two transistors are biased at a current density ratio of 10:1 at T = 300 °K. What is the difference in their base-emitter voltages and what is its temperature dependence?

7. 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.

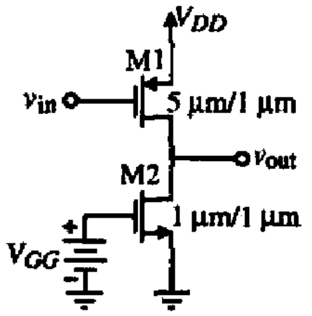
8. A CMOS amplifier is shown in figure. Assume M1 and M2 operate in the saturation region.

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

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

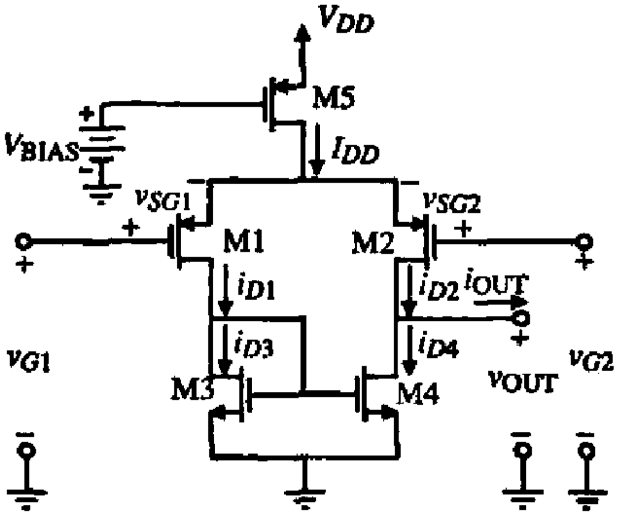
   (c) What is the small signal voltage gain, V_{out}/V_{in}, for this amplifier?

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

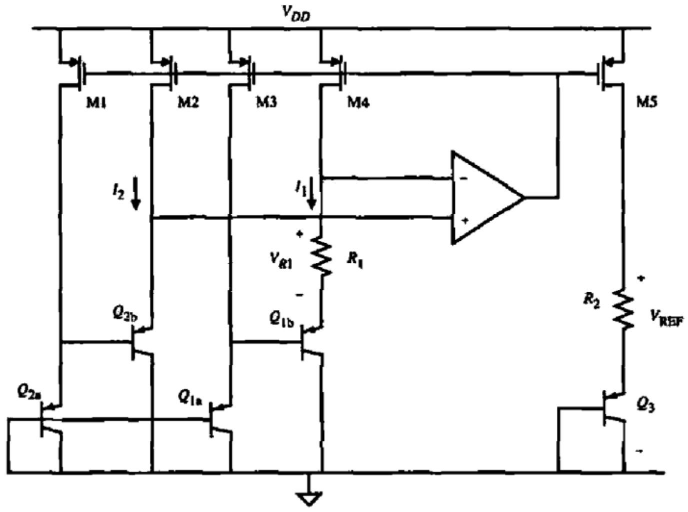


Create

1. Develop the expressions for V_{IC}(max) and V_{IC}(min) for the p-channel input differential amplifier of following figure.

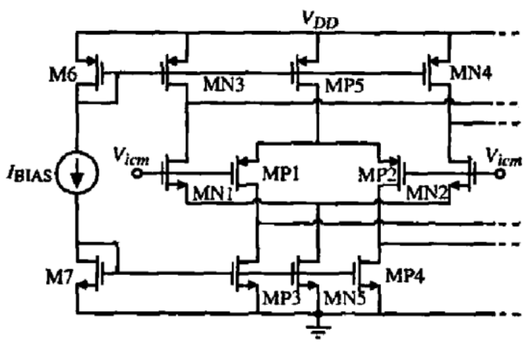


2. An improved bandgap reference generator is illustrated in figure below. Assume that the device M1 through M5 are identical in W/L. Further assume that the area ratio for the bipolar transistor is 10:1. Design the components to achieve an output reference output reference voltage of 1.262V. Assume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

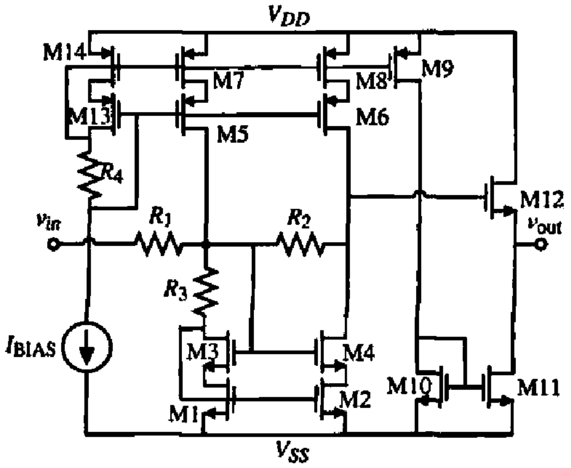


3. Design the current boosting mirror to achieve 100μA output when M2 is saturated. Assume that i_1=10 μA and W1/L1=10. Find W2/L2 and the value of V_{DS2} where i_2 =10 μA.

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.

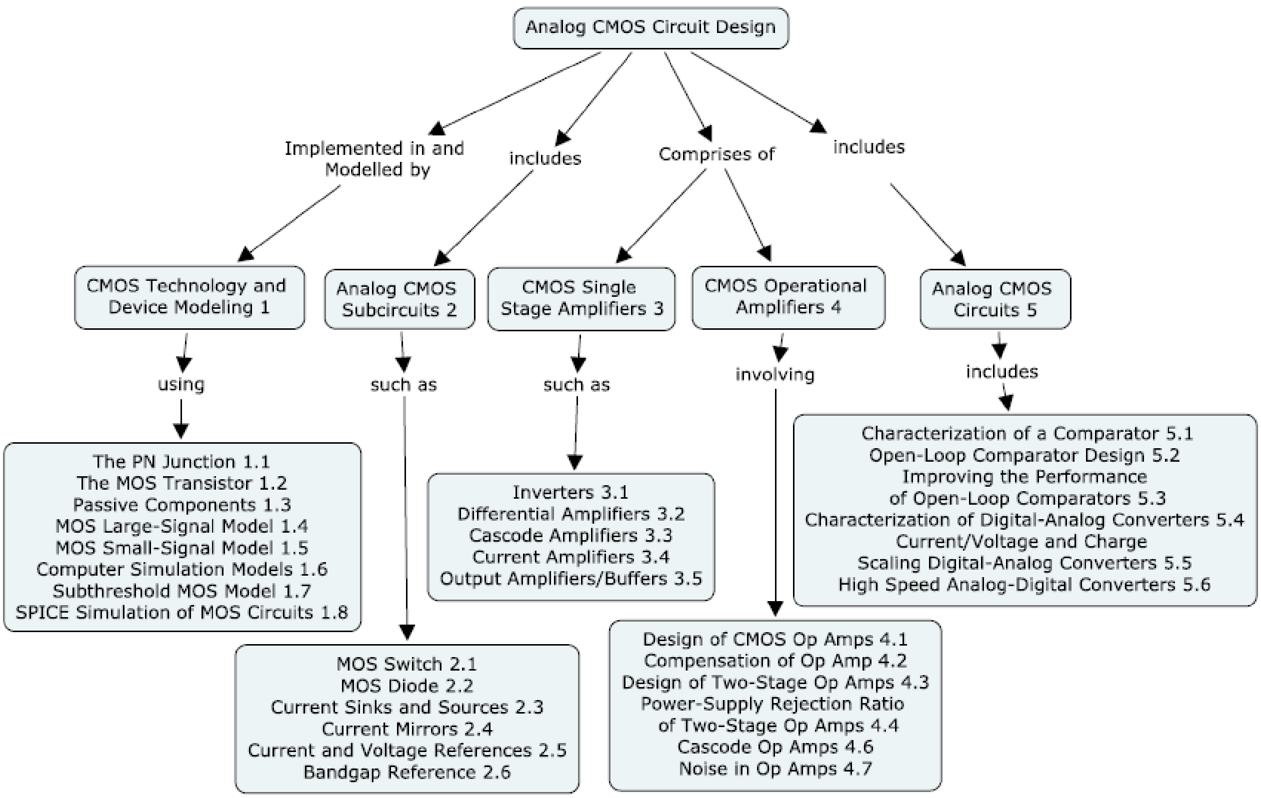


5. In the following figure replace R_1 with a differential amplifier using a current mirror load. Design the differential transconductance g_m so that it is equal to $1/R_1$.



6. Estimate the temperature dependence at 0 °C for a bandgap voltage reference that was designed to have zero temperature dependence at 20 °C. Present the result as ppm/°K.
7. 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.

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

Course Designers:

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

Sub code	Lectures	Tutorial	Practical	Credit
WT2K	3	1	-	4

WT2K Estimation and Detection Algorithms 3:1

Preamble:

This course aims at developing Estimation and Detection Algorithms for scalar and vector parameters of a system in noise. Further, it also aims at developing algorithms for detecting the desired signals from the noisy received signal.

Competencies

At the end of the course, the student will be able to

1. Formulate the estimation problem
2. Determine the CRLB for the given estimation problem
3. Design an estimator based on Maximum Likelihood, Maximum A Posteriori, Least square and Minimum Mean Square Error Method
4. Formulate the detection problem
5. Detect known signal in Gaussian noise, using matched filter and generalized matched filter
6. Detect random signal in Gaussian noise, using Estimator-Correlator
7. Design Detectors for array processing applications.

Assessment Pattern

S.No	Bloom's Category	Test 1	Test 2	Test 3/ End-semester examination
1	Remember	20	20	10
2	Understand	20	20	10
3	Apply	60	60	80
4	Analyze	0	0	0
5	Evaluate	0	0	0
6	Create	0	0	0

Course level Learning Objectives

Remember:

1. When an estimator is said to be unbiased?

2. State the invariance property of the Maximum Likelihood Estimator.
3. Define CRLB
4. State Neyman Pearson Theorem
5. What is Receiver Operating Characteristics?
6. What is Generalized Matched Filter?

Understand:

1. Compare the mean square error of MVU and Bayesian estimator (mmse)
2. Distinguish between ML and MAP criterions
3. In Bayesian estimator, if the cost function is absolute error, the estimator is defined to be the median of the posterior PDF. Justify
4. Explain the function of 'Clairvoyant Detector'?
5. Can an optimal estimator be obtained from CRLB? Explain
6. Compare the estimation performance of ML, MAP and MMSE based estimators.

Apply

1. The data $x(n) = Ar^n + w(n)$ for $n = 0,1,....N-1$ are observed, where w(n) is WGN with variance σ^2 and $r > 0$ is known.
   i. Find the CRLB for A.
   ii. Show that an efficient estimator exists and find its variance.
   iii. What happens to the variance as $N \to \infty$

2. Consider the observations $x(n) = A + w(n) \quad n = 0,1\cdots N-1$, where A is real number and w(n) is WGN with variance σ^2. Let the estimator $\hat{A} = \frac{1}{N}\sum_{n=0}^{N-1} x(n)$. Prove that the PDF $\hat{A}$ is $N(A, \sigma^2 / N)$

3. Independent bivariate Gaussian samples $\{\mathbf{x}(0), \mathbf{x}(1)\cdots\mathbf{x}(N-1)\}$ are observed. Each observation is a 2×1 vector which is distributed as $\mathbf{x}(n) \sim N(\mathbf{0,C})$ and $\mathbf{C} = \begin{bmatrix} 1 & \rho \\ \rho & 1 \end{bmatrix}$. Find the CRLB for the correlation coefficient ρ.

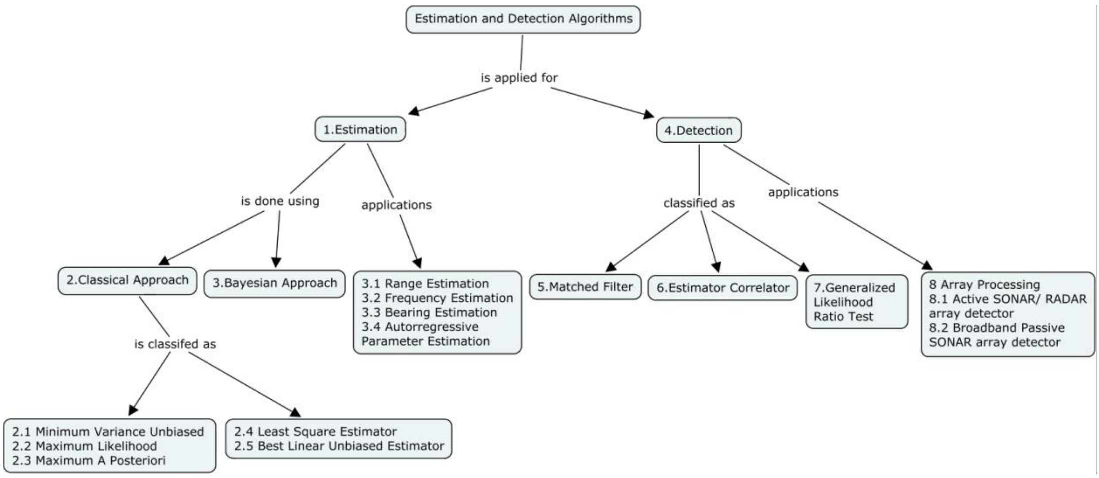
4. The data $x(n) = r^n + w(n)$ for $n = 0,1,....N-1$ are observed, where w(n) is WGN with variance σ^2 and r is to be estimated.
   i. Find the CRLB for r.
   ii. Does an estimator exists and if so find its variance

5. We observe two samples of a DC level in correlated Gaussian noise $x(0) = A + w(0), x(1) = A + w(1)$, where $\mathbf{w} = [w(0)\ w(1)]^T$ is zero mean with covariance matrix $\mathbf{C} = \sigma^2 \begin{bmatrix} 1 & \rho \\ \rho & 1 \end{bmatrix}$. The parameter ρ is the correlation coefficient between w(0) and w(1).
   i. Compute the CRLB for A
   ii. Compare the result in (a) when w(n) is WGN.
   iii. Explain what happens when $\rho = \pm 1$.
6. MAP Estimator:
   i. Assume that the conditional PDF $p(x[n] \mid \theta) = \theta \exp(-\theta x(n)) \quad x[n] > 0$ where the x[n]'s are independent and identically distributed and the prior PDF is $p(\theta) = \lambda \exp\{-\lambda\theta\} \quad \theta > 0$. Determine MAP estimator for θ.
   ii. The data $x(n) = A + w(n)$ for $n = 0,1,....N-1$ are observed, where A is unknown and the noise variance σ^2 is also unknown. The conditional PDF $p(\mathbf{x}/A,\sigma^2) = \frac{1}{\left(2\pi\sigma^2\right)^{\frac{N}{2}}} \exp\left(-\frac{1}{2\sigma^2}\sum_{n=0}^{N-1}\left(x(n)-A\right)^2\right)$.

      The prior PDF for σ^2 is $p(\theta) = \frac{\lambda \exp\left(-\frac{\lambda}{\sigma^2}\right)}{\sigma^4} \quad \sigma^2 > 0$
7. Consider the detection problem $\begin{array}{l} H_0 : x(n) = w(n), \quad n = 0,1,...N-1 \\ H_1 : x(n) = A + w(n), \quad n = 0,1,...N-1 \end{array}$

   w(n) is WGN with variance σ^2 and A is deterministically known. Derive expressions for Probability of False Alarm and Probability of Detection.

Concept Map:



Syllabus

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

Reference Books

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

Course Contents and Lecture Schedule

No.	Topic	No. of Lectures
1	**Estimation**	
1.1	Mathematical Estimation Problems	1
1.2	Assessing Estimator Performance	1
2	**Estimation Algorithms- Classical Approach**	
2.1	Minimum Variance Unbiased Estimation	2
2.2	Maximum Likelihood Estimation	2
2.3	Maximum A Posteriori Estimation	2
2.4	Least Square Estimation	2
2.5	Best Linear Unbiased Estimation	2
3	**Estimation Algorithms- Bayesian Approach**	3
3.1	**Signal Processing Examples**	
3.1.1	Range Estimation	1
3.1.2	Frequency Estimation	1
3.1.3	Bearing Estimation	1
3.1.4	Autoregressive Parameter Estimation	1
4	**Detection Algorithms**	2
4.1	Classical Approach -Neyman Pearson Theorem	2
4.2	Bayesian Approach-Minimization of Bayes Risk	2
4.3	Receiver Operating Characteristics	1
4.3	Examples	2
5	**Matched Filter**	3
5.1	Generalized Matched Filter	2
5.2	Multiple Signal Detection	2
5.3	Examples	2
6.	**Estimator Correlator**	3

No.	Topic	No. of Lectures
6.1	Examples	3
7	**Generalized Likelihood Ratio Test**	2
7.1	Composite Hypothesis Testing	2
7.2	Multiple Hypothesis Testing	2
7.3	Examples	2
8	**Detectors for Array Processing Applications**	2
8.1	Active SONAR/RADAR array detector	2
8.2	Broadband Passive SONAR array detector	2

Course Designers

1. S.J. Thiruvengadam sjtece@tce.edu
2. M.PremKumar premkumar@tce.edu

Sub code	Lectures	Tutorial	Practical	Credit
N2L	3	1	-	4

N2L Satellite Remote Sensing and Data Analysis 3:1

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.

Competencies: At the end of the course, the student will be able to

1. Determine the quality of the image using noise model statistics.
2. Improve the quality of a distorted image by geo-referencing.
3. Describe and determine the performance of different stretching techniques for enhancement.
4. Describe the role of spectral, spatial and scale space transforms on Satellite images.
5. Analyse the performance of supervised and unsupervised training for different sensor data.
6. Characterize the influence of feature extraction, in terms of accuracy on classified images.
7. Determine the performance of different feature extraction methods
8. Integrate two different sensor satellite data
9. Remove the data redundancies by suitable compression technique to transmit the satellite image efficiently

Tools

MATLAB, ENVI Softwares

Assessment Pattern

	Bloom's Category	Test 1	Test 2	Test3/End Semester Examination
1	Remember	20	20	20
2	Understand	40	40	20
3	Apply	40	40	40
4	Analysis	0	0	20
5	Evaluate	0	0	0
6	Create	0	0	0

Course level learning Objectives

Remember

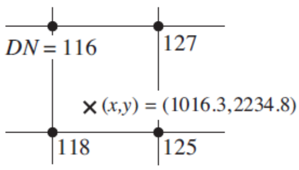
1. What is atmospheric window?
2. Define: spectral reflectance of earth surface features.
3. What is meant by geometric correction?
4. Write the law's 2D masks to ridges and waves.
5. What is meant by Scale space fusion?
6. Explain the terms; Fractal dimension, Lacunarity.
7. What are different types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

Understand

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?

Apply

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

Analyze

1.Given a multispectral image with a *DN* covariance matrix,

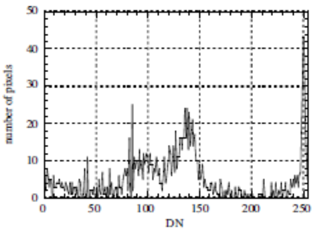
$$C = \begin{bmatrix} 1900 & 1200 & 700 \\ 1200 & 800 & 500 \\ 700 & 500 & 300 \end{bmatrix} \cdot$$

What is the correlation matrix? Now, suppose you do a calibration of the data to at-sensor radiance *L* as follows,

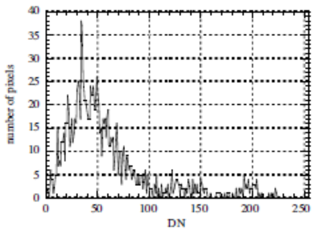
$$\begin{aligned} L_1 &= 2 \times DN_1 + 11 \\ L_2 &= 3 \times DN_2 + 4 \\ L_3 &= 5 \times DN_3 + 2 \end{aligned}$$

What are the covariance and correlation matrices of the calibrated data? Will the PCT of the calibrated data be the same as the PCT of the *DN* data? Will the standardized PCT be the same?

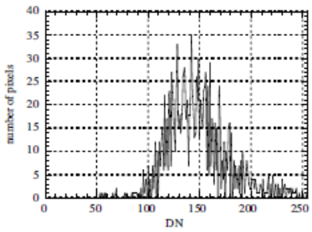
2. Given the following histograms of the (actual) HSI components of a three-band image, specify three *DN* transformations that will make the saturation of every pixel equal to 200, linearly stretch the intensity to increase the contrast, and leave the hue unchanged.



hue



saturation



intensity

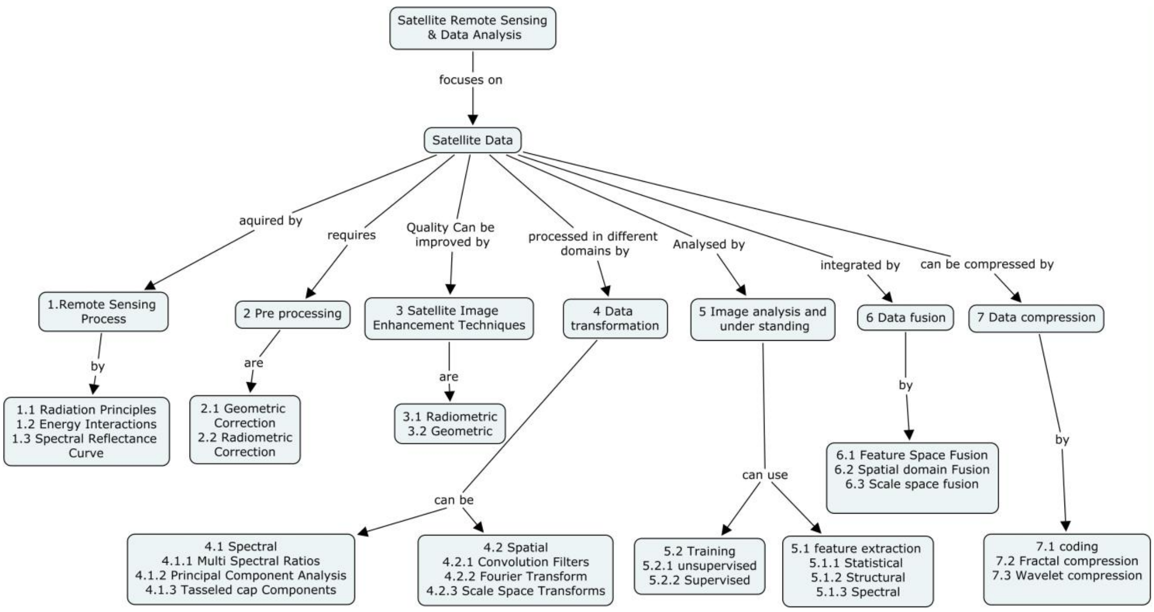
3.Suppose you calculate the local mean and standard deviation in a 3 X 3 pixel window, moved across an image. What is the statistical uncertainty in the mean values? What if the window is 5 X 5 pixels?

4. For a 4 bit input matrix obtain the Co-occurrence matrix and Analyze it by computing any six Haralick's statistical texture features .

10	10	12	0	0
5	0	10	10	12
1	1	2	0	10
5	5	0	10	12

5. In a multi spectral image of size 512 X 512, each pixel is associated with 7 bytes of colour information; How many bytes are required to store that image?

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.

Text Book:

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.
3. J. A. Richards **"Remote Sensing Digital Image Analysis: An Introduction", S**econd Revised Edition, 1993.

Reference Books:

1. John R. Jensen, "**Remote Sensing Of The Environment – An Earth Resource Perspective",** Pearson Education Series, 2003.
2. Rafael C.Gonzalez, Richard E.Woods, "**Digital Image Processing"** (3rd Edition) Rafael C.Gonzalez, Richard E.Woods, Prentice Hall, 2007.

Course Contents and Lecture Schedule

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

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

Course Designers

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

Sub Code	Lectures	Tutorial	Practical	Credit
WT2M	3	1	-	4

WT2M Computer Vision 3:1

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

Competencies: At the end of the course the student should be able to

9. Understand what is computer vision
10. Understand how image is formed through projections
11. Understand the essential topics such as segmentation and feature extraction
12. Apply the extracted features to computer vision applications such as object recognition and human activity recognition
13. Analyze different classifiers and choose suitable classifier for specific application

Assessment Pattern

	Bloom's Category	Test 1	Test 2	Test3/End Semester Examination
1	Remember	20	20	20
2	Understand	40	40	20
3	Apply	40	40	40
4	Analysis	0	0	20
5	Evaluate	0	0	0
6	Create	0	0	0

Course level learning Objectives

Remember

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

6. Define diffusion.

Understand

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

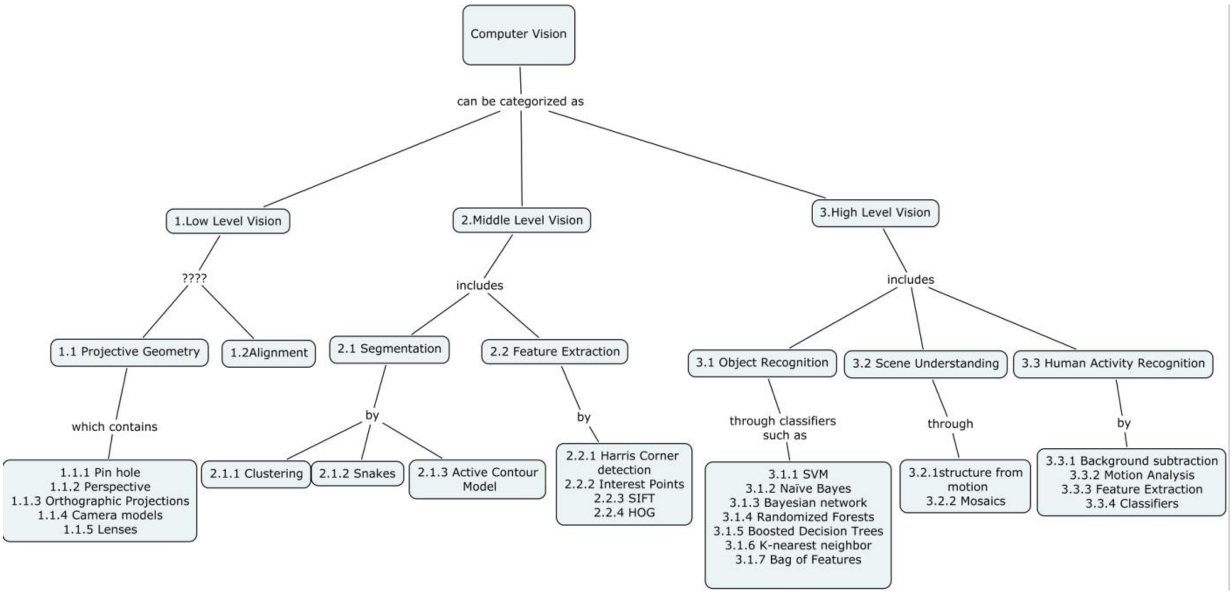
Apply

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

Analyse

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

Concept Map



Syllabus

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

Reference Books:

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

Course Contents and Lecture Schedule

No.	Topic	No. of Lectures
1	**Computer Vision-** Introduction, computer vision applications- **Low Level Vision**	2
1.1	**Projective** Geometry	2
1.1.1	Projection-Pinhole	1
1.1.2	perspective	1
1.1.3	orthographic	1
1.1.4	Vanishing points	1
1.1.5	Lenses	2
1.1.6	Camera models	1
1.1.7	Chrmatic aberration	1
1.1.8	Photon's life choices	2
1.1.9	image formation	1
1.2	Alignment	1
2.1	**Middle Level Vision-Segmentation**	1
2.1.1	Clustering	1
2.1.2	snakes	1
2.1.3	Active contour model	1
2.2	**Feature Extraction**	1
2.2.1	Harris corner detection	2
2.2.2	Interest points	1
2.2.3	SIFT	2
2.2.4	HOG	1
3.1	**High Level Vision-Object Recognition**	1
3.1.1	SVM	1
3.1.2	Naïve Bayes	2
3.1.3	Bayesian network	1
3.1.4	Randomized Forests	1
3.1.5	Boosted Decision Trees	1
3.1.6	K-nearest neighbor	1
3.1.7	Bag of Features	1
3.2	**Scene Understanding**	1
3.2.1	Structure from motion	2
3.2.2	Mosaics	1
3.3	**Activity Recognition**-Background subtraction	2

No.	Topic	No. of Lectures
3.3.1	Video Tracker	1
3.3.2	Motion Analysis	1
3.3.3	Feature Extraction	1
3.3.4	Classifiers	2
	Total Number of Hours	49

Course Designer

1. B.Yogameena, ymece@tce.edu

Sub Code	Lectures	Tutorial	Practical	Credit
WT27	0	0	3	1

WT27 RF Systems Laboratory 0:1

(Common with N27 RF Systems Laboratory)

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.

CURRICULUM AND DETAILED SYLLABI

FOR

M.E. DEGREE (Wireless Technologies) PROGRAM

THIRD SEMESTER

FOR THE STUDENTS ADMITTED FROM THE

ACADEMIC YEAR 2011-2012 ONWARDS

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

MADURAI – 625 015, TAMILNADU

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

Sub Code	Lectures	Tutorial	Practical	Credit
WT31	3	1	-	4

WT31 Modeling and Simulation of Communication Systems 3:1

(Common with N31 Modeling and Simulation of Communication Systems)

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.

Competencies: At the end of the course, a student will be able to

1. Present the basic concepts and properties of random variables , random processes and models that are used for simulating communication systems
2. Compute the response of a system driven by random inputs, using analytical and simulation techniques
3. Simplify and validate the simulation procedures using bounds and approximations
4. Generate sampled values of random process that are used to model signals, noise, interference and time varying channels in communication systems
5. Model fading and multipath channels that are used in the performance analysis of GSM, UWB, WiFi, WiMAX and LTE communication systems.
6. Estimate the parameters such as average level, probability density function, power spectral density delay and phase of a waveform
7. Estimate bit error rate using Monte Carlo simulation
8. Evaluate the performance of a communication system in terms of performance parameters such as outage probability, bit error rate, for a given scenario, using modeling and simulation.

Assessment Pattern

	Bloom's Category	Test 1	Test 2	End-semester examination
1	Remember	20	10	10
2	Understand	20	10	10
3	Apply	60	60	60
4	Analyze	0	0	0
5	Evaluate	0	0	0
6	Create	0	20	20

Course level Learning Objectives

Remember:

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

Understand:

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

Apply:

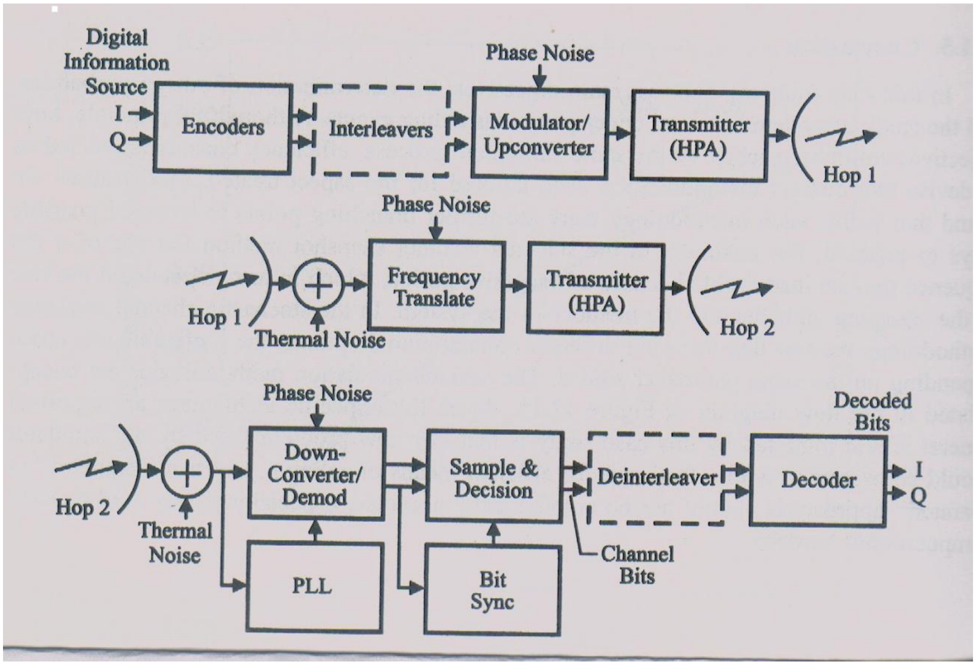
1. Write a program to generate samples from a Gaussian distribution using the Box-Muller method
2. Determine the probability density function of the following transformations
   a. $y = -\log(x)$, where x is uniform in [0,1]
   b. $y = x^2$, where x is Gaussian (0,1)

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 $\sigma^2 = \frac{1}{N}\sum_{n=0}^{N-1}(x(n) - A)^2$ 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.

Create:

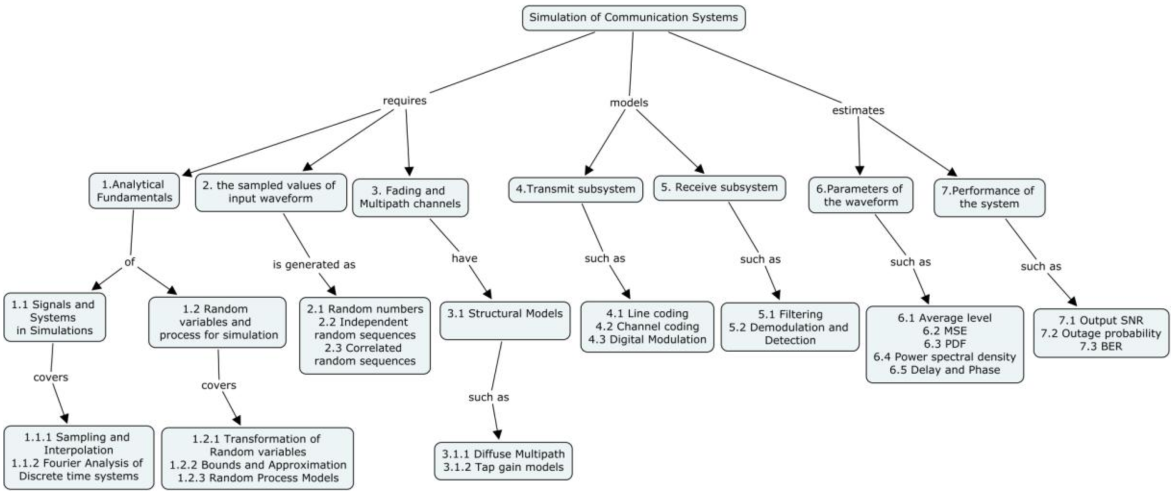
1. Given a digital satellite communication system shown in figure, what should be the interleaver depth to approach the coded performance of an independent error channel? In this system, the main factor which produces correlation among errors is phase noise, generated both by thermal noise and oscillator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

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

S. 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
	Total Number of Hours	45

Course Designers

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

Sub Code	Lectures	Tutorial	Practical	Credit
WT3A	3	1	-	4

WT3A MIMO OFDM Systems 3:1

(Common with N3A MIMO OFDM Systems)

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.

Competencies: At the end of the course, a student will be able to

1. Describe the concept of MIMO OFDM Wireless Communication System.
2. Obtain impulse response coefficients from the power delay profiles of the SISO, SIMO, MISO and MIMO channels.
3. Determine the capacity and bit error rate of MIMO OFDM system for a given power delay profile of the MIMO channel.
4. Estimate the MIMO channel impulse response using least square, MMSE and robust MMSE estimation algorithms.
5. Estimate and correct the frequency offset in the signal received at the MIMO OFDM receiver.
6. Estimate and correct the timing offset in the signal received at the MIMO OFDM receiver.
7. Analyze the performance of MIMO OFDM physical channel in WiMAX /LTE wireless standards.

Assessment Pattern

	Bloom's Category	Test 1	Test 2	End-semester examination
1	Remember	20	10	10
2	Understand	20	10	10
3	Apply	60	80	80
4	Analyze	0	0	0
5	Evaluate	0	0	0
6	Create	0	0	0

Course level Learning Objectives

Remember:

1. Define Doppler spread.
2. Draw the block diagram of OFDM communication system.
3. Write the signal model for OFDM system with 2 transmit antennas and two receiving antennas.
4. Define spatial multiplexing.
5. Define null steering and optimal beamforming.
6. List the major international standards that adopt MIMO OFDM.

Understand:

1. What are the gains available in MIMO systems?
2. Write the motivation behind using MIMO OFDM systems?
3. Distinguish between flat fading and frequency selective fading.
4. Distinguish between block type and comb type pilot structures used for channel estimation.
5. In which systems, channel reciprocity becomes useful information.
6. How complexity of MIMO OFDM spatial multiplexing receivers is reduced?

Apply:

1. Write a program to simulate SCM channel model.
2. A scattering function for a fading channel is given by $S(\tau, \lambda) = 1$ if $0 \leq \tau \leq 50\ \mu s$ and $|\lambda| < 5$ Hz, and it is zero otherwise.
    a. Determine the mulltipath intensity profile of the channel. What is its Doppler power spectrum?.
    b. What are the multipath delay spread, Doppler spread, coherence time and coherence bandwidth of the channel?
    c. 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?

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

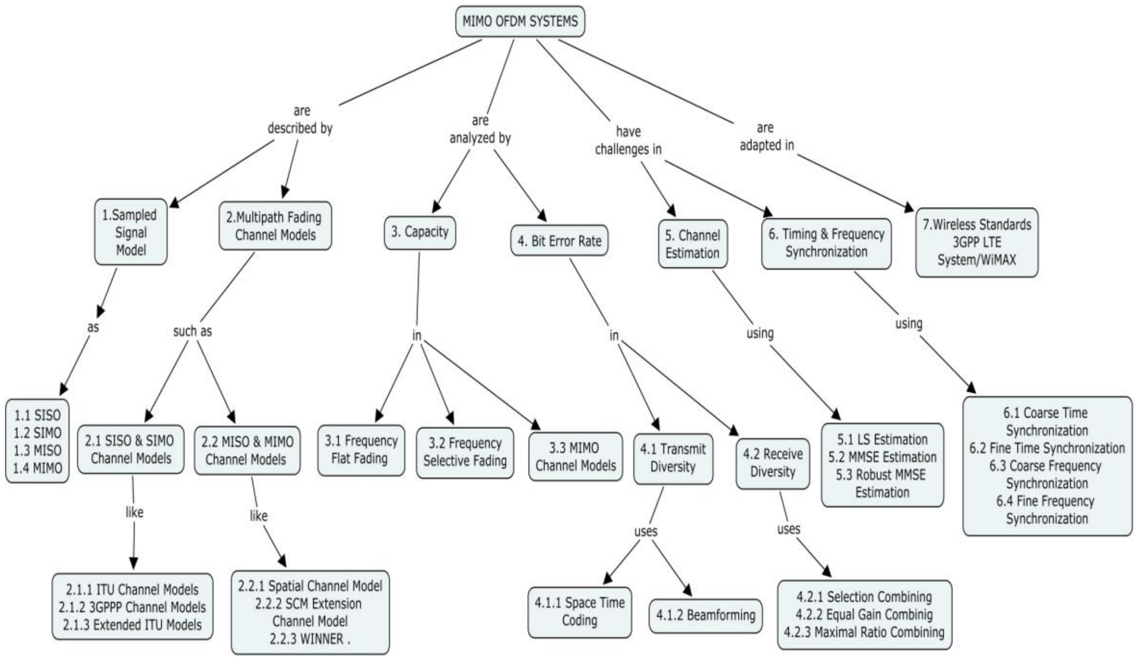
$$H = \begin{bmatrix} j & 1-j & 1 & -0.5 \\ -0.3 & 0.4+0.1j & 1-j & j \\ 0.2j & 0 & -0.5+0.5j & 1 \\ 1 & -j & 1 & 1 \\ -j & 0.6+0.5j & 2 & -1 \end{bmatrix}$$

   Using the singular value decomposition, determine the equivalent representation with parallel channels.
4. 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.
5. 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.
6. 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,

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

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

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:

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

Course Designers

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

Sub Code	Lectures	Tutorial	Practical	Credit
WT3B	3	1	-	4

WT3B Physical Layer LTE Systems 3:1

(Common with N3B Physical Layer LTE Systems)

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.

Competencies: At the end of the course, a student will be able to

1. Describe the FDD and TDD frame formats of LTE
2. Describe the physical signals and channels of downlink and uplink LTE systems
3. Carry out cell search using synchronization signal in LTE downlink system
4. Determine the downlink and uplink channel frequency response using reference signals
5. Characterize the modulation schemes such as OFDMA and OFDM, SC-FDMA Schemes used in the standard.
6. Describe the single user and multiuser modulation techniques in LTE downlink and uplink systems
7. Determine the BER performance of LTE downlink and uplink channels
8. Determine the outage probability performance of LTE downlink and uplink channels
9. Characterize the Downlink and Uplink physical layer design in LTE downlink environment.

Assessment Pattern

	Bloom's Category	Test 1	Test 2	End-semester examination
1	Remember	20	20	20
2	Understand	20	20	20
3	Apply	60	60	60
4	Analyze	0	0	0
5	Evaluate	0	0	0
6	Create	0	0	0

Course level Learning Objectives:

Remember:

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

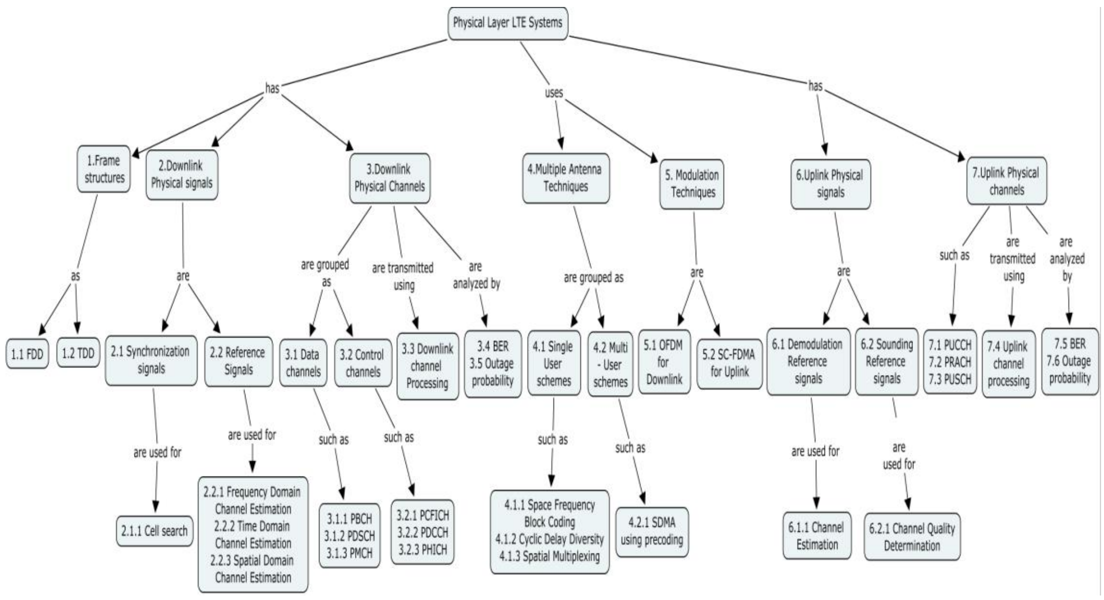
Understand

1. Distinguish between OFDM and SC-FDMA
2. What is DFT spread OFDM system? How does it relate to SC-FDMA?
3. Why is LTE named so? Is it more than just 4G speed?
4. Compare the features of LTE and WiMAX.
5. Distinguish between physical signals and physical channels in LTE systems
6. Distinguish between single user and multiuser MIMO techniques.

Apply:

1. Obtain the shift register implementation of scrambling sequence generator using the polynomial $g(x)=1+x+x^3$
2. Determine the pairwise probability of PCFICH channel assuming that CFI can take values between 1 and 4.
3. Compute and compare the autocorrelation amplitudes for PN sequence and Zadoff-Chu sequence at a zero time lag.
4. 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.
5. Construct convolutional encoder used in LTE with m=6,n=3,k=1 and rate 1/3 for the generator polynomials $g_o=\{1011011\}, g_1=\{1111001\}, g_2=\{1110101\}$
6. Compute PRACH sub-carrier spacing for $800\mu s$ interval.

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

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	2

	precoding	
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 Number of Hours	48

Course Designers:

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

Sub Code	Lectures	Tutorial	Practical	Credit
WT3C	3	1	-	4

WT3C RF MEMS 3:1
(Common with N3C RF MEMS)

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.

Competencies: At the end of the course, the student will be able to

1. Understand the Concept of miniaturization and the need of MEMS in various applications
2. Understand the concepts of various actuation mechanisms of MEMS
3. Know the fundamental and technological possibilities and constraints when designing and implementing RF MEMS subsystems.
4. Understand Micro fabrication techniques
5. Utilization of RF MEMS CAD software
6. Know the need and constraints in packaging

Assessment Pattern

	Bloom's Category	Test 1	Test 2	Test3/End Semester Examination
1	Remember	20	20	20
2	Understand	20	20	20
3	Apply	60	60	50
4	Analysis	0	0	10
5	Evaluate	0	0	0
6	Create	0	0	0

Course Level Learning Objectives:

Remember:

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.

Understand:

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.

Apply:

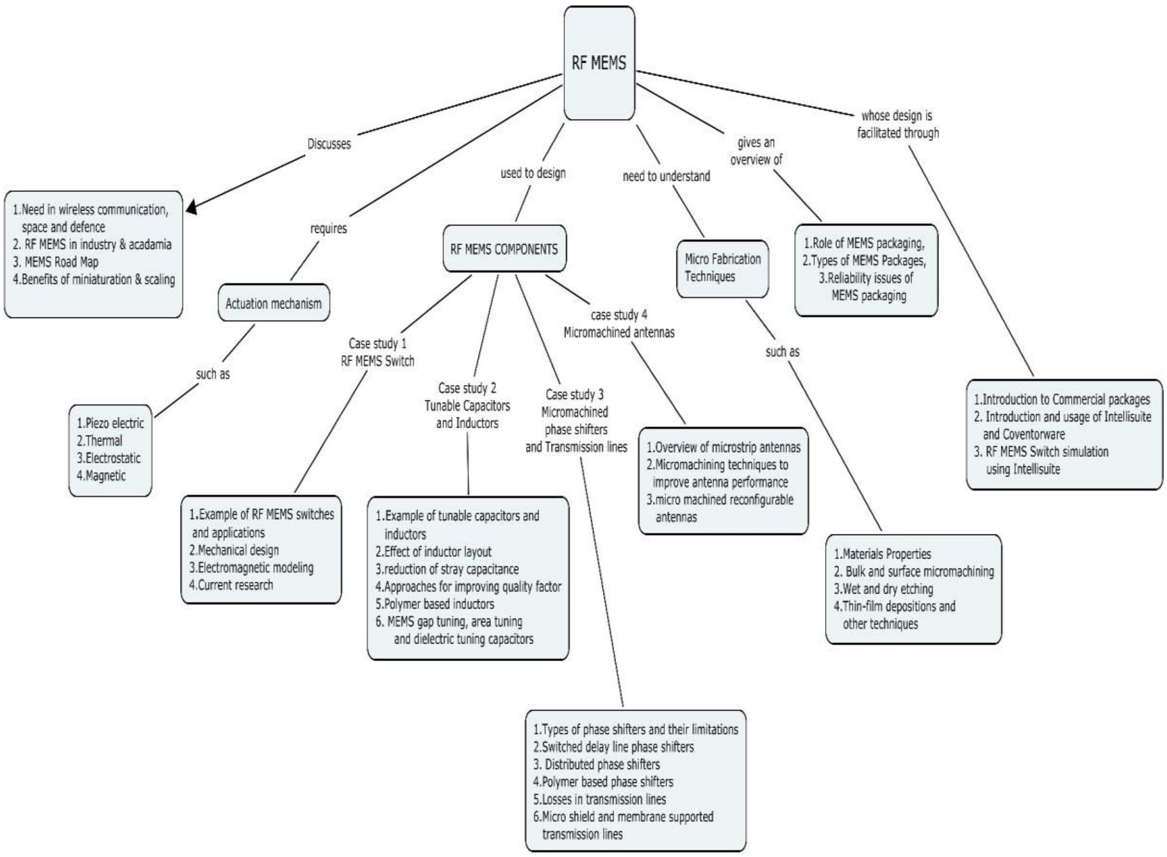
1. Design a RF MEMS shunt switch with an equivalent circuit approach operating at a frequency of 40 GHz.
2. Determine the Fragg frequency and the phase shift per unit length of a DMTL phase shifter at a frequency of 10 GHZ.
3. i) Applying the concepts of direct analogy between electrical and mechanical 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.

Analysis:

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.

Concept Map:



Syllabus:

RF MEMS: Introduction to RF MEMS: Application in wireless communications, space and defense applications, Benefits of Miniaturization and Scaling, RF MEMS in industry and academia, **Actuation Mechanisms in MEMS**: Piezoelectric, Electrostatic, Thermal, Magnetic, **RF MEMS Components: *Case study 1*:MEMS Switch,** Example of RF MEMS switches and applications, Mechanical design, Electromagnetic modeling (Capacitance, Loss, Isolation), Current research ***Case Study 2:*** **Tunable Capacitors and Inductors,** Example of tunable capacitors and inductors and their applications in circuits, Effect of inductor layout, reduction of stray capacitance of planar inductor , Approaches for improving quality factor, Polymer based inductors, MEMS gap tuning, area tuning and dielectric tuning capacitors, ***Case study 3:*** **Micromachined phase shifters and Transmission lines:** Types of phase shifters and their limitations, MEMS phase shifters: Switched delay line phase shifters, Distributed phase shifters, Polymer based phase shifters, Losses in transmission lines , Micro shield and membrane supported transmission lines ***Case study 4:*** **Micromachined antennas:** Overview of microstrip antennas, Micromachining techniques to improve antenna performance, micro machined reconfigurable antennas, **Micro fabrication Techniques:** Materials Properties, Bulk and surface micromachining, Wet and dry etching Thin-film depositions (LPCVD, Sputtering, Evaporation), other techniques (LIGA, Electroplating),**Packaging of RF MEMS :** Role of MEMS packaging, Types of MEMS Packages, Reliability issues of MEMS packaging. **Computer aided design of MEMS:** Introduction to Commercial packages, Introduction and usage of Intellisuite and Coventorware, RF MEMS Switch simulation using Intellisuite.

Reference Books:

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

Course Contents and lecture schedule:

Sl.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 applications in circuits	2
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 Number of hours	46

Course Designer

1. S.Kanthamani skmece@tce.edu

Sub Code	Lectures	Tutorial	Practical	Credit
N3D	3	1	-	4

N3D Video Surveillance Systems 3:1
(Common with WT3D Video Surveillance Systems)

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.

Competencies: At the end of the course, the student will be able to

1. Understand of what videos are and their standards
2. Understand digital video hardware
3. Understand the essential topics such as motion segmentation and video tracking
4. Apply video tracking algorithms for intelligent surveillance and medical applications
5. Analyse different background subtraction techniques for different scenario
6. Analyse to choose right sensor for the right job

Assessment Pattern

	Bloom's Category	Test 1	Test 2	Test3/End Semester Examination
1	Remember	20	20	20
2	Understand	40	40	20
3	Apply	40	40	40
4	Analysis	0	0	20
5	Evaluate	0	0	0
6	Create	0	0	0

Course level learning Objectives

Remember

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.
6. State different approaches for background subtraction

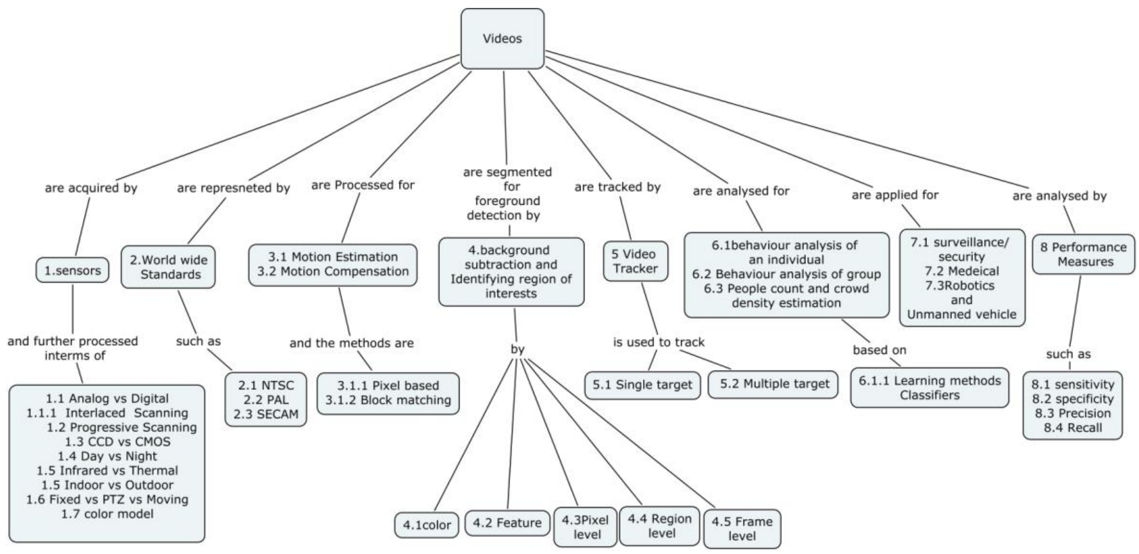
Understand

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

Apply and Analyse

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. Apply the suitable algorithm for tracking unmanned vehicle.
4. Analyze the video surveillance hardware for different applications.
5. Design and analyze the suitable algorithm for multiple target tracking.
6. Color or feature affects the background subtraction results. Analyze it.

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

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
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

No.	Topic	No. of Lectures
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 Number of Hours	46

Course Designer

1. B. Yogameena, ymece@tce.edu

Sub Code	Lectures	Tutorial	Practical	Credit
WT3E	3	1	--	4

WT3E Network Management 3:1
(Common with N3E Network Management)

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.

Competencies: The student at the end of the course should able to

1. Classify and analyze the different types of Network management Schemes.
2. Explain the SNMP - Network Management protocol
3. Analyze the operation of the different version of SNMP protocol
4. Implement the SNMP protocol through Remote Monitoring (RMON)
5. Design the Telecommunication Management Network (TMN)
6. Manage the Broadband network such as ATM and ADSL Technologies
7. Determine the Network Management Tools and systems (NMS)
8. Configure different Network Management applications

Assessment Pattern

	Bloom's Category	Test 1	Test 2	Test3/End Semester Examination
1	Remember	30	20	0
2	Understand	40	40	40
3	Apply	30	40	30
4	Analysis	0	0	30
5	Evaluate	0	0	0
6	Create	0	0	0

Course Level Learning Objectives:

Remember

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.

Understand

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

Apply

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.
6. 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?

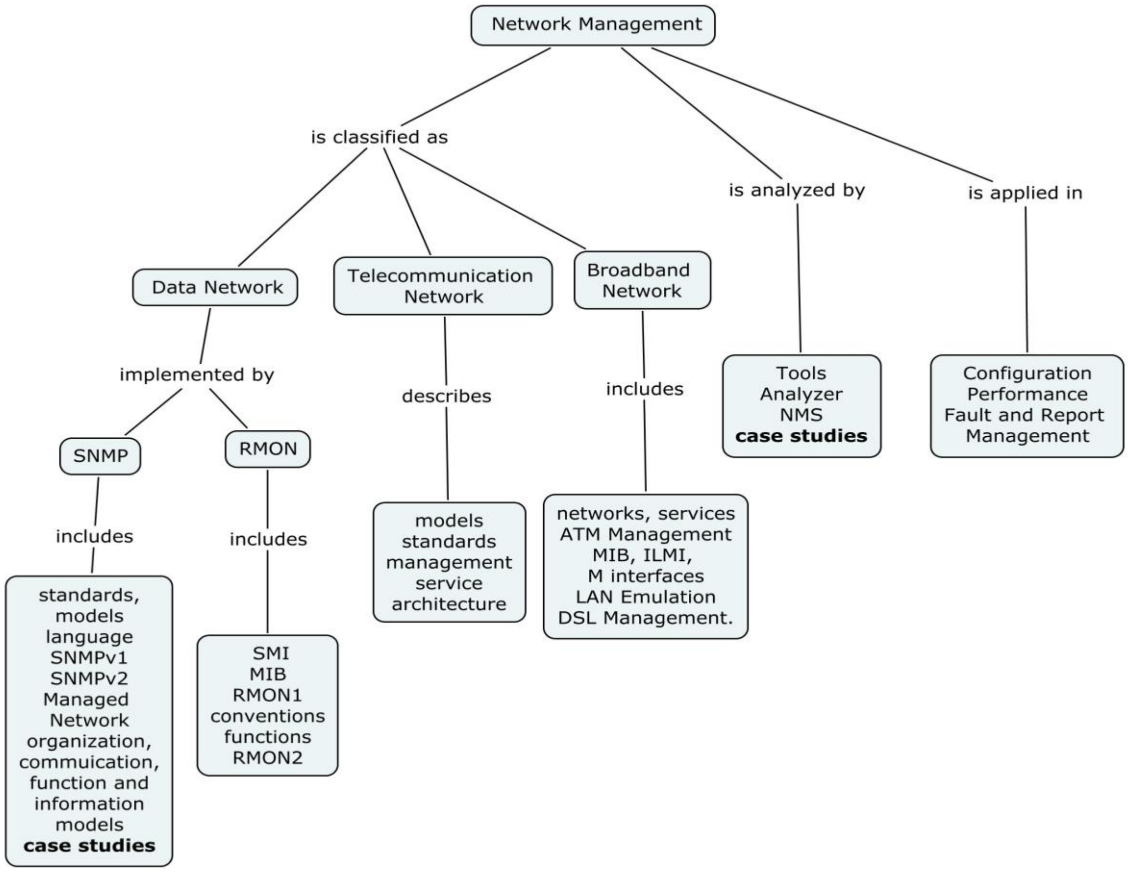
Analyze

1. 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.
2. 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?
3. 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.
4. 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.
5. 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.

- o Why would you suspect the frame size?
- o How would you use RMON to prove your suspicion?
- o How would you measure the types and distribution of frames in a token ring LAN?

6. 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: 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 Lectures schedule

S. 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
6.5	Security and Report management	3
	Total	40

Course Designers:

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

Sub code	Lectures	Tutorial	Practical	Credit
WT3F	3	1	-	4

WT3F Baseband Algorithms on FPGA 3:1
(Common with N3F Baseband Algorithms on FPGA)

Preamble: This course 'WT3D Baseband algorithms on FPGA' is preceded by 'WT16 Digital Logic Design with HDL' and 'WT12 Baseband Wireless Communication' in their First semester. Both the subjects form the basic for this course. 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.

Competencies: At the end of the course, the student will be able to

1. Explain the operation of the devices and tools used to design state-of-the-art DSP systems.
2. Represent a given decimal number in fixed or floating point number systems, including canonic signed digit, logarithmic, residue number system (RNS).
3. Compute nontrivial (transcendental) algebraic functions using CORDIC algorithm.
4. Write a VHDL/VerilogHDL program for FIR Filter using distributed arithmetic
5. Design and implement filter with pipelining and/or parallel processing.
6. Explain the different types of FFT algorithms including Cooley-Tukey, Winograd and Good-Thomas.
7. Implement FFT algorithms using Hardware Description languages.
8. Design and implement a Communication system block such as Viterbi decoder, Linear Block Code, universal modulator.

Assessment Pattern

	Bloom's Category	Test 1	Test 2	End-semester examination
1	Remember	30	20	20
2	Understand	40	30	30
3	Apply	30	40	30
4	Analyze	0	0	0
5	Evaluate	0	0	0
6	Create	0	10	20

Course Level Learning Objectives

Remember:

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

Understand:

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.

Apply:

1 Calculate the numberof 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.

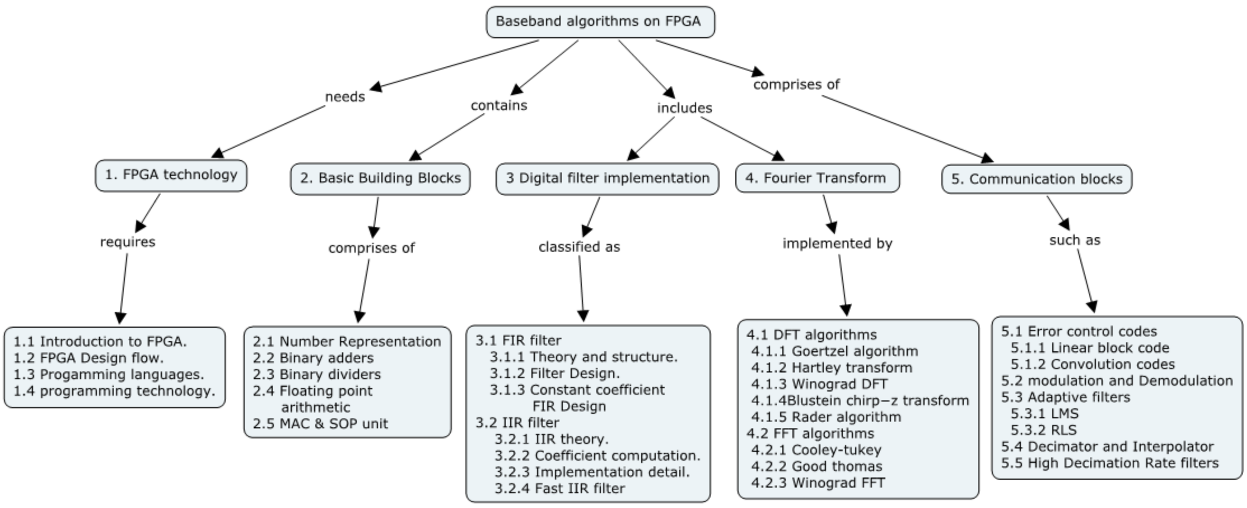
5 Find the transfer function of second order IIR filter having poles at 0.5 and 0.25 using 2 pipelined stages by applying scattered Look-ahead method.

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.

Create

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.

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, 2000
5. Sophocles J. Orfanidis, "Introduction to Signal Processing", Prentice Hall, 1996

Course Contents and Lecture Schedule:

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
	Total Number of hours	50

Course Designers

1. S. Rajaram rajaram_siva@tce.edu
2. V. Vinoth thyagarajan vvtece@tce.edu

Sub code	Lectures	Tutorial	Practical	Credit
WT3G	3	1	-	4

WT3G RF Test and Measurement 3:1
(Common with N3G RF Test and Measurement)

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.

Competencies: At the end of the course the student should be able to

1. Explain the basics of RF measurement and related parameters associated with the sample such as transmission line, RF components and EMI/EMC.
2. Explain the measurement techniques and procedure.
3. Experience testing of RF components/ systems and measurement of electromagnetic emission.
4. Test, analyze and validate the performance RF components and systems
5. Understand and analyze the issues with EMI/EMC through RF testing

Assessment Pattern:

	Bloom's Category	Test 1	Test 2	Test 3/End-semester examination
1	Remember	30	30	20
2	Understand	40	30	40
3	Apply	30	40	40
4	Analyze	0	0	0
5	Evaluate	0	0	0
6	Create	0	0	0

Course Level Learning Objectives:

Remember

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?

Understand:

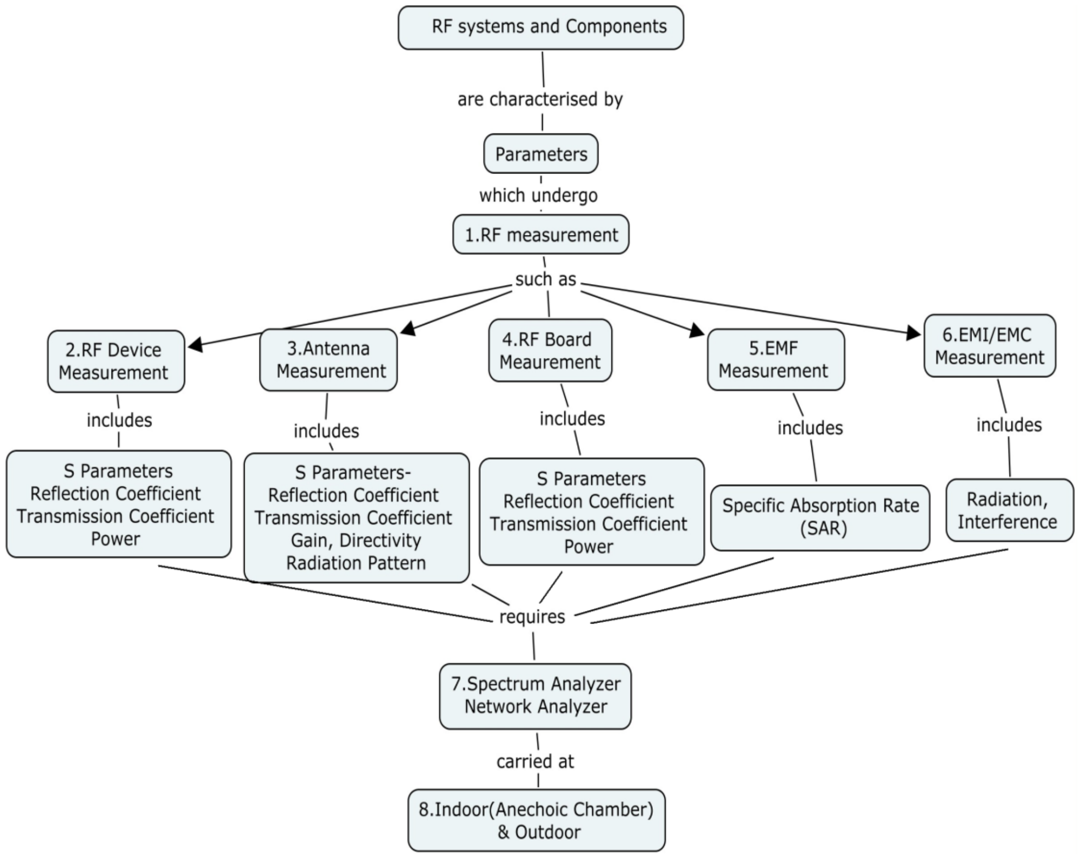
1. Obtain the S parameter of hybrid coupler.
2. How do you measure Z_0 in a printed transmission line fabricated on an ideal dielectric?
3. Compare network analyzer with spectrum analyzer.
4. What are the mandatory requirements for measuring far field pattern of an antenna?
5. What are the effects of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

Apply:

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:

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

Course Designers :

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

Sub Code	Lectures	Tutorial	Practical	Credit
WT3H	3	1	--	4

WT3H Cryptography with Coding Theory 3:1

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.

Competencies: At the end of the course, the student should able to

1. Know about cryptography
2. Explain and analyze classical cryptosystems
3. Describe the basic number theory concepts
4. Determine the data encryption standards and advanced encryption standards
5. Analyse the public key algorithm
6. Determine the hash function
7. Implement the security protocols
8. Configure different cryptographic applications

Assessment Pattern:

	Bloom's Category	Test 1	Test 2	Test 3/End-semester examination
1	Remember	30	20	0
2	Understand	40	40	40
3	Apply	30	40	30
4	Analyze	0	0	30
5	Evaluate	0	0	0
6	Create	0	0	0

Course Level Learning Objectives:

Remember:

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?

Understand:

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

Apply

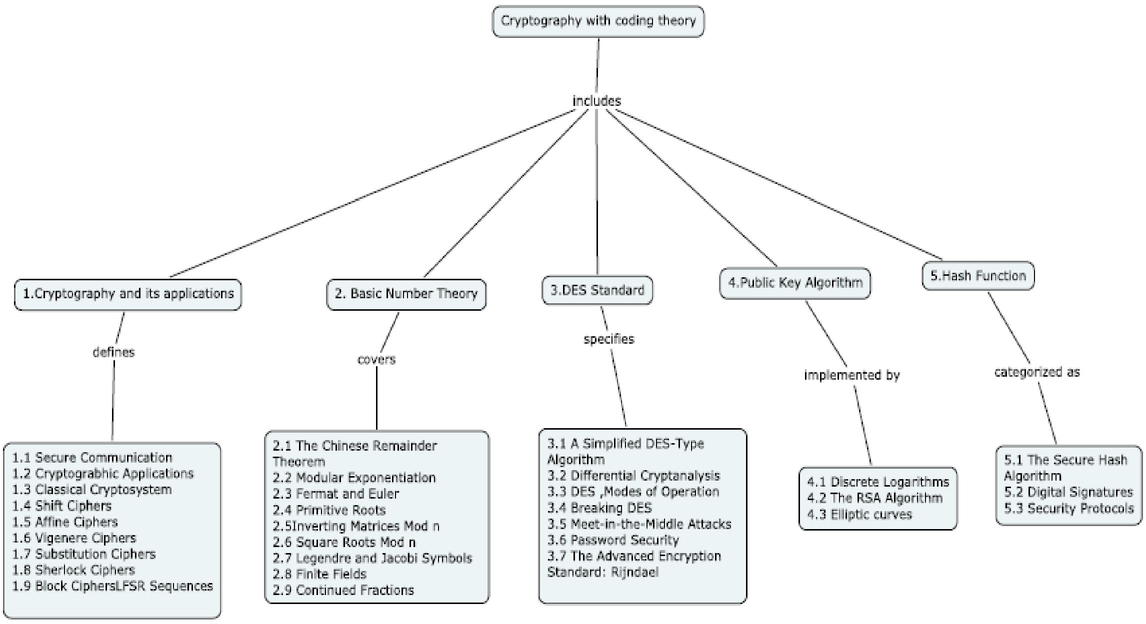
1. Suppose you encrypt using an affine cipher, then encrypt the encryption using another affine cipher (both are working mod 26).Is there any advantage to doing this, rather than using a single affine cipher? Why or why not?
2. Suppose we work mod 27 instead of mod 26 for affine ciphers. How many keys 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?

Analyze

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 Lectures schedule

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 Algorithm	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 Impostors	1
5.3.1	Key Distribution	2
5.3.2	Pretty Good Privacy	2
5.3.3	Secure Electronic Transaction	1
	Total Number of Hours	45

Course Designer:

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

Sub Code	Lectures	Tutorial	Practical	Credit
WT3J	3	1	--	4

WT3J Applied Cryptography 3:1

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

Competencies: At the end of the course, the student should able to

1. Know about fundamentals of cryptography
2. Explain and analyze different key Management concept
3. Describe the cipher concept
4. Configure different cryptographic protocols
5. Implement the different cryptographic schemes
6. Determine the role of secure routing protocols
7. Explain the concept of different cipher stream protocol
8. Design a secure data communication network.

Assessment Pattern

	Bloom's Category	Test 1	Test 2	Test 3/End semester examination
1	Remember	30	20	0
2	Understand	40	40	40
3	Apply	30	40	30
4	Analyze	0	0	30
5	Evaluate	0	0	0
6	Create	0	0	0

Course Level Learning Objectives

Remember

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?

Understand

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.

Apply

1. Let p be a prime and let α be an integer with p ∤ α. 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 ∤ α. Let h(x)= α^x (mod p). Explain why h(x) is not a good cryptographic hash function.

Analyze

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], $s_0 = \begin{pmatrix} 1 & 0 & 3 & 2 \\ 3 & 2 & 1 & 0 \\ 0 & 2 & 1 & 3 \\ 3 & 1 & 3 & 2 \end{pmatrix}$

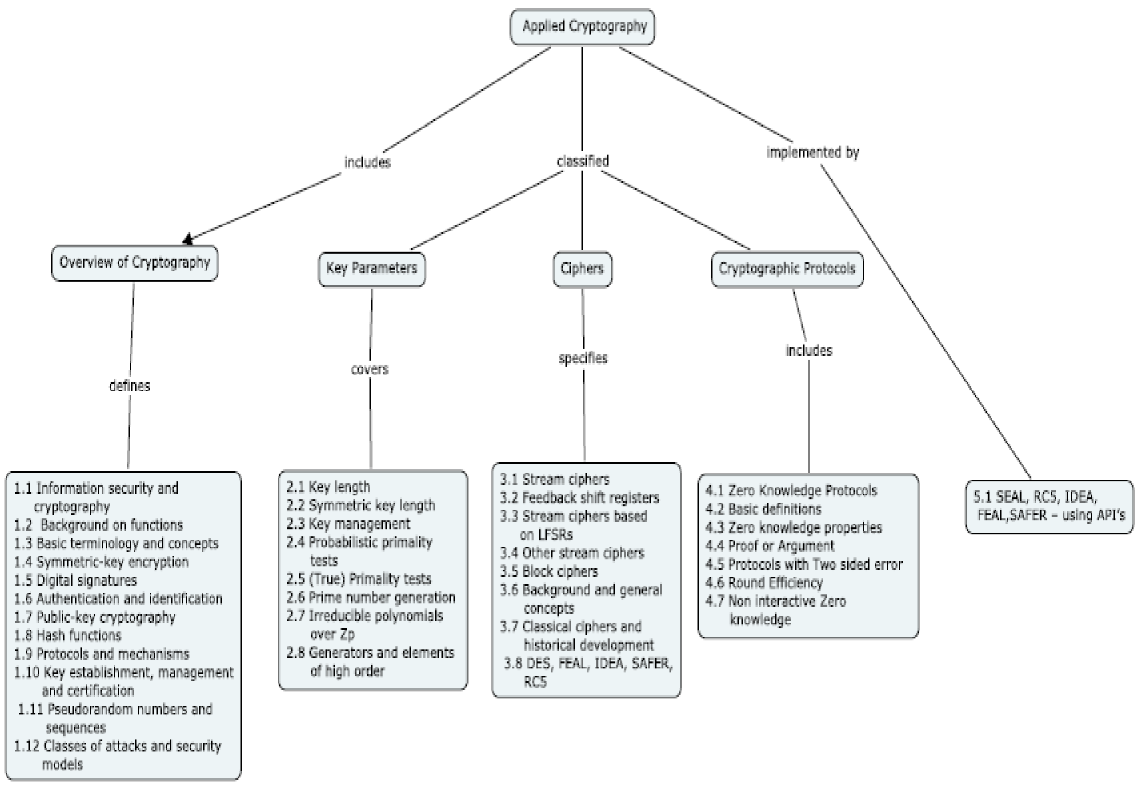
   $s_1 = \begin{pmatrix} 0 & 1 & 2 & 3 \\ 2 & 0 & 1 & 3 \\ 3 & 0 & 1 & 0 \\ 2 & 1 & 0 & 3 \end{pmatrix}$ and p_4=[2 4 3 1] and verify using decryption.

3. Encrypt the term "Network Security" using the Hill cipher with the key

$$k = \begin{bmatrix} 0 & 3 & 0 \\ 0 & 0 & 21 \\ 15 & 0 & 0 \end{bmatrix} \text{ such that } kk^{-1}=I.$$

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

Concept Map:



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 Lectures schedule

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
	Total Number of Hours	45

Course Designer:

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