M. TECH
IN
TELECOMMUNICATION ENGINEERING

CURRICULUM AND DETAILED SYLLABI

2019-2020

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR

M. G. AVENUE

DURGAPUR – 713209

WEST BENGAL

INDIA

CONTENTS

1. Curriculum for M. Tech. in Telecommunication Engineering

(2019-20)

Department of Electronics and Communication Engineering

FIRST SEMESTER

Sl. No	Sub. Code	Subject	L-T-P/S	Credits
1	EC1001	Advanced Digital Communication	4-0-0	4
2	EC1002	Information Theory & Coding	4-0-0	4
3	EC1003	Random Process	4-0-0	4
4	EC90XX	Elective-I	4-0-0	4
5	EC90XX	Elective-II	4-0-0	4
6	EC1051	Telecommunication Laboratory	0-0-4	2
7	EC1052	Term Paper	0-0-4	2
TOTAL			**20-0-8**	**24**

SECOND SEMESTER

Sl. No	Sub. Code	Subject	L-T-P/S	Credits
1	EC2001	Telecommunication Networks	4-0-0	4
2	EC2002	Wireless Communication	4-0-0	4
3	EC90XX	Elective-III	4-0-0	4
4	EC90XX	Elective-IV	4-0-0	4
5	EC90XX	Elective-V	4-0-0	4
6	EC2051	Design and Simulation Laboratory	0-0-4	2
7	EC2052	Project-I	0-0-2	1
8	EC2053	Seminar (Non-Project)	0-0-2	1
TOTAL			**20-0-8**	**24**

THIRD SEMESTER

Sl. No	Sub. Code	Subject	L-T-P/S	Credits
1	EC3051	Project-II	0-0-22	11
2	EC3052	Seminar	0-0-4	2
TOTAL			**0-0-26**	**13**

FOURTH SEMESTER

Sl. No	Sub. Code	Subject	L-T-P	Credits
1	EC4051	Project-III	0-0-22	11
2	EC4052	Seminar & Viva-Voice	0-0-6	3
TOTAL			**0-0-28**	**14**

2. Summary of the Curriculum

Semester	L	T	S	C	H
I	20	0	8	24	28
II	20	0	8	24	28
III	0	0	26	13	26
IV	0	0	28	14	28
Grand Total: [H / C]	40/40	0	70/35	75	110
Grand Total (in %): [H / C]	**36/53**	**0**	**64/47**		

3. Distribution of the credit points and contact hours

A. Core Courses:

Sl. No.	Course Code	Course Title	Credit	Hours
1.	EC1001	Advanced Digital Communication	4	4
2.	EC1002	Information Theory & Coding	4	4
3.	EC1003	Random Process	4	4
4.	EC2001	Telecommunication Networks	4	4
5.	EC2002	Wireless Communication	4	4
Total			**20**	**20**
Total (%)			**27.7%**	**18.2 %**

B. Elective Courses:

Sl. No.	Course Code	Course Title	Credit	Hours
1.	EC 90xx	Elective – I	4	4
2.	EC90xx	Elective – II	4	4
3.	EC90xx	Elective – III	4	4
4.	EC90xx	Elective – IV	4	4
5.	EC90xx	Elective – V	4	4
Total			**20**	**20**
Total (%)			**26.7 %**	**18.2 %**

C. Laboratory and Sessional Courses:

SI. No.	Course Code	Course Title	Credit	Hours
1.	EC1051	Telecommunication Laboratory	2	4
2.	EC1052	Term Paper	2	4
3.	EC2051	Design and Simulation Laboratory	2	4
Total			**6**	**12**
Total (%)			**8 %**	**10.9 %**

D. Project & Seminar:

SI. No.	Course Code	Course Name	Credit	Hours
1.	EC2052	Project-I	1	2
2.	EC2053	Seminar (Non-Project)	1	2
	EC3051	Project-II	11	22
3.	EC3052	Seminar	2	4
	EC4051	Project-III	11	22
4.	EC4052	Seminar & Viva-Voice	3	6
Total			**29**	**58**
Total (%)			**38.7 %**	**52.7 %**

4. List of Elective Courses:

Sl. No.	SUBJECT CODE	SUBJECT	L-T-P	CREDIT
1.	EC9011	COOPERATIVE COMMUNICATION NETWORK	4-0-0	4
2.	EC9012	STATISTICAL SIGNAL PROCESSING	4-0-0	4
3.	EC9013	OPTICAL COMMUNICATION	4-0-0	4
4.	EC9014	QUEUING THEORY FOR TELE- COMMUNICATION	4-0-0	4
5.	EC9015	SOFTWARE ENGINEERING	4-0-0	4
6.	EC9016	COMPUTER SIMULATION OF ELECTRONIC CIRCUITS	4-0-0	4
7.	EC9017	SPEECH SIGNAL PROCESSING	4-0-0	4
8.	EC9018	IMAGE PROCESSING	4-0-0	4
9.	EC9019	MICROPROCESSORS AND MICROCONTROLLER	4-0-0	4
10.	EC9020	NEURAL NETWORKS	4-0-0	4
11.	EC9021	DETECTION AND ESTIMATION THEORY	4-0-0	4
12.	EC9022	FIBRE OPTIC NETWORK	4-0-0	4
13.	EC9023	INFORMATION SECURITY AND CRYPTOGRAPHY	4-0-0	4
14.	EC9024	SATELLITE COMMUNICATION	4-0-0	4
15.	EC9025	MICROWAVE CIRCUITS AND TECHNIQUE	4-0-0	4
16.	EC9026	ADVANCED ANTENNA ARRAY SYNTHESIS	4-0-0	4
17.	EC9027	MICROWAVE MEASUREMENTS AND DESIGN	4-0-0	4
18.	EC9028	NETWORK INFORMATION THEORY	4-0-0	4
19.	EC9029	ANTENNA ANALYSIS AND SYNTHESIS	4-0-0	4
20.	EC9030	ARTIFICIAL INTELLIGENCE AND SOFT COMPUTING	4-0-0	4
21.	EC9031	VOICE AND PICTURE CODING	4-0-0	4
22.	EC9032	OPERATING SYSTEM	4-0-0	4
23.	EC9033	MATHEMATICAL METHOD IN TELECOMMUNICATION	4-0-0	4
24.	EC9034	DIGITAL SIGNAL PROCESSING & APPLICATION	4-0-0	4
25.	EC9035	TELECOMMUNICATION SYSTEM	4-0-0	4
26.	EC9036	EMBEDDED SYSTEMS	4-0-0	4
27.	EC9037	BROADBAND COMMUNICATION	4-0-0	4
28.	EC9038	ERROR CONTROL CODING	4-0-0	4
29.	EC9039	CAD FOR VLSI	4-0-0	4
30.	EC9040	VLSI FOR DIGITAL SIGNAL PROCESSING	4-0-0	4
31.	EC9041	MIXED SIGNAL IC DESIGN	4-0-0	4
32.	EC9042	LOW POWER CIRCUITS AND SYSTEMS	4-0-0	4
33.	EC9043	DSP ARCHITECTURES IN VLSI	4-0-0	4
34.	EC9044	RF IC DESIGN	4-0-0	4
35.	EC9045	SOC DESIGN	4-0-0	4
36.	EC9046	FPGA BASED DESIGN	4-0-0	4
37.	EC9047	MEMS & MICROSYSTEMS TECHNOLOGY	4-0-0	4
38.	EC9048	ARCHITECTURAL DESIGN IN IC	4-0-0	4
39.	EC9049	NANOELECTRONICS	4-0-0	4
40.	EC9050	COMPUTER ARCHITECTURE	4-0-0	4
41.	EC9051	TESTING AND VERIFICATION OF VLSI CIRCUITS	4-0-0	4

Note: Other than the above-mentioned courses, any course including core and elective offered by another PG program of the Department / Institute can be opted as elective subjects without any constraint.

5. Assessment Followed:

The assessment method followed from the academic year 2019-2020 is briefly mentioned as follows.

A. Theory Courses (15 + 25 + 60)

In the subjects, total 100 marks consists of the following three components.

(i) Continuous Assessment 1 (CA1): (15 marks)

This is realized with class tests, quizzes, home assignments, surprise tests or a combination of these components. If more than two class tests are conducted, average marks are considered.

(ii) Continuous Assessment 2 (CA2): (25 marks, 2 hours)

Mid-term examination covers half of the syllabus. The exam is conducted at the middle of the semester following the academic calendar. The evaluation is done within a fortnight and the answer scripts are shown to the students so that they can understand their shortcomings in learning the subject.

(iii) End-term Examination: (60 marks, 3 hours)

End-term examination covers the full syllabus. The exam is centrally conducted at the end of the semester. After the evaluation, the answer scripts are shown to the students. Model answers are also provided.

** It is to be mentioned here that, in the previous two academic years - 2017-2018 and 2018-2019, the assessment methods and distributions of the three components corresponding to the total 100 marks are as given below.

a) Continuous Assessment (CA): 20 marks – This is based on quizzes, home assignments, class test and surprise tests.
b) Mid-Semester Assessment (MA): 30 marks – A mid-semester examination is conducted tentatively within 7-8 weeks after beginning of teaching in each semester.
c) End-Semester Examination: 50 marks – The examination is conducted at the end of teaching session of the semester.

Based on the feedback taken from the concerned stakeholders of the Institute as well as academic, industry and R&D personnel, PG curriculum has been revised in the academic year 2019-2020.

B. Laboratory Courses (40 + 40 + 20)

For the evaluation of Laboratory Courses, total 100 marks has following three components

(i) **Continuous Assessment (CA): 40 marks** – The students are evaluated based on their performance on day to day basis in conducting the experiments and obtaining the experimental results in the Laboratory. Attendance, general attentiveness/ sincerity /behaviour of student and occasional instant quizzes are considered in this component.

(ii) **End-Semester Assessment (EA): 40 marks** – The end-semester evaluation consists of two subcomponents. 20 marks for the performance of the students in conducting the experiment or program assigned during the end-semester examination and 20marks for viva-voce examination.

(iii) **Laboratory Reports: 20 marks**– 20 marks is awarded based on the representation of the experimental results, writing ability of the associated theory, analysis of the obtained results and observation/concluding remarks drawn corresponding to each experiment performed in the laboratory throughout the semester including the end-semester examination.

6. Program Outcomes (POs) and Program Specific Outcomes (PSOs)

A. Program Outcomes (Pos):

NBA has defined the following three POs for the PG programs:

PO 1: An ability to independently carry out research /investigation and development work to solve practical problems

PO 2: An ability to write and present a substantial technical report/document

PO 3: Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program

B. Program Specific Outcomes (PSOs):

In addition to the three POs, 3 program specific outcomes (PSOs) have been defined by the Department as follows -

PSO 1: Understanding mathematical modelling of communication systems and networks

PSO 2: Enhancing the knowledge of RF front end circuit design and radio propagation phenomena

PSO 3: Equip with modern computational and hardware tools for designing communication systems

**** Course Articulation Matrices:** Connection between the courses and the POs and PSOs is given along with the detailed syllabus. The correlation levels are denoted with 1, 2 or 3 as 1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High).

DETAILED SYLLABI OF THE COURSES

A. Core Courses

Department of Electronics and Communication Engineering							
Course Code	**Title of the course**	Program Core (PCR) / Electives (PEL)	**Total Number of contact hours: 43**				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
EC 1001	**Advanced Digital Communication**	PCR	4	0	0	4	4

Pre-requisites:	Course Assessment methods (Continuous (CT) and end assessment (EA))
• Fourier analysis and LTI systems • Fundamentals of analog and digital communications • Basic knowledge of random variables and random processes	Assignments, Quiz, Mid-semester Examination and End Semester Examination

Course Outcomes	**CO1:** **Identify** the fundamental differences between analog and digital communication systems and the explicit need to study digital communication as a separate course. **Identify** building blocks that constitute a digital communication system. **CO2:** **Explain** why each building block is necessary and the working principle of each such block. **CO3:** **Apply** geometric concepts to understand signal constellations and its variants. **Apply** signal processing tools to infer time and frequency domain representation of signals in context to digital communications. **CO4:** **Analyze** error performance of digital communication systems in the presence of additive noise. **CO5:** **Evaluate and access** communication systems based on resource availability (bandwidth, power, etc.) and performance requirement (BER, SER, etc.). **CO6:** **Develop** strong mathematical foundation and intuition to **pursue any advanced topic in communications** (wireless communication, detection and estimation theory, etc.).
Topics Covered	**Module 1.** Introduction **(1 hrs.)** **Module 2.** Autocorrelation, Cross correlation**,** Energy Spectral Density (ESD) and Power Spectral Density (PSD) **(4 hrs.)** **Module 3.** Digital communication through band-limited channels **(3 hrs.)** **Module 4.** Concept of signal space and vector **(5 hrs.)** **Module 5.** Optimum receivers for AWGN channels: Correlation and matched filter receivers **(7 hrs.)** **Module 6.** Fundamentals of Detection and Estimation theory **(7 hrs.)** **Module 7.** Coherent and noncoherent modulation, M-ary modulation techniques **(6 hrs.)** **Module 8.** Spread spectrum for digital communications **(4 hrs.)** **Module 9.** Multichannel communications with OFDM fundamentals **(6 hrs.)** **Total Lecture: 43**
Text Books, and/or reference material	Text Books: 1. S. Haykin, "Digital Communication Systems" , (4th edition), John Willey 2. J. G. Proakis and M. Salehi "Digital Communications" (6th edition), McGrawhill 3. Bernard Sklar, "Digital Communications" (2th edition), Pearson Education Reference Books: 1. Richard van Nee & Ramjee Prasad "OFDM for Multimedia Communications", Artech House

EC 1001: Advanced Digital Communication (Core)
[(Mapping between course outcomes (Cos) and program outcomes (POs)]

CO	Statement	PO 1	PO 2	PO 3	PSO 1	PSO 2	PSO 3
CO 1	Identify the fundamental differences between analog and digital communication systems and the explicit need to study digital communication as a separate course. Identify building blocks that constitute a digital communication system.	2	1	2	3	1	1
CO 2	Explain why each building block is necessary and the working principle of each such block.	2	3	1	3	2	2
CO 3	Apply geometric concepts to understand signal constellations and its variants. Apply signal processing tools to infer time and frequency domain representation of signals in context to digital communications.	3	2	1	2	2	1
CO 4	Analyze error performance of digital communication systems in the presence of additive noise.	3	1	1	3	2	1
CO 5	Evaluate and access communication systems based on resource availability (bandwidth, power, etc.) and performance requirement (BER, SER, etc.).	3	1	1	2	1	2
CO 6	Develop strong mathematical foundation and intuition to pursue any advanced topic in communications (wireless communication, detection and estimation theory, etc.).	2	1	3	3	1	1
Average		**2.5**	**1.5**	**1.5**	**2.7**	**1.5**	**1.3**

<table>
<tr><th colspan="9">Department of Electronics and Communication Engineering</th></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours: 42</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>EC 1002</td><td>Information Theory & Coding</td><td>(CORE)</td><td>4</td><td>0</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="3">Pre-requisites: Probability Theory, Digital Communication Fundamentals</td><td colspan="5">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="3">NIL</td><td colspan="5">Assignments, Quiz, Mid-semester Examination and End Semester Examination</td></tr>
<tr><td>Course Objectives</td><td colspan="7">To understand the role of information theory for an efficient, error-free and secure delivery of information using binary data streams.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: Understand the concept of Information and quantitative form of characterization of information
CO2: Gain knowledge about techniques for information compression and its application
CO3: Understand Channel Capacity and Shannon’s Law on Information capacity. Appreciate information theoretic results as fundamental limits on performance of communication systems
CO4: Understand the fundamentals of Network Information Theory as basic limitation of information flow in a network.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Module 1. Entropy, Relative Entropy and Mutual Information
Introduction, Definition and Measure of Information, Entropy, Joint entropy, Conditional entropy, Relative Entropy and Mutual Information, Chain rules, Jensen inequality, log sum inequality, Data processing Inequality, Fano’s inequality. (8L)
Module 2. Source Coding and Data Compression
Source Coding Theorem, Variable length coding, Kraft inequality, Optimal codes, Lempel Ziv coding, Huffman coding, Shannon Fano Elias coding, Rate distortion function (10L)
Module 3. Channel Capacity
Channel models, Definition and Properties of Channel Capacity, Binary Symmetric Channel, Binary Erasure channel, Symmetric Channels, Channel Coding theorem, Converse to coding theorem.(8L)
Module 4. Differential entropy and Gaussian Channel
Differential entropy, properties of differential entropies, Joint and Conditional differential entropy, Relative Entropy and Mutual information, Gaussian Channel, Information Capacity Theorem, Parallel Gaussian Channels. (8L)
Module 5. Network Information Theory
Discrete Memory less Multiple Access Channel, Gaussian MAC, interfering MAC, Capacity Region, Slepian Wolf-Encoding. (8L)
Total Lecture: 42</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">1. Elements of Information Theory, Thomas M.Cover and Joy.A. Thomas, Wiley
2. Information Theory Coding and Cryptography, Third Edition, Ranjan Bose, McGraw Hill Education Pvt. Limited.
3. Networks Information Theory: Gamal and Kim, Cambridge University Press.</td></tr>
</table>

EC 1002: Information Theory & Coding (Core)
[(Mapping between course outcomes (Cos) and program outcomes (POs)]

CO	Statement	PO 1	PO 2	PO 3	PSO 1	PSO 2	PSO 3
CO 1	Understand the concept of Information and quantitative from of characterization of information.	3	1	1	3	1	1
CO 2	Gain knowledge about techniques for information compression and its application.	2	2	2	3	1	2
CO 3	Understand Channel Capacity and Shannon's Law on Information capacity. Appreciate information theoretic results as fundamental limits on performance of communication systems.	2	2	1	3	1	1
CO 4	Understand the fundamentals of Network Information Theory as basic limitation of information flow in a network.	3	1	3	3	1	1
Average		**2.5**	**1.5**	**1.8**	**3.0**	**1.0**	**1.3**

Department of Electronics and Communication Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	**Total Number of contact hours: 45**				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
EC1003	**Random Process**	PCR	4	0	0	4	4
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
NIL		Assignments, Quiz, Mid-semester Examination and End Semester Examination					
Course Outcomes	**CO1:** Characterize probability models and function of random variables. **CO2:** Evaluate and apply moments & characteristic functions and understand the concept of inequalities and probabilistic limits. **CO3:** Recognize, interpret and apply a variety of deterministic and nondeterministic random processes that occur in engineering. **CO4:** Calculate the autocorrelation and spectral density of a random process and recognize the relation beteen them.						
Topics Covered	**Module 1.** Introduction: Basic of Probability theory, Bernoulli's Trials (3L) **Module 2.** Random Variables: PDF of Continous random variables, PMF of discrete random variables, Conditional probability density function, (6L). **Module 3.** Function of one random variable (3L) **Module 4.** Mean, Variance, Moments, Characteristics functions of random variables (5L) **Module 5.** Two random variables, Joint density and distribution function, Two functions of two random variables (6L) **Module 6.** Stationary random processes, Autocorrelation function, Cross correlation function, Covariance, PSD (7L) **Module 7.** Linear systems with random inputs (4L) **Module 8.** Markov Processes, Markov chain, CTMC, DTMC (6L) **Module 9.** Poisson process, Poissson distribution, Gaussian process (5L) **Total Lecture: 45**						
Text Books, and/or reference material	Text Books: 1. Probability, random variables and stochastic processes- Popoulis, Pillai; TMH 2. Probability, random variables and stochastic processes- Peebles						

EC1003 Random Process (Core)
[(Mapping between course outcomes (Cos) and program outcomes (POs)]

CO	Statement	PO 1	PO 2	PO 3	PSO 1	PSO 2	PSO 3
CO 1	Characterize probability models and function of random variables.	1	2	1	3	1	1
CO 2	Evaluate and apply moments & characteristic functions and understand the concept of inequalities and probabilistic limits.	2	1	2	3	1	1
CO 3	Recognize, interpret and apply a variety of deterministic and nondeterministic random processes that occur in engineering.	2	1	2	3	2	1
CO 4	Calculate the autocorrelation and spectral density of a random process and recognize the relation between them.	1	2	1	3	1	2
Average		**1.5**	**1.5**	**1.5**	**3.0**	**1.3**	**1.3**

Department of Electronics and Communication Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours: 45				Credit
			Lecture (L)	Tutorial (T)	Practical (S)	Total Hours	
EC2001	**Telecommunication Networks**	PCR (Program Core)	4	0	0	4	4

Pre-requisites	Course Assessment methods (Continuous (CT) and end assessment (EA))
1. Communication Engineering 2. Engineering Mathematics	Assignments, Quiz, Mid-semester Examination and End Semester Examination

Course Outcomes

CO1: Understand the basics of traffic engineering.

CO2: Analyze queue performance in traffic conservation.

CO3: Explain the information flow in network traffic.

CO4: Realize the switching classifications.

CO5: Interpret the importance of interconnection networks.

Topics Covered

Module 1: Traffic Engineering [4 hours]
Network traffic load and parameters, grade of service and blocking probability, modelling switching systems, incoming traffic and service time characterization, blocking models and loss estimates.

Module 2: Queuing Analysis [4 hours
Introduction, queue throughput, access probability, traffic conservation, queue performance (M/M/1, M/M/1/B, M^m/M/1/B, M/M^m/1/B, D/M/1/B, M/D/1/B), systems of communicating Markov chains.

Module 3: Modeling Traffic Flow Control Protocols [4 hours]
Leaky bucket, token bucket analysis through M/M/1/B and M^m/M/1/B protocols, virtual scheduling.

Module 4: Modeling Error Control Protocols [4 hours]
Queuing analysis of stop and wait, go-back-N, selective repeat, hybrid ARQ.

Module 5: Modeling Medium Access Control Protocols [6 hours]
Queuing analysis of IEEE 802.1p, ALOHA, slotted ALOHA, IEEE 802.3(CSMA/CD), CSMA/CA, IEEE 802.11 (DCF function for adhoc wireless LANs & PCF function for infrastructure wireless LANs), IEEE 802.11e.

Module 6: Modeling Network Traffic [4 hours]
Flow traffic models, Continuous time modelling (Poison traffic description), Discrete time modelling (interarrival time for Bernoulli traffic), Self-similar traffic, Heavy tailed distributions, Pareto traffic distribution, Traffic data rate modelling with arbitrary source distribution, Interarrival time traffic modelling with arbitrary source distribution, Destination statistics, Packet length statistics, Packet transmission error description.

Module 7: Switches and Routers [5 hours]
Media access techniques (TDMA, SDMA, FDMA, CDMA), Circuit and Packet switching, Packet switching hardware, Basic switch components, Switch functions, Switch performance measures, Switch classifications (input queuing, output queuing, shared buffer, multiple input queuing, multiple output queuing, multiple input /output queuing, virtual routing/virtual queuing).

Module 8: Interconnection Networks [6 hours]
Network design parameters, classification of networks (static assignment TDMA, random assignment TDMA), space division switching (crossbar network contention, arbitration and analysis), multistage interconnection networks, Routing analysis of Generalized cube network, Banyan network, Augmented data manipulator network, Improved logical neighbourhood.

Module 9: Switch Modeling [3 hours]

	Congestion and performance bounds in input and output queuing switch, Performance bounds on shared buffer switch, Comparing these three, modeling other switch types, certain existent types (individual analysis and comparison of Promina 4000 and VRQ switches). **Total Lecture: 45**
Text Books, and/or reference material	Text Books: [T1] Telecommunication Switching Systems and Networks – T. Viswanathan – PHI. [T2] Analysis of Computer Communication and Networks – Fayez Gebali – Springer. Reference Books: [R1] Communication Networks - A. Leon Garcia and I. Widjaja – TMH. [R2] Data communications and Networking – B.A. Forouzan – TMH.

2001 Telecommunication Network (Core)
[(Mapping between course outcomes (Cos) and program outcomes (POs)]

CO	Statement	PO 1	PO 2	PO 3	PSO 1	PSO 2	PSO 3
CO 1	Understand the basics of traffic engineering.	3	1	1	3	2	1
CO 2	Analyze queue performance in traffic conservation.	2	2	2	3	1	2
CO 3	Explain the information flow in network traffic.	2	2	1	3	1	2
CO 4	Realize the switching classifications.	3	1	3	3	1	1
CO 5	Interpret the importance of interconnection networks.	1	1	2	3	2	2
Average		**2.2**	**1.4**	**1.8**	**3.0**	**1.4**	**1.6**

<table>
<tr><td colspan="8">Department of Electronics and Communication Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours: 45</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>EC 2002</td><td>Wireless Communication</td><td>PEL
(Open Elective)</td><td>4</td><td>0</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="2">Pre-requisites: Digital communication Fundamentals</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">NIL</td><td colspan="6">Assignments, Quiz, Mid-semester Examination and End Semester Examination</td></tr>
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<table>
<tr><td>Course Objective</td><td>The course teaches fundamentals of Wireless Communication like Cellular Systems, Wireless Channel models and some Fundamental Physical layer issues</td></tr>
<tr><td>Course Outcomes

After going through the course, student will be able to</td><td>On successful completion of this course, students should have the skills and knowledge to
CO1: Apply Cellular concepts to evaluate the signal reception performance in a cellular network and traffic analysis to design cellular network with given quality of service constraints.
CO2: Determine the type and appropriate model of wireless fading channel based on the system parameters and the property of the wireless medium.
CO3: Analyze and design receiver and transmitter diversity techniques.Determine the appropriate transceiver design of multi-antenna systems and evaluate the data rate performance.
CO4: Application of Fundamental Digital Communication Concepts in Fading Channel. Understanding suitable Modulation Schemes for Wireless Channel
CO5: Describe and differentiate four generations of wireless standard for cellular networks. Understand wireless communication systems with key 3G (e.g., CDMA) and 4G (OFDM) technologies</td></tr>
<tr><td>Topics Covered/ Syllabus</td><td>Module 1. Introduction to Wireless Personal Communication, Mobile radio systems. (02hrs)
Module 2. Cellular systems concepts, principles, system design fundamentals, spectrum efficiency, frequency management, channel assignment, handoff, power control, Call blocking, Erlang B, erlang C, Cell splitting and Directional antenna etc. (06 hrs)
Module 3. Characterization of wireless radio channel, propagation path models. Fading and Shadowing, Statistical Characterization of fading Channel. (08 hrs)
Module 4. Receiver Techniques for fading Channel: Detection of Signal in Fading Channel, Coherent and Non coherent detection Diversity Techniques, Time and Frequency Diversity, Repetition Code, Receive Diversity (SC, MRC, EGC, Switch & Stay), BER and outage with Diversity, Transmit Diversity, Alamouti Code, MIMO fundamentals, Equalization, Fading mitigation. (12 hrs)
Module 5. Capacity of fading Channels: Slow fading Channel, Capacity with Receive Diversity and Transmit diversity, Multi User Capacity (03 hrs)</td></tr>
</table>

	Module 6. Modulation schemes for wireless Communication (MSK, GMSK), OFDM **(05 hrs)** **Module 7.** Multiple access techniques: TDMA, FDMA, spread spectrum techniques, Cellular CDMA, Wide-band CDMA, Multiple access Performance of CDMA, Capacities of multiple access schemes, comparison. **(06 hrs)** **Module 8.** Wireless Networks and Standards: GSM, CDMA cellular standard, 3G, 4G **(03 hrs)** **Total Lecture: 45**
Text Books, and/or Reference material	<u>Text Books</u>: 1. Wireless Communication : Andrea Goldsmith, Cambridge University Press 2. Principles of Modern Wireless Communication Systems Theory and Practice: Aditya K Jagannatham, McGraw-Hill India. 3. Fundamentals of Wireless Communication: David TSE and Pramod Viswanathan, Cambridge University Press <u>Reference Books/materials</u>: 1. Wireless Communications: Principles and Practice: Theodore Rappaport, Pearson, 2nd Edition 2. Wireless Communication: Andreas. F. Molisch , John Wiley and Sons 3. Wireless Communication and Networking: Mark and Zhuang, PHI

EC 2002: Wireless Communication (Core)
[(Mapping between course outcomes (Cos) and program outcomes (POs)]

CO	Statement	PO 1	PO 2	PO 3	PSO 1	PSO 2	PSO 3
CO 1	Apply Cellular concepts to evaluate the signal reception performance in a cellular network and traffic analysis to design cellular network with given quality of service constraints.	1	2	2	2	3	3
CO 2	Determine the type and appropriate model of wireless fading channel based on the system parameters and the property of the wireless medium.	1	1	1	3	3	2
CO 3	Analyze and design receiver and transmitter diversity techniques. Determine the appropriate transceiver design of multi-antenna systems and evaluate the data rate performance.	2	2	1	2	3	2
CO 4	Application of Fundamental Digital Communication Concepts in Fading Channel. Understanding suitable Modulation Schemes for Wireless Channel	2	1	3	3	3	3
CO 5	Describe and differentiate four generations of wireless standard for cellular networks. Understand wireless communication systems with key 3G (e.g., CDMA) and 4G (OFDM) technologies	1	2	3	2	3	2
Average		**1.4**	**1.6**	**2.0**	**2.4**	**3.0**	**2.4**

Laboratory Courses

1. Telecomm Simulation lab (EC 1051)

Course outcomes (Cos):

CO1: To train the students to work with rf and microwave test and measurement instruments

CO2: To enhance the ability to design microwave planar and non-planar components

CO3: Analyse a given signal or system to know the property of a signal or system.

CO4: Design methods to convert analog filters into digital filters (construct simple IIR and FIR filter).

RF and Microwave Group of Lab Assignments

Any Four from the Group

1. Design and simulation of WR-90 waveguide with UG-39 flange and observing the filed characteristics of the TE_{10} mode. CO#2
2. Design and analysis of a Type N to WR-90 waveguide transition CO#2
3. Design and simulation of a rectangular microstrip patch antenna CO#2
4. Design and simulation of quadrature hybrid coupler. CO#2
5. Analysis of a 90º bent microstrip line using electromagnetic simulation. CO#2
6. Design and simulation of a 50-Ohm microstrip line with and without mitering.CO#2
7. Measuring signal power of a mobile radio signal using microwave power meter. CO#1
8. Measuring spectral characteristics of a mobile radio signal with a spectrum analyzer. CO#1
9. Characterization of microwave component using Vector Network Analyzer. CO#1
10. Design and analysis of a half wavelength microstrip planar resonator at 3GHz.CO#2
11. Understanding of basic operation of Spectrum Analyzer.CO#1
12. Design and Characterization of a N Type connector.CO#1
13. Design an characterization of a 3.5 mm MA connector.CO#2

DSP Computational Experiments:

Exp. Ds1. CO#3

a) Find the linear and circular convolution & plot for the following input and system response:

$$x(n) = \{2\ 1\ 3\ \underset{\uparrow}{}\ 5\ 9\}$$

$$h(n) = \{5\ \underset{\uparrow}{5}\ 9\ 8\ 2\}$$

b) Study the Autocorrelation of a given sequence and verify its properties.

Exp. Ds2. CO#3

Choose an N-point discrete-time sequence x[n]. Write MATLAB codes to compute:

a) The N-point DFT using frequency sampling method

b) The N-point DFT by Matrix method

Exp. Ds3. CO#3

Choose any discrete-time sequence x[n]. Write MATLAB codes to perform the following operations on this sequence:

a) x[-n] (Time Reversal)

b) x[n-N] (Time Shifting)

c) x[n/L] (Up-Sampling) with some chosen value of L

d) x[Mn] (Down-Sampling) with some chosen value of M

Exp. Ds4. CO#4

Design using MATLAB

A. Butterworth Low Pass Filter

B. Butterworth High Pass Filter

C. Butterworth Band Pass Filter

D. Design the given LP Butterworth Filter with the following specifications: passband attenuation=4dB, stopband attenuation=30dB, passband frequency=400Hz, stopband frequency=800Hz, sampling frequency=2000Hz.

Exp. Ds5. CO#4

Design a minimum order Low-pass, High-pass FIR filters and an IIR filters with your own specifications. Plot the frequency and phase response and verify whether the design meets the specification. Find the corresponding transfer function and plot the corresponding poles and zeros in z plane.

EC 1051: Telecommunication Laboratory

[(Mapping between course outcomes (Cos) and program outcomes (POs)]

CO	Statement	PO 1	PO 2	PO 3	PSO 1	PSO 2	PSO 3
CO 1	To train the students to work with RF and microwave test and measurement instruments.	2	3	2	2	3	1
CO 2	To enhance the ability to design microwave planar and non-planar components.	2	3	2	2	3	1
CO 3	Analyse a given signal or system to know the property of a signal or system.	3	3	2	2	1	3
CO 4	Design methods to convert analog filters into digital filters (construct simple IIR and FIR filter).	3	3	3	2	1	3
Average		**2.5**	**3.0**	**2.3**	**2.0**	**2.0**	**2.0**

2. Design and Simulation lab EC 2051

Assignments for Telecomm lab (M.Tech 2nd semester)

1. Generation of Discrete and Continuous random variables.

(a) Discrete (i) Poisson (ii) Binomial (iii) Geometric

(b) Continuous (i) Gaussian (ii) Exponential (iii) Lognormal (iv) Rayleigh
(v) Erlang (all rvs from (ii) to (v) are to be generated using Gaussian r.v s only)
(vi) Generate Gaussian from uniform r.v-s

Generate the r.v-s with suitable chosen parameters.

2. (a) Generate the pdf of the r.v-s by simulation. Match the simulated pdf with the corresponding analytical pdf-s. [show this for (b) i , b(iii) and b(iv) cases].

   (b)Generation of pdf of any arbitrary random variable
   (i) U = X+Y, where X and Y are exponential r.v.
   (ii) V=X/Y, X & Y are exponential r.v.

3. (a) Simulation of AWGN channel and BER performance of BPSK.

(Generate BPSK at baseband, Tx through a channel corrupted by Gaussian noise of a given noise var. Rx the signal bit, compare it with Tx bit and estimate BER via no. of iteration).
Plot the BER vs Eb/No.

4. Simulation of BPSK Performance in Rayleigh fading Channel
   Repeat the above Expt no.3 (a) for a Rayleigh faded channel.

References

[1] Simulation Modeling and Analysis , by Kelton & Law, McGrawHill

[2] Contemporary Communication Systems, M.F. Mesiya , McGraw Hill

[3] Modern Communication Systems Using MATLAB, Prakis, Salehi and Bauch, Cengage Learning

[3] Communication Systems Modeling and Simulation using MATLAB and SimuLink
By Raveendranathan, University Press

C01: To understand discrete event simulation and techniques for simulation of Discrete and Continuous random variables. (Expt 1)

C02: To learn simulation of PDF and matching with analytical PDF (Expt. 2)

C03: Understand simulation of Digital modulation in Baseband.Learn techniques for estimation of BER by simulation, Understand the size of iterations, confidence interval etc. (Expt 3)

C04: Simulation of Rayleigh Fading and to learn BER simulation in fading channel. (Expt 4)

CO5: Get Familiarity with developing own program in MATLAB platform. (Expt-1,2,3,4)

EC 2051: Design and Simulation Laboratory

[Mapping between course outcomes (Cos) and program outcomes (POs)]

CO	Statement	PO 1	PO 2	PO 3	PSO 1	PSO 2	PSO 3
CO 1	To understand discrete event simulation and techniques for simulation of Discrete and Continuous random variables.	1	3	2	3	2	3
CO 2	To learn simulation of PDF and matching with analytical PDF.	2	3	2	3	2	3
CO 3	Understand simulation of Digital modulation in Baseband. Learn techniques for estimation of BER by simulation, Understand the size of iterations, confidence interval etc.	2	3	2	3	3	3
CO 4	Simulation of Rayleigh Fading and to learn BER simulation in fading channel.	3	3	2	3	3	3
CO 5	Get Familiarity with developing own program in MATLAB platform.	3	3	3	3	3	3
Average		**2.2**	**3.0**	**2.2**	**3.0**	**2.6**	**3.0**

B. Elective Courses

Department of Electronics and Communication Engineering								
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	**Total Number of contact hours: 43**				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
EC 9012	**Statistical Signal Processing**	PEL	4	0	0	4	4

Pre-requisites	Course Assessment methods (Continuous (CT) and end assessment (EA))
NIL	Assignments, Quiz, Mid-semester Examination and End Semester Examination

Course Outcomes	**CO1:** Understanding **statistical** models in the **analysis** of **signals** using Stochastic processes **CO2:** To familiarize students with application of hypothesis testing to signal and event detection problems. **CO3:** Design and development of optimum filters using classical and adaptive algorithms.
Topics Covered	**Module 1.** **Background and Preview:** The filtering problem, Linear Optimum Filters, Adaptive Filters, Linear Filter Structures, Approaches to develop linear adaptive filters, Adaptive Beamforming (4L) **Module 2.** **Stochastic Processes and Models:** Partial characterization of a discrete-time stochastic process, Mean Ergodic Theorem, Correlation Matrix, Stochastic models, Wold decomposition, Asymptotic stationarity of an autoregressive process, Yule-Walker eqns., complex Gaussian Process, Power Spectral Density and its properties, transmission of stationary process through a linear filter, Power spectrum estimation (6L) **Module 3.** **Weiner Filters:** The statement of Linear Optimum Filtering, Principle of Orthogonality, minimum mean-square error, Wiener-Hopf equations (3L) ***Module 4.*** **Linear Prediction**: Forward Linear Prediction, Backward Linear Prediction (3L), Levinson-Durbin Algorithm, Properties of prediction-error filters, Autoregressive modelling of a stationary random process, Cholesky Factorization, Lattice Predictors, All-pole, All-pass Lattice Filter (5L) **Module 5.** **Method of Steepest Descent**: Basic idea of steepest descent algorithm, Steepest descent applied to Wiener filter, stability, Examples (3L) **Module 6.** **Least-Mean-Square (LMS) Adaptive Filters:** Structure and operation of LMS algorithm, LMS Adaptation algorithm, Statistical LMS theory, comparison between LMS algorithm and steepest descent algorithm, directionality of convergence of the LMS algorithm for non-white inputs, Robustness of the LMS Filter, bounds on step size, transfer function approach for deterministic inputs, Normalized LMS Adaptive filters (6L) **Module 7.** **Method of Least Squares**: Statement of Least Squares Estimation problem. Data windowing, Minimum sum of error squares, Normal Equations and Linear Least Squares Filters, Time-Averaged correlation matrix, Properties of Least Squares estimates, Singular Value Decomposition (SVD), Pseudo-inverse, Interpretation of singular values and singular vectors, Minimum-Norm solution to the Linear Least Squares problem (6L) **Module 8.** **Recursive Least Squares (RLS) Adaptive Filters** - Matrix Inversion Lemma, Exponentially weighted RLS algorithm, selection of the regularizing parameter, Update recursion for the Sum of Weighted Error Squares, Example of a single weight adaptive noise canceller, convergence analysis of the RLS algorithm, Robustness of RLS Filters (5L) **Module 9.** **Kalman Filters**: Recursive MMSE for scalar random variables, Statement of the Kalman Filtering problem, The Innovations process, Estimation of the state using Innovations

	process, Filtering, Initial Conditions, Kalman Filter as the unifying basis for RLS Filters, Kalman Filter variants, the Extended Kalman Filter (5L) **Total Lecture: 43**
Text Books, and/or reference material	**Text Books:** T1 - Adaptive Filter Theory - Simon Haykin (Fourth Edition) **Reference Books:** R1 - Fundamentals of Statistical Signal Processing: Estimation Theory - Steven M. Kay R2 - Statistical Digital Signal Processing and Modeling - Monson H. Hayes R3 - Probability, Random Variables and Stochastic Processes - Athanasios Papoulis and S. Unnikrishna Pillai

EC 9012: Statistical Signal Processing
[Mapping between course outcomes (Cos) and program outcomes (POs)]

CO	Statement	PO 1	PO 2	PO 3	PSO 1	PSO 2	PSO 3
		Program Outcomes					
CO 1	Understanding **statistical** models in the **analysis** of **signals** using Stochastic processes	3	2	3	3	1	2
CO 2	To familiarize students with application of hypothesis testing to signal and event detection problems.	3	2	3	3	1	2
CO 3	Design and development of optimum filters using classical and adaptive algorithms.	3	2	3	3	1	3

Department of Electronics and Communication Engineering								
Course Code	**Title of the course**	Program Core (PCR) / Electives (PEL)	**Total Number of contact hours: 40**					Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours		
EC 9013	**Optical Communication**	PEL	4	0	0	4		4

Pre-requisites:	Course Assessment methods (Continuous (CT) and end assessment (EA))
• Electronic Devices and Circuits • Electromagnetic fields Theory • Analog and Digital Communication	Assignments, Quiz, Mid-semester Examination and End Semester Examination

Course Outcomes	**CO1:** Students will be able to learn the intricacies of design constraints at optical frequency. **CO2:** The basic training for understanding circuits and system level implementation in lightwave technology. **CO3:** The students can design components and choose appropriate sources and receivers for an optical network. **CO4:** Understanding the usage of OTDR in monitoring an optical communication system.
Topics Covered	**Module 1.** **Introduction to optical communication:** Overview of general communication, advantages of optical communication; Shannon noiseless coding theorem and Shannon noisy coding theorem. **2H** **Module 2.** **Optical Fiber:** Classification of Fibers, Fiber materials and fabrication methods, Ray optics representation and wave optics representation for step index and graded index fibers, Modes, Phase and group velocity, Power flow in step index fibers.**8H** **Module 3.** **Propagation Characteristics in Optical Fibers:** signal attenuation in fiber, dispersion, classification and effect of dispersion in information transfer, review of fiber connectors, couplers, optical filter, isolator, circulator and attenuator.**6H** **Module 4.** **Design aspects of optical communication:** optical fiber systems, modulation schemes, digital and analog fiber communication system, system design consideration, emitter and detector design, fiber choice, connectors, various amplifiers and its characteristics; OTDR **8H** **Module 5.** **Optical transmitter:** Basic concepts, characteristics of semiconductor injection LASER, LED, transmitter design **2H** **Module 6.** **Optical Receiver:** Basic concepts, p-n and p-i-n photo detectors, Avalanche photo detectors, MSM photo detector, receiver design, receiver noise, receiver sensitivity, optical amplifier and its applications; Direct detection; Coherent communication: Basic concept, detection principles, practical considerations, modulation and demodulation schemes, heterodyne and homodyne detection, single and multicarrier systems, DPSK system. **6H** **Module 7.** **Wavelength division multiplexing (WDM):** multiplexing techniques, topologies and architectures, wavelength shifting, WDM demultiplexer, optical add/drop multiplexers. **4H** **Module 8.** **Dense wavelength division multiplexing (DWDM):** system considerations, multiplexers and demultiplexers; Fiber amplifier for DWDM, SONET/SDH transmission, modulation formats, NRZ and RZ signaling, DPSK system modeling. Potential applications and future prospects of optical fibers, multimode intensity sensors and single mode, Interferometric sensors. Recent trends in optical communication.**4H** **Total Lecture: 40**

Text Books, and/or reference material	**Text Books:** [1] J. M. Senior, "Optical Fiber Communications", PHI, 2nd Ed. [2] G. Keiser, "Optical Fiber Communication", McGraw Hill, 3rd Ed. [3] Ghatak & Thyagarajan, "Introduction to fiber Optics", Cambridge University press. [4] Henry Zanger and Cynthia Zanger, *Fiber Optics Communication and Other Application*, Macmillan Publishing Company, Singapore 1991. **Reference Books:** [1] J.H.Franz&V.K.Jain, "Optical Communications", Narosa Publishing House. [2] Ghatak&Thyagarajan, "Contemporary Optics", Series Title: Optical Physics and Engineering, Springer [3] AmnonYariv and PochiYeh, Photonics: Optical electronics for Modern Communication, 6th Ed., New York, Oxford University Press

EC 9013 Optical Communication
[Mapping between course outcomes (Cos) and program outcomes (POs)]

CO	Statement	Program Outcomes					
		PO1	**PO2**	**PO3**	**PSO1**	**PSO2**	**PSO3**
CO1	Students will be able to learn the intricacies of design constraints at optical frequency.	**1**	**1**	**2**	**2**	**3**	**1**
CO2	The basic training for understanding circuits and system level implementation in lightwave technology.	**3**	**2**	**3**	**2**	**1**	**2**
CO3	The students can design components and choose appropriate sources and receivers for an optical network.	**2**	**1**	**3**	**1**	**2**	**1**
CO4	Understanding the usage of OTDR in monitoring an optical communication system.	**2**	**2**	**3**	**2**	**2**	**2**

<table>
<tr><th colspan="9">Department of Electronics and Communication Engineering</th></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours: 43</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>EC 9014</td><td>Queuing Theory for Telecommunication</td><td>PEL (Program Elective)</td><td>4</td><td>0</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">1. Communication Networks
2. Engineering Mathematics</td><td colspan="6">Assignments, Quiz, Mid-semester Examination and End Semester Examination</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: To understand the concept of queuing models and apply in Engineering
CO2: To understand significance of advanced queuing theory in Communication Networks
CO3: To develop expertise to analyse and design Communication Networks</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Module 1. Problem Overview [4 hours]
Introduction to stochastic process, Evolution of queuing and queuing network models and their optimization for traffic congestion and performance.

Module 2. Mathematical Models and Properties of Queues [6 hours]
Modelling of infinite and finite buffer queuing networks especially analysing four categories of queuing networks (Product Form, Non-Product Form, Blocking, Transportation and Loss queues).

Module 3. Transportation and Loss Queues [7 hours]
State dependent M/G/c/c queues and queuing network models incorporating micro and macro aspects of traffic flow to capture throughput volume, speeds, density and congestion in transportation systems.

Module 4. Open Queuing Network Algorithms [7 hours]
Topological network design and computer implementation for performance and optimization of Product Form (Jackson) network, Non-Product Form networks (queuing network approximation algorithm of Whitt), Blocking networks (Expansion method for exponential blocking, generalized expansion method for more general distributions).

Module 5. Closed Queuing Network Performance Models [8 hours]
Product Form networks (Gordon and Newell algorithms), Non-Product Form networks through generalized service time distributions, closed queuing analysis of Blocking networks, movement of goods from one queue to another in closed transportation and loss networks.

Module 6. Optimal Resource Allocation Problems in Topological Network Design [9 hours]
Resource allocation problems in improving stochastic flow process, Accessibility and egress addressed optimal routing optimization in design of queues, Optimal topology problems examined through integer and non-linear programming aspects (fixed and spatially generated topology).
Total Lecture: 43</td></tr>
</table>

Text Books, and/or reference material	Text Book: [T1]. Introduction to Queuing Networks, Theory and Practice – Smith, J. MacGregor (Springer). Reference Book: [R1]. Data Networks – D. Bertsekas and R. Gallager (Prentice Hall).

EC 9014 Queuing Theory for Telecommunication
[Mapping between course outcomes (Cos) and program outcomes (POs)]

CO	Statement	Program Outcomes					
		PO1	**PO2**	**PO3**	**PSO1**	**PSO2**	**PSO3**
CO1	To understand the concept of queuing models and apply in Engineering	**3**	**2**	**3**	**3**	**1**	**2**
CO2	To understand significance of advanced queuing theory in Communication Networks	**3**	**2**	**3**	**3**	**1**	**1**
CO3	To develop expertise to analyse and design Communication Networks	**3**	**2**	**3**	**3**	**1**	**1**
CO4							

<table>
<tr><th colspan="9">Department of Electronics and Communication Engineering</th></tr>
<tr><td rowspan="2">Total Number of contact hours</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours: 41</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>EC 9021</td><td>Detection and Estimation Theory</td><td>PEL</td><td>4</td><td>0</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">NIL</td><td colspan="6">Assignments, Quiz, Mid-semester Examination and End Semester Examination</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: To familiarize students with Classical Statistical Inference Techniques and their applications to Communication and Signal processing
CO2: To familiarize students with Signal Detection Theory
CO3: To develop required mathematical skills for design and implementation of statistical signal processing algorithm</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Module 1. Review of random variables, stochastic processes and vector spaces (3L)
Module 2. Introduction to detection theory – The motivation (1L)
Module 3. Simple binary hypothesis testing. Concepts of apriori probabilities, cost functions and risk, probability of false alarm, probability of detection, probability of miss, likelihood ratios (3L)
Module 4. Baye's Hypothesis Tests: Maximum likelihood (ML) detection, Maximum aposteriori probability (MAP) detection, decision regions. Solved examples (4L)
Module 5. Minimax tests (2L)
Module 6. Neyman Pearson tests (1L)
Module 7. Performance evaluation: Receiver Operating Characteristic (ROC) (2L)
Module 8. M-ary hypothesis tests: Baye's criterion with decision regions (2L)
Module 9. Estimation Theory:
The motivation (1L)
Random parameters Baye's Estimation (2L)
Real (non-random) parameter estimation: Cramer-Rao bounds (3L)
Multiple parameter estimation (2L)
Composite hypothesis (3L)
Module 10. The General Gaussian problem: Definition, Equal Covariance matrix (independent components with equal variance, independent components with unequal variance, and the general case), Equal Mean Vectors (i.i.d signal components, i.n.i.d signal components, arbitrary signal components) (8L)
Module 11. Performance bounds and approximations (4L)
Total Lecture: 41</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Text Books: T1 – Detection, Estimation and Modulation Theory (Part I) – Harry L Van Trees
Reference Books: R1 – Decision and Estimation Theory – James L Melsa and David L Cohn
R2 – Probability, Random Variables and Stochastic Processes – Athanasios Papoulis and S. Unnikrishna Pillai</td></tr>
</table>

EC 9021 Detection and Estimation Theory (Elective)

[Mapping between course outcomes (Cos) and program outcomes (POs)]

CO	Statement	PO 1	PO 2	PO 3	PSO 1	PSO 2	PSO 3
		Program Outcomes					
CO 1	To familiarize students with Classical Statistical Inference Techniques and their applications to Communication and Signal processing	3	3	3	3	1	2
CO 2	To familiarize students with Signal Detection Theory	3	3	3	3	1	2
CO 3	To develop required mathematical skills for design and implementation of statistical signal processing algorithm	3	3	3	3	1	3

<table>
<tr><th colspan="9">Department of Electronics and Communication Engineering</th></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours: 41</td><td rowspan="2" colspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>EC 9018</td><td>Image Processing</td><td>PEL</td><td>4</td><td>0</td><td>0</td><td>4</td><td colspan="2">4</td></tr>
<tr><td colspan="3">Prerequisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="3">1. Signals and Systems
2. Digital Electronics
3. Digital Signal Processing</td><td colspan="6">Assignments, Quiz, Mid-semester Examination and End Semester Examination</td></tr>
<tr><td colspan="2">Course Outcomes</td><td colspan="7">CO1: Understand image enhancement and restoration techniques.
CO2: Analyze digital images through multiresolution techniques.
CO3: Understand the application of morphological processing and segmentation in digital images.
CO4: Interpret digital image recognition techniques.</td></tr>
<tr><td colspan="2">Topics Covered</td><td colspan="7">Module 1. Digital Image Fundamentals: Image acquisition, Sampling, Quantization, Resolution, Relationship between pixels, Geometric transforms, Convolution and Correlation. (4L)
Module 2. Image Enhancement: Gray level intensity transforms, Histogram processing, Image sharpening and smoothening operations (spatial and frequency based). (7L)
Module 3. Image Restoration: Model of image degradation, Noise models, Restoration in the presence of noise only spatial filtering, Periodic noise reduction by frequency domain filtering, Estimating the degradation function, Weiner filtering, Constrained least squares filtering, Image interpolation and resampling. (5L)
Module 4. Multi-resolution Image Processing: Short time Fourier transform, Wavelet function, Wavelet series, Discrete wavelet transform and multi-resolution analysis, Image decomposition and compression using discrete wavelet transform. (5L)
Module 5. Compression and Encoding of Image: Redundancy, Entropy coding, Lossy compression, Lossless compression, Quality preserving adaptive compression. (4L)
Module 6. Morphological Processing: Dilation and erosion, Opening and closing, Hit or Miss transform, Algorithms for feature extraction. (4L)
Module 7. Image Segmentation: Detection of discontinuities, Edge linking and boundary detection, Thresholding, Region based segmentation, Segmentation by morphological watersheds, Use of motion in segmentation. (6L)
Module 8. Patterns in Images and their Applications: Basics of features, Principal component analysis, Decision tree and feature hierarchy, Scale invariant feature transform, Histogram of oriented gradient. (6L)
Total Lecture: 41</td></tr>
<tr><td colspan="2">Text Books, and / or reference material</td><td colspan="7">Text Books:
1. Digital Image Processing: R C Gonzalez and R E Woods; Pearson Education.
2. Guide to Signals and Patterns in Image Processing- Foundations, Methods and Applications: Apurba Das; Springer.
3. Digital Image Processing and Computer Vision: Sonka, Hlavac and Boyle; Cengage Learning (India Edition).
Reference Books:
1. Digital Image Processing: K R Castleman; Pearson Education.
2. Digital Image Processing: S Sridhar; Oxford Higher Education.</td></tr>
</table>

EC 9018 Image Processing (Elective)

[Mapping between course outcomes (Cos) and program outcomes (POs)]

CO	Statement	PO 1	PO 2	PO 3	PSO 1	PSO 2	PSO 3
		Program Outcomes					
CO 1	**Understand** image enhancement and restoration techniques	3	3	3	3	3	2
CO 2	**Analyze** digital images through multiresolution techniques	3	3	3	3	3	2
CO 3	**Understand** the application of morphological processing and segmentation in digital images	3	3	3	2	2	2
CO 4	**Interpret** digital image recognition techniques	3	3	3	3	2	2
Average		**3**	**3**	**3**	**2.75**	**2.5**	**2**

Department of Electronics and Communication Engineering								
Course Code	**Title of the course**	Program Core (PCR) / Electives (PEL)	**Total Number of contact hours: 40**				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
EC 9024	**Satellite Communication**	PEL	3	1	0	4	4

Pre-requisites:	Course Assessment methods (Continuous (CT) and end assessment (EA))
1. Knowledge in Electromagnetic fields with problem solving capability (studied in EM Theory). 2. Analog and Digital Communication 3. Introductory knowledge on information theory and coding	Assignments, Quiz, Mid-semester Examination and End Semester Examination

Course Outcomes

CO1: To compute the satellite orbit parameters, design orbits and can be able to classify them based on Kepler's six elements.

CO2: Understand the concept of satellite launching and positioning of satellites in orbits

CO3: Can do computations of link design and classify different losses in propagation for space communication.

CO4: Assimilate the concept of multiple accessing technique in satellite communication.

CO5: Develop ability to classify different types of application of satellite communication.

Topics Covered

Module 1. Historical background, Basic concepts, Frequency allocation for satellite services, orbital & spacecraft problems, comparison of networks and services, modulation techniques used for satellite communication. Spectrum Management **(2L)**

Module 2. Orbits- Two body problem, orbital mechanics, geostationary orbit, change in longitude, orbital manoeuvres, orbital transfer, and orbital perturbations. Launch Vehicles- principles of Rocket propulsion, powered flight, Launch vehicles for communication satellite **(8L)**

Module 3. RF link- noise, the basic RF link, satellite links (up and down) , optimization RF link, inter satellite link, noise temperature, Antenna temperature, overall system temperature, propagation factors, rain attenuation model. Tropospheric and Ionospheric effect. **(8L)**

Module 4. Satellite subsystems and satellite link design- Altitude and orbit control (AOC) Subsystem, TT&C, power system, spacecraft antenna, transponder, Friis transmission equation, G/T ratio of earth station. **(8L)**

Module 5. Multiple access- FDMA, TDMA, CDMA techniques, comparison of multiple access techniques, error connecting codes. **(8L)**

Module 6. Application of satellite in remote sensing and surveillance; Basic of remote sensing, Electromagnetic Radiation principles, Atmospheric window, Indian satellite sensing satellite system, Active, Passive, ground based and space based remote sensing. **(6L)**

Total Lecture: 40

Text Books, and/or reference material	**Text Books** [1] Dennis Roddy, *Satellite Communication*, 4/e, McGraw Hill [2] Louis J. Ippolito, Jr.*SatelliteCommunications Systems Engineering: Atmospheric Effects, Satellite Link Design and System Performance*, Second Edition. **Reference Books** [3] Recommendation ITU-R P.618-11, P Series Radio Wave Propagation. [4] Pratt and Bostian, *Satellite Communication*, 2/e, John Wiley and Sons. [5] Floyd F. Sabins, *Remote Sensing: Principles and Interpretation*, 3rd edition (August 1996), W H Freeman & Co. [6] Tri T Ha, *Digital Satellite Communication*, McGraw Hill

EC9024 Satellite Communication (Elective)
[Mapping between course outcomes (Cos) and program outcomes (POs)]

CO	Statement	Program Outcomes					
		PO1	PO2	PO3	PSO1	PSO2	PSO3
CO1	To compute the satellite orbit parameters, design orbits and can be able to classify them based on Kepler's six elements.	1	1	2	2	3	1
CO2	Understand the concept of satellite launching and positioning of satellites in orbits	3	2	3	2	1	2
CO3	Can do computations of link design and classify different losses in propagation for space communication.	2	1	3	1	2	1
CO4	Assimilate the concept of multiple accessing techniques in satellite communication.	2	2	3	2	2	2
CO5	Develop ability to classify different types of application of satellite communication.	1	3	2	2	1	3

<table>
<tr><td colspan="9">Department of Electronics and Communication Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours: 40</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>EC 9025</td><td>Microwave Circuits and Techniques</td><td>PEL</td><td>4</td><td>0</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="3">Pre-requisites:</td><td colspan="5">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="3">1. Knowledge in Electromagnetic fields with problem solving capability (studied in EM Theory).
2. Analog circuits
3. Optional acquaintance to a preliminary course of microwave engineering.</td><td colspan="5">Assignments, Quiz, Mid-semester Examination and End Semester Examination</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: Students will be able to learn the intricacies of design constraints at high frequency.
CO2: The basic training for understanding circuit design at microwave frequencies for our Country's defense and space applications would be enriched.
CO3: The students can design planar circuits and can provide reasoning for the obtained results.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Module 1. Introduction: Microwave and mm wave spectrum, Typical applications of microwave and mm wave, Safety considerations. Difference in High frequency and relatively low frequency behaviour of Lumped circuit components. Miniaturization and design of Lumped components at high RF. Realization of reactive elements as microwave and mm wave planar circuit components.[1][2] 2H
Module 2. Review of Transmission line theory. Concept of Scattering Matrix N-port networks-Properties of S matrix, Transmission matrix and their relationships 4H
Module 3. Microwave and mm wave Waveguide and Resonators
Rectangular Waveguide- design consideration, TE and TM modes, TE_{10} mode analysis, cut-off frequency, propagation constant, intrinsic wave impedance, phase and group velocity, power transmission,attenuation, waveguide excitation, wall current; Introduction of circular waveguide; Rectangular waveguide resonator design consideration, resonant frequency, Q-factor, excitation.[1][3] 6H
Module 4. Planar Transmission lines and Resonators
Propagation characteristics, comparison for different characteristics of the above mentioned lines. strip line, micro-strip line, coplanar waveguide, Slot line-design consideration, Substrate integrated waveguide, non radiating dielectric guides, Design synthesis and analysis[1][2] 6H
Module 5. Passive Components and their S-matrix Representation
Microwave and mm wave passive components and their S matrix representation: Attenuators, Phase shifter, Directional coupler, Bethe-hole coupler, magic tee, hybrid ring, circulators, Isolators; design of planar power dividers and couplers; design procedure of filter using insertion loss method-specification, low-pass prototype design, scaling and conversion, implementation. [2][3] 8H
Module 6. Microwave and mm wave devices and Application to switches and mixers
TED (Gunn diode) & Avalanche Transit Time (IMPATT) device, Schottky diode, PIN & applications; Microwave bipolar transistor, Microwave field effect transistor. [2] 6H
Module 7. Microwave Amplifier Design
Basic consideration in the design of microwave amplifier- transistor S-parameter, Stability, matching network, noise figure; matching network design using lumped elements and L-Section. Design of LNA.[1][4] 6H
Module 8. Microwave and mm wave measurement basics
VSWR meter, tunable detector, slotted line and probe detector, spectrum analyzer, network analyzer, measurement of VSWR – low, medium and high, measurement of power: low, medium and high, frequency measurement.[1][4] 4H
Total Lecture: 40</td></tr>
</table>

Text Books, and/or reference material	**Text Books:** [1] David. M. Pozar, *Microwave Engineering*, 2/e, 1998 (John Wiley & Sons). [2] R Ludwig and P Bretchko, *RF Circuit Design: Theory and Application*, Pearson Education, New Delhi [3] Samuel Y Liao, *Microwave Devices and Circuits*, 3/e, PHI. [4] Sisodia and Raghuvanshi, *Microwave Circuits and Passive Devices*, New Age International [5] G H Bryant, *Principles of microwave Measurement*, London : P. Peregrinus Ltd. on behalf of the Institution of Electrical Engineers, c1988 **Reference Books:** [1] P A Rizzi, *Microwave Engineering: Passive Circuits*, 2000, PHI [2] R E Collin, *Foundations of Microwave Engineering*, John Wiley and Sons India Pvt. Ltd.

EC 9025: Microwave Circuits & Techniques (Elective)
[Mapping between course outcomes (Cos) and program outcomes (POs)]

CO	Statement	PO 1	PO 2	PO 3	PSO 1	PSO 2	PSO 3
CO 1	Students will be able to learn the intricacies of design constraints at high frequency.	2	1	2	2	3	1
CO 2	The basic training for understanding circuit design at microwave frequencies for our Country's defense and space applications would be enriched.	2	3	1	1	3	1
CO 3	The students can design planar circuits and can provide reasoning for the obtained results.	3	2	1	1	3	1
Average		**2.3**	**2.0**	**1.3**	**1.3**	**3.0**	**1.0**

Department of Electronics and Communication Engineering							
Course Code	**Title of the course**	Program Core (PCR) / Electives (PEL)	**Total Number of contact hours: 41**				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
EC9029	**Antenna Analysis and Synthesis**	PEL	4	0	0	4	4

Pre-requisites:	Course Assessment methods (Continuous (CT) and end
• Knowledge of electromagnetic engineering and transmission lines • Analog and digital Communication systems • Wireless communication (optional)	Assignments, Quiz, Mid-semester Examination and End Semester Examination

Course Outcomes	After the completion of the course the student will be able to **CO1:** **Ability to characterize** resonance and radiation property of an antenna based on application **CO2:** **Learn** various design parameters that affects an antenna and antenna array patterns. **CO3:** **Understand** different types of antenna based on the radiation mechanism like wire antenna, aperture antennas, traveling wave antenna. **CO4:** **Understand** different types of antenna based on the design mechanism like log periodic antenna, log spiral antenna and electrically long antenna as well as electrically small antenna. **CO5:** **Design** suitable antenna feeding mechanism as well as matching mechanism.
Topics Covered	**Module 1.** Brief review on Antenna Fundamentals; Vector potentials and solution of the vector potential wave equation; Antenna theorems and definitions. [3L] **Module 1.** Radiation theory and derivation of dipole, loop antennas; Log-periodic antenna, Log spiral principle, Chu's limit. [6L] **Module 2.** Antenna element design and characterization; Linear, planar and circular array theorems and pattern synthesis. [5L] **Module 3.** Integral Equations, Moment method, self and mutual impedances [5L] **Module 4.** Scanning antennas; signal processing antennas, travelling wave and broadband antennas, Concepts of Smart Antennas. [5L] **Module 5.** Microstrip antennas - Operating principle, modes, field patterns, Impedance, Feeding techniques, polarization, Arrays and feed network. [5L] **Module 6.** Aperture antennas – Hygen's principle, Babinet's Principle, Fourier Transform theory and its applications, The Geometrical Theory of Diffraction and Uniform theory of diffraction techniques and their applications. [6L] **Module 7.** Antenna measurements - Antenna Ranges, Impedance Measurements, RadiationPatterns, Gain Measurements, Directivity, Measurements, RadiationEfficiency, Current Measurements, PolarizationMeasurements [6L] **Total Lecture: 41**

Text Books, and/or reference material	**Text Books:** 4. C. A. Balanis, *Antenna Theory : Analysis and Design*, John Wiley & Sons, 2004 5. John D.Kraus, Ronald J.Marhefka "Antennas for all Applications" Fourth Edition, Tata McGraw- Hill, 2006. **Reference books:** 3. E C Jordan and K G Balmain, *Electromagnetic Waves & Radiating Systems*, Pearson 4. R. C. Johnson and H. Jasik, "Antenna Engineering hand book", Mc-Graw Hill, 1984. 5. I. J. Bhal and P. Bhartia, "Micro-strip antennas", Artech house, 1980. 6. Online Reference Material(s): 1. https://nptel.ac.in/courses/117107035/

EC 9029: Antenna Analysis & Synthesis (Elective)
[Mapping between course outcomes (Cos) and program outcomes (POs)]

CO	Statement	PO 1	PO 2	PO 3	PSO 1	PSO 2	PSO 3
CO 1	Ability to characterize resonance and radiation property of an antenna based on application.	3	1	2	2	3	1
CO 2	Learn various design parameters that affects an antenna and antenna array patterns.	3	2	1	2	3	2
CO 3	Understand different types of antenna based on the radiation mechanism like wire antenna, aperture antennas, traveling wave antenna.	2	1	1	2	3	1
CO 4	Understand different types of antenna based on the design mechanism like log periodic antenna, log spiral antenna and electrically long antenna as well as electrically small antenna.	2	1	1	1	3	1
CO 5	Design suitable antenna feeding mechanism as well as matching mechanism.	2	1	1	2	3	2
CO 6	Analyze and synthesize different types of antennas for different wireless communications.	3	3	3	3	3	1
Average		**2.5**	**1.5**	**1.5**	**2.4**	**3.0**	**1.3**

Department of Electronics and Communication Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	**Total Number of contact hours: 40**				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
EC9030	**Artificial Intelligence and Soft Computing**	PEL (Dept. Elective)	4	0	0	4	4

Pre-requisites:	Course Assessment methods (Continuous (CT) and end assessment (EA))
NIL	Assignments, Quiz, Mid-semester Examination and End Semester Examination

Course Outcomes	**CO1:** Basics of optimization and soft computing algorithms **CO2:** Learn different soft computing algorithms **CO3:** Learn artificial neural network and its training **CO4**: Study of radial basis function neural and its training **CO5**: Study of machine learning algorithms and clustering
Topics Covered	**Module 1. Introduction to Optimization and soft computing algorithms [08 hrs.]** Introduction to optimization, Constrained and unconstrained optimization, Introduction to Optimization based on soft computing, Genetic algorithms, Quantum particle swarm optimization, Whale optimization, Crow search algorithm. **Module 2. Review of different soft computing algorithms part-I [07 hrs.]** Flower pollination algorithm, Teaching learning based optimization, Sine cosine algorithm, Moth flame optimization. **Module 3. Review of different soft computing algorithms part-II [05 hrs.]** Backtracking search optimization Algorithm, Particle swarm optimization, Firefly algorithm **Module 4. Basics of artificial neural network and its training [07 hrs.]** Introduction to artificial neural network, Supervised Learning Neural Networks, Perceptrons, Adaline, Multilayer feed forward neural network, Training of neural network using backpropagation algorithm, Training of neural network using soft computing technique **Module 5. Radial basis function neural networks and K-means clustering [06 hrs.]** Radial Basis Function Neural Networks (RBF), Training of RBF using pseudo inverse technique ,Data clustering using K-means **Module 6. Study of machine learning algorithms [07 hrs.]** Extreme learning machine (ELM), Kernel based ELM, Random vector functional link neural network (RVFL), Training and testing of ELM and RVFLCNN. **Total Lecture: 40**
Text Books, and/or reference material	Text Books: 1. Principles of Soft Computing, S N Sivanandam, S. Sumathi, John Wiley & Sons 2. A beginners approach to Soft Computing, Samir Roy & Udit Chakraborty, Pearson 3. Neural Networks: A Classroom Approach,1/e by Kumar Satish, TMH Reference Books: 1. S. Rajasekaran and G.A.V.Pai, Neural Networks, Fuzzy Logic and Genetic Algorithms, PHI 2. Neuro-Fuzzy and Soft computing, Jang, Sun, Mizutani, PHI 3. Neural Networks: A Comprehensive Foundation (2nd Edition), Simon Haykin, Prentice Hall.

EC 9030: Artificial Intelligence and Soft Computing (Elective) [Mapping between course outcomes (Cos) and program outcomes (POs)]

CO	Statement	PO 1	PO 2	PO 3	PSO 1	PS O 2	PSO 3
CO 1	Basics of optimization and soft computing algorithms.	2	2	3	1	1	3
CO 2	Learn different soft computing algorithms.	3	2	2	1	1	3
CO 3	Learn artificial neural network and its training.	2	2	2	1	1	3
CO 4	Study of radial basis function neural and its training.	3	2	3	1	1	3
CO 5	Study of machine learning algorithms and clustering.	2	2	2	1	1	3
Average		**2.4**	**2.0**	**2.4**	**1.0**	**1.0**	**3.0**

<table>
<tr><th colspan="9">Department of Electronics and Communication Engineering</th></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours: 45</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>EC 9034</td><td>Digital Signal Processing & Application</td><td>Electives (PEL)</td><td>4</td><td>0</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="2">Pre-requisites:</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">Signals and Systems, Higher Engg. Mathematics</td><td colspan="6">Assignments, Quiz, Mid-semester Examination and End Semester Examination</td></tr>
<tr><td>Course Objective</td><td colspan="7">The course teaches Introduction to DSP; Digital Systems – Characterization, Description and Testing; FIR and IIR: Recursive and Non Recursive; Discrete Fourier Transform; Z Transform; Discrete Time Systems in Frequency Domain; Simple Digital Filters; Digital Processing of Continuous Time Signals; Analog Filter Design; Digital Filter Structure, Synthesis and Design</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">On successful completion of this course, students will be able to to:

CO1: Analyse a given signal or system using tools such as Fourier transform and z-transform to know the property of a signal or system.

CO2: Process signals to make them more useful; and how to design a signal processor for a given problem, construct simple IIR and FIR filter.

CO3: Design and Analysis of various types of Analog Butterworth and Chebyshev Filters

CO4: Design methods to convert analog filters into digital filters.

CO5: Perform Frequency transformations in Analog and Digital domains. Realization of Digital FIR and IIR Filter Structure.</td></tr>
<tr><td>Topics Covered/ Syllabus</td><td colspan="7">Module 1. Introduction: reasons behind digital processing of signals, brief historical development, organization of the course. (L=1)

Module 2. Theory of discrete time linear system sequences, linear time invariant systems, causality, stability, difference equations, frequency response, discrete Fourier series, relation between continuous and discrete systems, Inverse Systems, Stability. (L=3)

Module 3. Z –transform: definition, properties of Z transform, system function, digital filter implementation from the system function, region of convergence in the Z plane, determining filter coefficients from the singularity locations, geometric evolution of Z transform in the Z plane, relationship between Fourier transform and Z transform, inverse Z transform. (L=4)

Module 4. Transform technique: Fourier transform, its properties, inverse Fourier transform, discrete Fourier transform, properties of DFT, circular convolution, computations for evaluating the DFT, decimation in time and decimation in frequency FFT algorithms, discrete Hilbert transform. (L=5)</td></tr>
</table>

	Module 5. Digital filter structures: system describing equations, filter categories, All Pass Filters, Comb Filters, direct form I and II structures, cascade and parallel communication of second order systems, Polyphase representation of filters, linear phase FIR filter structures, Compensatory Transfer Functions, frequency sampling structure for the FIR filter. Test for Stability using All Pass Functions. (L=7) **Module 6.** IIR filter design techniques: Analog Filter Design, Analog Butterworth lowpass filter design techniques, Analog Chebyshev LPF, Design methods to convert analog filters into digital filters, frequency transformation for converting lowpass filters into other types, all-pass filters for phase response compensation. (L=6) **Module 7.** Digital Filter Structures: IIR Realizations, All Pass Realizations, FIR and IIR Lattice Synthesis, IIR Design by Bilinear Transformation, Digital to Digital Frequency Transformation. (L=6) **Module 8.** FIR filter design techniques: Windowing method for designing FIR filters, DFT method for approximating the desired unit sample response, combining DFT and window method for designing FIR filter, frequency sampling method for designing FIR filter (L=6) **Module 9.** Non-Linear System Identification Schemes, Fractional-order digital differentiators (DDs) and digital integrators (DIs), Fractional-order low-pass Butterworth and Chebyshev filter. (L=7) **Total Lecture: 45.**
Text Books, and/or Reference material	Text Books: 1) Discrete-Time Signal Processing (Second Edition), Alan V. Oppenheim, Ronald W. Schafer, and John R. Buck, Pearson Education India 2) Digital Signal Processing: Principles, Algorithms and Applications (3rd Edition), John G. Proakis, Dimitris G. Manolakis, and D Sharma, Pearson Education India 3) Richard G. Lyons, Understanding Digital Signal Processing, Prentice Hall, 1996. ISBN: 0201634678. 4) Digital Signal Processing: A Computer - Based Approach By Sanjit K. Mitra, McGraw-Hill Higher Education 5) Digital Signal Processing by Tarun Kumar Rawat, Oxford University Press, ISBN: 9780198081937
	Reference Books/materials: 1) S. W. Smith, The Scientist and Engineer's and Guide to Digital Signal Processing, California Technical Publishing, 1997. ISBN: 0-9660176-3. 2) Digital Signal Processing using MATLAB, Vinay K. Ingle, John G. Proakis, Brooks/Cole-Thomson Learning 1) 3) https://nptel.ac.in/courses/117/102/117102060/

EC 9034: Digital Signal Processing & Applications (Elective) [Mapping between course outcomes (Cos) and program outcomes (POs)]

CO	Statement	PO 1	PO 2	PO 3	PSO 1	PSO 2	PSO 3
CO 1	Analyse a given signal or system using tools such as Fourier transform and z-transform to know the property of a signal or system.	2	1	2	2	2	3
CO 2	Process signals to make them more useful; and how to design a signal processor for a given problem, construct simple IIR and FIR filter.	1	1	1	1	1	3
CO 3	Design and Analysis of various types of Analog Butterworth and Chebyshev filters.	2	2	1	1	1	3
CO 4	Design methods to convert analog filters into digital filters.	1	2	3	2	1	3
CO 5	Perform Frequency transformations in Analog and Digital domains. Realization of Digital FIR and IIR Filter Structure.	2	1	1	1	1	3
Average		**1.6**	**1.4**	**1.6**	**1.4**	**1.2**	**3.0**

<table>
<tr><th colspan="9">Department of Electronics and Communication Engineering</th></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)/OEL</td><td colspan="4">Total Number of contact hours: 40</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>EC9036</td><td>EMBEDDED SYSTEMS</td><td>PEL</td><td>3</td><td>1</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="3">Pre-requisites:</td><td colspan="5">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="3">Basic Electronics, Mechanics</td><td colspan="5">Assignments, Quiz, Mid-semester Examination and End Semester Examination</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: Understand concept of contemporary Embedded systems
CO2: Apply analysis techniques to physical systems
CO3: Understand case study in Embedded system
CO4: Design of Embedded systems</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Module 1. Introduction to Embedded systems: Motivation based on applications of embedded systems, Basics of Embedded systems, functional blocks. (L- 02)

Module 2. Modeling of Embedded system: Mathematical modeling of physical systems to fit into embedded systems, Continuous Dynamics, Discrete Dynamics, Hybrid Systems, actor models, Composition of State Machines (L- 08)

Module 3. Cyber physical system architecture and Industry 4.0, Background of Industry standards, Cyber physical system, IoT, Industry 3.0, Industry 4.0 (L- 04)

Module 4. Microcontrollers, Sensors, Actuators, Basics of Microcontrollers, 8951, Arduino microcontroller development board, I/Os, Sensors, Actuators (L- 14)

Module 5. Data networking, Data communication techniques, Internet, Ethernet, WiFi, Bluetooth and Cellular, LoRa (L- 06)

Module 6. Case study in embedded system, Case study based on applications (L- 06)

Total Lecture: 40</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7"><u>Text Books</u>:
1. Introduction to Embedded Systems - a Cyber Physical Systems Approach, By Edward Ashford Lee, Sanjit Arunkumar Seshia
2. Principles of measurement systems. By Bentley
3. Industry 4.0 the industrial internet of things, by Alasdair Gilchrist
4. Data Communications And Networking (SIE) by Behrouz Forouzan
5. Class notes and Research Articles</td></tr>
</table>

EC 9036: Embedded Systems (Elective)

[Mapping between course outcomes (Cos) and program outcomes (POs)]

CO	Statement	PO 1	PO 2	PO 3	PSO 1	PSO 2	PSO 3
CO 1	Understand concept of contemporary Embedded systems.	1	2	1	1	1	3
CO 2	Apply analysis techniques to physical systems.	2	1	2	2	1	3
CO 3	Understand case study in Embedded system.	2	1	2	1	2	3
CO 4	Design of Embedded systems.	1	2	1	1	1	3
Average		**1.5**	**1.5**	**1.5**	**1.3**	**1.3**	**3.0**

<table>
<tr><th colspan="9">Department of Electronics and Communication Engineering</th></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours: 40</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>EC9038</td><td>Error Control Coding</td><td>PCR</td><td>4</td><td>0</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="2">Pre-requisites:</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">Linear Algebra, Probability, Communication Engineering</td><td colspan="6">Assignments, Quiz, Mid-semester Examination and End Semester Examination</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: Acquire idea about different types of error control coding techniques.
CO2: Understand generator matrix, encoding and decoding of different codes.
CO3: Learn LDPC, BCH, RS and Turbo codes.
CO4: Analyze and mitigate errors in channels.
CO5: Differentiate between different coding strategies.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Module 1. Introduction to Linear Algebra: Group, Ring, Field, Vector Space. [L9]

Module 2. Binary Linear Block Codes : Generator and Parity Check Matrices, Dual Codes, Decoding, General properties of linear block codes, Hamming Code. [L10]

Module 3. Cyclic Codes: Algebraic description, Encoding and Decoding of Cyclic codes. [L4]

Module 4. BCH Codes: Properties, Encoding and Decoding. [L3]

Module 5. Reed Solomon (RS) Codes: Definition, Decoding of RS codes. [L1]

Module 6. Convolution Codes: Definition, Encoding Trellis and State representation, Viterbi decoding, Error probability. [L7]

Module 7. LDPC Codes : Definition, Construction, Regular and irregular LDPC, Belief Propagation, Tanner Graph, Decoding, Iterative Decoding [L3]

Module 8. Turbo Codes: Definition, Construction methods, Decoding [L3]
Total: Lecture 40.</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7"><u>Text Books</u>:
1. Error Control Coding; Fundamentals and applications: Shu Lin and Daniel.J.Costello Jr. Second Edition, Pearson India.
2. Essentials of Error Control Coding by Moreira and Farrel, Wiley India
<u>Reference Books</u>:
1. Error Correction Coding: Mathematical Methods and Algorithms by Todd.K. Moon, Wiley India.</td></tr>
</table>

EC 9038: Error Control Coding (Elective)

[Mapping between course outcomes (Cos) and program outcomes (POs)]

CO	Statement	PO 1	PO 2	PO 3	PSO 1	PSO 2	PSO 3
CO 1	Acquire idea about different types of error control coding techniques.	3	1	1	3	2	1
CO 2	Understand generator matrix, encoding and decoding of different codes.	2	2	2	3	1	2
CO 3	Learn LDPC, BCH, RS and Turbo codes.	2	2	1	3	1	2
CO 4	Analyze and mitigate errors in channels.	3	1	3	3	1	1
CO 5	Differentiate between different coding strategies.	1	1	2	3	2	2
Average		**2.2**	**1.4**	**1.8**	**3.0**	**1.4**	**1.6**

Department of Electronics and Communication Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	**Total Number of contact hours : 40**				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
EC9039	**CAD for VLSI**	PCR	4	0	0	4	4
Pre-requisites:		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Digital Design and Programming Language		Assignments, Quiz, Mid-semester Examination and End Semester Examination					
Course Objectives	To provide an introduction to the fundamentals of Computer-Aided Design tools for the modeling, design, analysis, test, and verification of digital Very Large Scale Integration (VLSI)systems.						
Course Outcomes	**CO1:** Extend knowledge of CAD tools, Verilog and their applications in Xilinx to verify the circuit functionality in digital domain. **CO2:** Introduce students to the concepts and use of Verilog in the Xilinx to a digital system. **CO3:** Provide sufficient knowledge and experience so that students will be able to make meaningful design choices when asked to design any digital circuit to meet or exceed design specifications.						
Syllabus/Topics Covered	**Module-I:** (L – 03) Overview of Digital Design with Verilog HDL: Evolution of CAD, emergence of HDLs, typical HDL-based design flow, Verilog HDL, Trends in HDLs. **Module-II:**(L – 03) Hierarchical Modeling Concepts: Top-down and bottom-up design methodology, differences between modules and module instances, parts of a simulation, design block, stimulus block. **Module-III:**(L – 03) **Basic Concepts:** Lexical conventions, data types, system tasks, compiler directives.Memory modelling Logic Synthesis: Introduction synthesis of different Verilog constructs. **Module-IV:**(L –03) **Modules and Ports:** Module definition, port declaration, connecting ports, hierarchical name referencing.Introduction to Reconfigurable computing, FPGAs, the Altera /Xilinx flow. **Module-V:**(L – 02) **Gate-Level Modeling:** Modeling using basic Verilog gate primitives, description of and/or and buf/not type gates, rise, fall and turn-off delays, min, max, and typical delays. **Module-VI:**(L – 03) **Dataflow Modeling:** Continuous assignments, delay specification, expressions, operators, operands, operator types.						

	Module-VII:(L – 03) **Behavioural Modeling:** Structured procedures, initial and always, blocking and nonblocking statements, delay control, generate statement, event control, conditional statements, multiway branching, loops, sequential and parallel blocks. **Module-VIII:**(L – 04) **Tasks and Functions:** Differences between tasks and functions, declaration, invocation, automatic tasks and functions. **Module-IX:**(L – 04) **Useful Modeling Techniques:** Procedural continuous assignments, overriding parameters, conditional compilation and execution, useful system tasks. **Module-X:**(L – 04) **Flip-Flop and Counter Design:** Synchronous and asynchronous flip flop design with set and reset, design of basic counters. **Module-XI:**(L – 04) Introduction to FPGAs **Module-X:** (L – 04) Essential System Verilog for UVM: Overview of basic SystemVerilog, UVM verification environment: introduction to UVM methodology and universal Verification Components (UVC) structure, stimulus modeling, creating a simple **Total Lecture: 40**
Text / Ref. Books	**Text Books:** 1. Verilog HDL, Samir Palnitkar, Second Edition, Pearson Education, 2004 2. Verilog HDL Synthesis, J. Bhaskar, BS publications, 2001. **Reference:** 1. Fundamentals of Digital Logic with Verilog Design, Brown & Vranesic, McGraw-Hill Companies, Incorporated, 2007.

EC9039 CAD for VLSI (Elective)

[Mapping between course outcomes (Cos) and program outcomes (POs)]

CO	Statement	PO 1	PO 2	PO 3	PSO 1	PSO 2	PSO 3
CO 1	Extend knowledge of CAD tools, Verilog and their applications in Xilinx to verify the circuit functionality in digital domain.	1	1	3	2	2	1
CO 2	Introduce students to the concepts and use of Verilog in the Xilinx to a digital system.	2	1	3	2	2	1
CO 3	Provide sufficient knowledge and experience so that students will be able to make meaningful design choices when asked to design any digital circuit to meet or exceed design specifications.	3	2	3	3	3	1
Average		**2**	**1.33**	**3**	**2.33**	**2.33**	**1**

Department of Electronics and Communication Engineering								
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	**Total Number of contact hours: 40**				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
EC9041	**Mixed Signal IC Design**	PEL (Elective)	4	0	0	4	4
Pre-requisites / Co-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
NIL		Class Assignments, Quiz, Mid and End Term examinations					

Course Objective	To introduce the fundamental concepts of mixed-signal circuit design;
Course Outcomes	After going through the course, student will be able to **CO1:** Analyze and explain differential amplifiers **CO2:** Understand the design methodology for mixed signal IC design using gm/Id concept. **CO3:** Understand various compensation schemes used in opamp **CO4:** Design the CMOS opamp and based on given specification **CO5:** Appreciate the fundamentals of data converters and also optimized their performances **CO6:** Able to design mixed-signal building blocks like comparators and PLL.
Topics Covered/ Syllabus	**Module 1.** CMOS operational transconductance amplifiers, Design method using gm/Id technique, Design of OTA-C filter. (L – 04) **Module 2.** Frequency compensation schemes: Dominant-Pole Compensation, Shunt-Capacitance Compensation, Miller Compensation, Pole-Zero Compensation, Feed-forward Compensation. (L – 04) **Module 3.** Design of fully differential amplifiers, Types of common mode feedback circuits, Gilbert Cell. (L – 05) **Module 4.** Switched capacitor circuits, design of switched capacitor amplifiers and integrators, effect of opamp finite gain, bandwidth and offset, circuit techniques for reducing effects of opamp imperfections, switches and charge injection and clock feed-through effects. (L – 08) **Module 5.** Frequency compensation schemes: Dominant-Pole Compensation, Shunt-Capacitance Compensation, Miller Compensation, Pole-Zero Compensation, Feed-forward Compensation. (L – 05 **Module 6.** Fundamentals of data converters; Nyquist rate A/D converters (Flash, interpolating, folding flash, SAR and pipelined architectures); Nyquist rate D/A converters - voltage, current and charge mode converters; Oversampled A/D and D/A converters. (L – 08). **Module 7.** Basic PLL topology, dynamics of simple PLL, phase detectors, Phase frequency detector, Loop filters, Charge Pump PLLs, Ring Oscillator, VCO (L – 06). **Total Lecture: 40**
Text Books, and/or Reference material	Text Books: 1. R. Gregorian and Temes- Analog MOS integrated circuits for signal processing 2. R. Gregorian - Introduction to CMOS Opamps and Comparators.
	Reference: 1. D. Johns and K. Martin - Analog integrated circuit

EC9041 Mixed Signal IC Design

[Mapping between course outcomes (Cos) and program outcomes (POs)]

CO	Statement	PO 1	PO 2	PO 3	PSO 1	PSO 2	PSO 3
CO 1	Analyze and differential amplifiers.	2	1	3	1	1	1
CO 2	Understand the design methodology for mixed signal IC design using gm/Id concept.	1	1	3	2	1	1
CO 3	Understand various compensation schemes used in opamp.	1	1	3	2	1	1
CO 4	Design the CMOS opamp and based on given specification.	2	2	3	3	2	1
CO 5	Appreciate the fundamentals of data converters and also optimized their performances.	2	2	3	2	2	1
CO 6	Able to design mixed-signal building blocks like comparators and PLL.	3	3	3	2	3	1
Average		**1.83**	**1.67**	**3**	**2**	**1.67**	**1**

Department of Electronics and Communication Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	**Total Number of contact hours: 40**				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
EC9042	**Low Power Circuits and Systems**	PEL	4	0	0	4	4
Pre-requisites:		Course Assessment methods: (Continuous (CT), Mid-semester assessment (MA) and end assessment (EA)):					
EC1013: Digital and Analog IC Design.		Assignments, Quiz, Mid-semester Examination and End Semester Examination					
Course Objectives	• This course deals with issues and models to design low-power VLSI circuits and systems, and fundamentals of power dissipation, • Students will be able to estimate power dissipation due to switching, short circuit.						
Course Outcomes	**CO1:** **Acquire** knowledge of the fundamentals and applications of Low-power circuits. **CO2:** **Identify** various leakage/ switching power sources in a MOSFET and a digital circuits. **CO3:** **Analyze the v**arious issues to power dissipation and techniques to minimize/optimize **CO4:** **Learn** various leakage/ switching power reduction mechanisms at device level and circuit level. **CO5:** **Design and implementation** of a power-aware circuits and systems. **CO6:** **Evaluate** the performance of low power circuits and systems						
Syllabus/ Topics Covered	**Module I.** Introduction: Need for Low power VLSI chips - Low Power Design Methodology - Logic synthesis for Low power. **(L – 05)** **Module II.** Sources of power dissipation in CMOS circuits: static power dissipation-diode leakage power, sub-threshold leakage power, gate and other tunnel currents; dynamic power dissipation - short circuit power, switching power, Glitching power; degrees of freedom. **(L – 04)** **Module III.** Power Analysis and Estimation: Gate level Analysis, Architecture level Analysis, Data Correlation Analysis, Monte-Carlo Simulation, Probabilistic Power Analysis. Statistical Techniques - Estimation of Glitching Power - Sensitivity Analysis - Circuit Reliability - Power Estimation at the circuit level - High level Power Estimation - Estimation of maximum power. **(L – 07)** **Module IV.** Static Power Optimization Techniques: Leakage current in deep sub micrometer transistors- Transistor Leakage Mechanism, Leakage Current Estimation. Multiple threshold voltages, various approaches for the fabrication of multiple threshold voltage transistors, variable threshold voltage CMOS (VTCMOS), transistor tracking approach, run time leakage power- multiple-threshold voltage (MTCMOS), power gating technique and various issues related to power gating approaches, state retention strategy, power management techniques, dual-V_t technique, delay and energy constrained dual-V_t techniques. **(L – 08)**						

	Module V.	Dynamic Power Optimization Techniques: Supply voltage scaling approaches: parallelism, pipelining, using multiple supply voltage, module level voltage selection, clustered voltage scaling, level converters, multiple supplies inside a block, supply voltage limitations, Optimum supply voltage, multi-level voltage scaling (MVS), dynamic voltage and frequency scaling (DVFS), adaptive voltage scaling (AVS), System level approach- hardware/software co-design, encoding techniques, clock gating, gated clock finite state machines (FSMs), pre-computational logic, basic approach of minimizing glitching power, Dynamic CMOS and Pass-transistor logic styles. **(L – 08)**
	Module VI.	Low Power Static RAM Architectures: Organization, MOS Static RAM Memory Cell, Banked Organization, Voltage Swing Reduction, Power Reduction. **(L – 04)**
	Module VII.	Low Voltage CMOS VLSI Technology: BICMOS and Silicon On Insulator (SOI) Technology. Recent Trends in low power VLSI Designs & its research issues in industry. **(L – 04)** **Total Lecture: 40**
Text / Ref. Books	**Text Books:** 1. Anantha P Chandrakasan and Robert W Brodersen, "Low Power Digital CMOS Design", Kluwer Academic Publishers, Holland, 1995. 2. Ajit Pal, "Low Power VLSI Circuits and Systems", Springer, 2015. **References:** 1. Gary B Yeap K, "Practical Low Power Digital VLSI Design", Kluwer Academic Publishers, 1998. 2. Kuo J B and Lou J H, "Low Voltage CMOS VLSI Circuits", John Wiley and Sons, Singapore, 1999. 3. Kaushik Roy and Sharat C Prasad, "Low Power CMOS VLSI circuit Design", John Wiley and Sons, 2000.	

EC9041 Low Power Circuits and Systems

[Mapping between course outcomes (Cos) and program outcomes (POs)]

CO	Statement	PO 1	PO 2	PO 3	PSO 1	PSO 2	PSO 3
CO 1	**Acquire** knowledge of the fundamentals and applications of Low-power circuits	2	1	2	2	1	1
CO 2	**Identify** various leakage/ switching power sources in a MOSFET and a digital circuits.	3	1	3	3	3	1
CO 3	**Analyze the** various issues to power dissipation and techniques to minimize/optimize	3	2	3	3	3	1
CO 4	**Learn** various leakage/ switching power reduction mechanisms at device level and circuit level.	3	2	3	2	2	1
CO 5	**Design and implementation** of a power-aware circuits and systems	2	1	2	3	3	2
CO 6	**Evaluate** the performance of low power circuits and systems	2	1	2	3	3	2
Average		**2.50**	**1.33**	**2.50**	**2.67**	**2.50**	**1.33**

Department of Electronics and Communication Engineering

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	**Total Number of contact hours: 40**				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
EC9044	**RF IC Design**	PEL	4	0	0	4	4

Pre-requisites / Co-requisites:	Course Assessment methods (Continuous (CT) and end assessment (EA))
Communication Theory, Signals and Systems, Analog IC Design	Assignments, Quiz, Mid-semester Examination and End Semester Examination
Course Objective	The objective of the course is to give the student fundamental knowledge on Radio Frequency (RF) integrated circuits design. The course discusses methods and techniques for RF front-end design oriented to CMOS technology.
Course Outcomes	After going through the course, student will be able to **CO1:** Analyze various architectures of today's digital radio transmitters and receivers **CO2:** Analyze and design basic RF building-blocks in CMOS technology **CO3:** Define basic RF measurements parameters such as S-parameters, sensitivity, noise figure, IIP3 **CO4:**Assimilat the design techniques VCO, LNA as well as other front end circuits
Topics Covered/ Syllabus	**Module 1.** Basic Concepts in RF Design, Architectures, Transmission media andReflections, Maximum power transfer, Scattering Parameters **(L –6)** **Module 2.** Modern IC technologies (SiGe, CMOS), fundamental limitation of speed of transistors **(L – 4)** **Module 3.** Different Noise Mechanisms: Classical two-port noise theory, noise models for active and passive components **(L – 6)** **Module 4.** Low Noise Amplifiers: SNR, LNA topologies, power constrained noise optimization, linearity and large signal performance **(L – 6)** **Module 5.** Passive and Active Mixers: multiplier-based mixers, sub-sampling mixers, diode-ring mixers. **(L – 4)** **Module 6.** RF Passive Components: Characteristics of passive IC components at RF frequencies – interconnects, resistors, capacitors, inductors and transformers – Transmission lines. **(L – 5)** **Module 7.** Oscillators: Basic Principles, Cross-Coupled VCO, Phase Noise **(L – 4)** **Module 8.** RF power amplifiers – Class A, AB, B, C, D, E and F amplifiers, modulation of power amplifiers, linearity considerations **(L – 5)** **Total Lecture: 40**

Text Books, and/or Reference material	**<u>Text Books</u>:** 1. R Ludwig and P Bretchko, *RF Circuit Design: Theory and Application*, Pearson Education, New Delhi	
	Reference: 1. Behzad Razavi, RF Microelectronics Prentice Hall of India, 2001 2. Thomas H. Lee, The Design of CMOS Radio Frequency Integrated Circuits, Cambridge University Press.	

EC 9044 RF IC Design (Elective)

[Mapping between course outcomes (Cos) and program outcomes (POs)]

CO	Statement	PO 1	PO 2	PO 3	PSO 1	PSO 2	PSO 3
CO 1	Analyze various architectures of today's digital radio transmitters and receivers	2	1	2	2	1	1
CO 2	Analyze and design basic RF building-blocks in CMOS technology	3	1	3	3	3	1
CO 4	Define basic RF measurements parameters such as S-parameters, sensitivity, noise figure, IIP3	3	2	3	2	2	1
CO 5	CO#4:Assimilat the design techniques VCO, LNA as well as other front end circuits	2	1	2	3	3	2
Average		**2.50**	**1.33**	**2.50**	**2.67**	**2.50**	**1.33**

<table>
<tr><th colspan="9">Department of Electronics and Communication Engineering</th></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours: 40</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>EC9046</td><td>FPGA based Design</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">Boolean algebra, Logic design fundamentals</td><td colspan="6">Assignments, Quiz, Mid-semester Examination and End Semester Examination</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: Learn logic synthesis techniques – two level and multilevel synthesis.
• CO2: Be able to design systems using FPGAs and CPLDs.
• CO3: Learn sequential machine design using FPGAs.
• CO4: Learn to design systems for low power operation.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Module-I: (L – 05)
Logic design fundamentals: Two level synthesis – SOP/POS forms, Logic minimization, Limitations of two level synthesis, introduction to multi-level synthesis.

Module-II: (L – 05)
Programmable Logic Devices: Programmable Logic Array (PLA) architecture; Programmable Array Logic (PAL), PAL vs. PROM, Fan-in expansion feature, Architecture for sequential circuit implementation, Typical PAL chips; Complex Programmable Logic Devices (CPLD).

Module-III: (L – 07)
Programmable Gate Arrays: Gate Array concept, Mask programmable and Field Programmable Gate Arrays; Look up tables (LUT) Configurable logic blocks (CLB), logic design using LUT's; Multi-level synthesis techniques – Factoring and Functional decomposition, Shannon's Expansion Theorem; Generalized FPGA Architecture.

Module-IV: (L – 06)
Sequential Circuit Design: Finite State Machines, Moore and Mealy Machines; State diagrams, State table, State assignment, derivation of next-state and output expressions, state minimization; State assignment for low power operation; CAD tools for FSM synthesis.

Module-V: (L – 04)
Advanced features of modern FPGAs: Block RAMs, Embedded processor, Communication ports, Analog interface.

Module-VI: (L – 06)
Typical case studies: Simple logic functions – Decoder, encoder, multiplexer, demultiplexer, BCD to seven-segment decoder, keyboard/display interface; memory elements and arrays; sequential machine design – sequence generators, timing generators, a typical machine design (example: vending machine); A simple CPU design.

Module-VII: (L – 04)
Design analysis: Static timing analysis, Power analysis, Resource utilization, noise, clock network, DRC, debugging methods.

Module-VIII: (L – 04)</td></tr>
</table>

	FPGA as a Hardware Debugging platform: Hardware troubleshooting methods, Looking into the chip – Logic State Analyzer and its use; Concept of Hardware emulation – simulation vs. Emulation, FPGA as a Hardware emulator, Break-points and their utility, setting break-points in FPGA based design. **Total Lecture: 40**
Text Books, and/or reference material	**Text Books:** 1. Fundamentals of Digital Logic with Verilog Design by S. Brown and Z. Vranesic (McGraw Hill Education (India) Pvt. Ltd.) **Reference Books:** 1. A Verilog HDL Primer by J. Bhasker (B.S. Publications, Hyderabad *in arrangement with* Star Galaxy Publishing, USA)

EC 9046 FPGA based Design (Elective)

[Mapping between course outcomes (Cos) and program outcomes (POs)]

CO	Statement	PO 1	PO 2	PO 3	PSO 1	PSO 2	PSO 3
CO 1	Learn logic synthesis techniques – two level and multilevel synthesis.	2	1	2	2	1	1
CO 2	Be able to design systems using FPGAs and CPLDs.	3	1	3	3	3	1
CO 3	Learn sequential machine design using FPGAs.	3	2	3	3	3	1
CO 4	Learn to design systems for low power operation.	3	2	3	2	2	1
Average		**2.75**	**1.5**	**2.75**	**2.5**	**2.25**	**1**

<table>
<tr><th colspan="9">Department of Electronics and Communication Engineering</th></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours: 40</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>EC9047</td><td>MEMS & Microsystems Technology</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">NIL</td><td colspan="6">Assignments, Quiz, Mid-semester Examination and End Semester Examination</td></tr>
<tr><td>Course Objectives</td><td colspan="7">Develop fundamental concepts of MEMS system
Develop MEMS device modeling techniques
Learn MEMS device fabrication process
Learn MEMS device packaging</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: Understand characteristics of MEMS system
CO2: Understand basic building blocks of general MEMS systems
CO3: Apply qualitative and quantitative analysis techniques in general MEMS systems
CO4: Design techniques in MEMS
CO5: Investigate complex designs in MEMS systems
CO6: Understand synthesis and fabrication of MEMS system</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Module-1: (L – 06)
MEMS device fabrication process

Module-2: (L – 07)
Lumped Modeling, Statics, Dynamics, Quasi static analysis, Energy Methods

Module-3: (L – 06)
Elasticity, Structures, Thermal Energy Domain, Fluids, Electronics

Module-4:(L – 07)
Effect of noise, Feedback systems

Module-5:(L – 07)
Integration of MEMS systems, Scaling effect, Reliability of MEMS devices

Module-6:(L – 07)
Case studies in MEMS.
Total Lecture: 40</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7"><u>Text Books</u>:
1. Microsystem Design by Stephen D. Senturia, Springer
<u>Reference Books</u>:
1. Micro and Smart Systemsby K.J. Vinoy, S. Gopalakrishnan, K.N. Bhat, V.K. Aatre G.K. Ananthasuresh, Wiley</td></tr>
</table>

EC 9047 MEMS & Microsystems Technology (Elective)

[Mapping between course outcomes (Cos) and program outcomes (POs)]

CO	Statement	PO 1	PO 2	PO 3	PSO 1	PSO 2	PSO 3
CO 1	**Understand** characteristics of MEMS system	2	1	3	1	1	1
CO 2	**Understand** basic building blocks of general MEMS systems	1	1	3	2	1	1
CO 3	**Apply qualitative and quantitative analysis** techniques in general MEMS systems	1	1	3	2	1	1
CO 4	**Design** techniques in MEMS	2	2	3	3	2	1
CO 5	**Investigate complex designs** in MEMS systems	2	2	3	2	2	1
CO 6	**Understand** synthesis and fabrication of MEMS system	3	3	3	2	3	1
Average		**1.83**	**1.67**	**3**	**2**	**1.67**	**1**

<table>
<tr><td colspan="9">Department of Electronics and Communication Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours : 40</td><td rowspan="2" colspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>EC9049</td><td>Nanoelectronics</td><td>PEL</td><td>4</td><td>0</td><td>0</td><td>4</td><td colspan="2">4</td></tr>
<tr><td colspan="2">Pre-requisites:</td><td colspan="7">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">Microelectronics and Semiconductor Device Physics (Solid State Devices)</td><td colspan="7">Assignments, Quiz, Mid-semester Examination and End Semester Examination</td></tr>
<tr><td>Course Objectives</td><td colspan="8">• To present the state of art in the areas of semiconductor device physics and materials technology to enable the Nano-Electronics.
• To study the fundamentals of standard CMOS technology and the issue in scaling MOSFET in the sub-100nm regime will be elaborated.
• Emerging studies for need of non-classical transistors with new device structure and nanomaterials will be elucidated.</td></tr>
<tr><td>Course Outcomes</td><td colspan="8">CO1: Demonstrate understanding of fundamental of nanodevices fabrication techniques
CO2: Demonstrate understanding of nanotechnology concepts for device fabrication and characterization.
CO3: To quire fundamental understanding for electronics and optical properties of nanomaterials.
CO4: To acquire knowledge of basic nanodevice principles and fabrication approaches for various nanoscale devices.</td></tr>
<tr><td>Syllabus/Topics Covered</td><td colspan="8">Module-I: (L – 10)
Introduction to nanotechnology, the size of things, history of nanotechnology, fabrication method (top-down and bottom-up), emerging applications of nanotechnology.

Module-II: (L – 10)
Electronic and Optical properties of nanostructures. Energy sub-bands. Electron transport in two –dimensional electron gas (density of states), Carrier scattering, resistance of a ballistic conductor, Transmission probability calculation, Electron tunneling, Resonant tunneling, Coupled nanoscale structures, and Superlattices,

Module-III: (L – 10)
Nanotechnology: Deposition techniques for Nanoscale Devices, Nanolithography, Self-Assembly Techniques, Nanomaterials, Nanoparticles, Nanowires, Nanomagnetic Materials, Nanostructure Surfaces; Instrumentation for nanoscale electronics: The Atomic Force Microscope (AFM), Scanning Tunneling Microscope and scanning near field optical microscope.

Module-IV: (L – 10)
Shrink-down approaches: Electronic devices Based on Nanostructures: Advance Heterostructure Devices, Downscaling of the MOSFET. Nanoscale FET Transistors, the Ballistic FET, Resonant</td></tr>
</table>

	Tunneling Devices and Circuits, Single Electron Transistor and Related Devices. Devices based on carbon nanotubes, Spintronic Devices; Optoelectronic Devices using Nanostructures: Quantum well and Quantum Dot LASERS, Quantum Cascade LASER, Quantum well-infrared photodetector, Superlattice LASER. **Total Lecture: 40**
Text / Ref. Books	**Text Books:** 1. Introduction to Nanotechnology, C.P. Poole Jr., F.J. Owens, Wiley (2003). 2. Nanoelectronics and Information Technology (Advanced Electronic Materials and Novel Devices), Waser Ranier, Wiley-VCH (2003). **Reference:** 1. Nanosystems, K.E. Drexler, Wiley (1992) 2. The Physics of Low-Dimensional Semiconductors, John H. Davies, Cambridge University Press, 1998. 3. Fundamentals of Modern VLSI Devices, Y. Taur and T. Ning, Cambridge University Press. 4. Karl Goser, "Nanoelectronics and Nanosystems," Springer, 2004

EC 9049 Nanoelectronics (Elective)

[Mapping between course outcomes (Cos) and program outcomes (POs)]

CO	Statement	PO 1	PO 2	PO 3	PSO 1	PSO 2	PSO 3
CO 1	Demonstrate understanding of fundamental of nanodevices fabrication techniques	2	1	2	2	1	1
CO 2	Demonstrate understanding of nanotechnology concepts for device fabrication and characterization.	3	1	3	3	3	1
CO 3	To quire fundamental understanding for electronics and optical properties of nanomaterials.	3	2	3	3	3	1
CO 4	To acquire knowledge of basic nanodevice principles and fabrication approaches for various nanoscale devices.	3	2	3	2	2	1
Average		**2.75**	**1.5**	**2.75**	**2.5**	**2.25**	**1**

<table>
<tr><th colspan="10">Department of Electronics and Communication Engineering</th></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2" colspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours: 40</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>EC9051</td><td colspan="2">Testing and Verification of VLSI Circuits</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="3">Pre-requisites:</td><td colspan="6">Course Assessment methods: (Continuous (CT), Mid-semester assessment (MA) and end assessment (EA)):</td></tr>
<tr><td colspan="3">Digital Design.</td><td colspan="6">Assignments, Quiz, Mid-semester Examination and End Semester Examination</td></tr>
<tr><td colspan="2">Course Objectives</td><td colspan="7">To expose the students, the basics of testing and verification techniques for the digital IC design.</td></tr>
<tr><td colspan="2">Course Outcomes</td><td colspan="7">CO1: Extend knowledge of the requirement of fault modeling in VLSI circuits.
CO2: Generate test vectors to test a circuit efficiently covering maximum faults.
CO3: Introduce students to the concepts Memory testing techniques.
CO4: Understanding Built-in-Self Test and its application in modern digital design
CO5: Use modern tools for testing and verification.</td></tr>
<tr><td colspan="2">Syllabus/Topics Covered</td><td colspan="7">Module-I: (L – 05)
Physicalfaultsandtheirmodeling.Faultequivalenceanddominance;fault collapsing, Fault simulation: parallel, deductive and concurrent techniques; critical pathtracing.

Module-II: (L – 05)
Test generation for combinational circuits: Boolean difference,D-algorithm, Podem, random etc. Exhaustive, random and weighted test pattern generation; aliasing and its effect on fault coverage.

Module-III: (L – 05)
PLA testing: cross-point fault model, test generation, easily testable designs.

Module-IV: (L – 05)
Memory testing: permanent, intermittent and pattern-sensitive faults; test generation.

Module-V: (L – 05)
Delay faults and hazards; test pattern generation techniques, ATPG and its different types.

Module-VI: (L – 05)
Test pattern generation for sequential circuits: ad-hoc and structures techniques scan path and LSSD, boundary scan.

Module-VII:(L – 05)
Built-in self-test techniques: LBIST and MBIST. Verification: logic level (combinational and sequential circuits), RTL-level (data path and control path). Verification of embedded systems. Use of formal techniques: decision diagrams, logic-based approaches.</td></tr>
</table>

	Module-VIII: (L – 05) ASIC/IP Verification, direct and random testing, Error detection and correction codes. **Total Lecture: 40**
Text / Ref. Books	**Text Books:** 1. Essentials of Electronic Testing, M. L. Bushnell and V. D. Agrawal,3rd Kluwer Academic Publishers 2002 **References:** 1. Delay Fault Testing for VLSI Circuits,A. Krstic and K-T Cheng,3rd Kluwer Academic Publishers. 2003 2. Testing of Digital Systems, N. K. Jha and S. Gupta, 2nd, Cambridge University Press. 2003 3. Digital Systems Testing and Testable Design, M. Abramovici, M. A. Breuer and A. D. Friedman, 3rd, Wiley-IEEE Press. 1994 4. Fault Tolerant and Fault Testable P. K. Lala, 4th, Hardware Design, Prentice-Hall. 1986

EC 9051 Testing and Verification of VLSI Circuits (Elective)

[Mapping between course outcomes (Cos) and program outcomes (POs)]

CO	Statement	PO 1	PO 2	PO 3	PSO 1	PSO 2	PSO 3
CO 1	Extend knowledge of the requirement of fault modeling in VLSI circuits.	1	1	1	2	1	1
CO 2	Generate test vectors to test a circuit efficiently covering maximum faults.	2	2	3	2	1	1
CO 3	Introduce students to the concepts Memory testing techniques.	2	2	2	3	2	1
CO 4	Understanding Built-in-Self Test and its application in modern digital design	2	2	3	2	2	1
CO 5	Use modern tools for testing and verification.	2	2	3	3	2	2
Average		**1.8**	**1.8**	**2.4**	**2.4**	**1.6**	**1.2**