Scheme of Teaching

M. Tech. (Digital Communication Engineering)

I Semester **CREDIT BASED**

Subject Code					
		L	**T**	**P**	**CREDITS**
1MTDC01	Applied Mathematics	3	0	0	3
1MTDC02	Radiating Systems	3	0	1	4
1MTDC03	Wireless Networks	3	1	0	4
1MTDC04	Advanced Digital Communication	3	0	0	3
1MTDC05	Elective -1	3	0	0	3
1MTDC06	Elective – 2	3	0	0	3
1MTDC07	Research Methodology and IPR	2	0	0	2
	Total				**22**

Note : Two electives to be chosen from the list below:
Elective will be offered for a minimum strength of six candidates (out of 18) / eight candidates (out of 24)

Program Elective			
MTDC01	Error Control Coding	MTDC03	Fifth Generation Networks
MTDC02	Optical Communication and Networks	MTDC04	Advanced Satellite Communication
MTDC01/ MTDC02	Estimation and Detection Techniques	20ECDCPESD	Software Defined Radio

Note: The Course Code: 20 (year) EC (Electronics and Communication Engineering) DC (Digital Communication Engineering) PC (Program core), PE (Program Elective) ZZ (course abbreviation), ALLP (All programme), RM(Research Methodology), IC(Institution Core).
GC/GE: Group Core / Group Elective

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II Semester **CREDIT BASED**

Subject Code	Course Title				
		L	**T**	**P**	**CREDITS**
2MTDC01	Advanced Wireless Communication	3	0	1	4
2MTDC02	Advanced DSP	3	1	0	4
2MTDC03	Wireless Communication Networks Analytics	3	1	0	4
2MTDC04	Elective -4	3	0	0	3
2MTDC05	Elective -5	3	0	0	3
2MTDC06	Open Elective	4	0	0	4
	Total				**22**

Note : Two electives to be chosen from the list below:
Elective will be offered for a minimum strength of six candidates (out of 18) / eight candidates (out of 24)

Program Elective			
2MTDC01	Advanced Techniques for Wireless Reception	2MTDC04	Multimedia Compression Techniques
2MTDC02	Communication Networking Systems	2MTDC05	Communication System Security
2MTDC03	Long Term Evolution Networks	2MTDC06	Green Radio Communication Networks

Open Elective

2MTDC07	Quality and Reliability of Engineering systems

M. Tech. (Digital Communication Engineering)

III Semester **CREDIT BASED**

Subject Code	Course Title				
		L	**T**	**P**	**CREDITS**
3MTDC01	Program Elective 5	2	1	0	3
3MTDC02	Project work (phase I)				8
3MTDC03	Internship				9
3MTDC04	Technical Seminar I	0	0	2	2
3MTDC05	Audit Course 1				2 Units
	Total				**22**

Program Elective

3MTDC01	RF & Microwave Circuits
3MTDC02	Network on Chip

M. Tech. (Digital Communication Engineering)

IV Semester **CREDIT BASED**

Subject Code	Course Title				
		L	**T**	**P**	**CREDITS**
4MTDC01	Technical Seminar II				02
4MTDC02	Project work (phase 2)				20
4MTDC03	Audit Course 2				2 Units
	Total				**22**

I SEMESTER

PROGRAM CORE SYLLABUS

Prerequisites: Basic Calculus

Course Outcomes

Course Code	**1MTDC01**	**Course Title**	**Applied Mathematics**
Credits	**03**	**L-T-P**	**3-0-0**

CO 1	Demonstrate knowledge and understanding of the underlying concepts of random variables and stochastic processes	PO 3
CO 2	Demonstrate knowledge of the mathematical concepts and computational aspects of linear algebra and graph theory	PO 3
CO 3	Analyse domain related engineering problems and develop analytical problem solving approach making use of the theoretical concepts	PO 1

Unit 1 08 hrs

Review of basic probability theory. Definition of random variables and probability distributions, probability mass and density functions, expectation operator, illustrativeexamples

Unit 2 08 hrs

Moments, central moments, characteristic functions, probability generating functions - illustrations Poisson, Gaussian and Erlang distribution examples. Pair of random variables – Joint PMF, PDF, CDF.

Unit 3 07 hrs

Random Processes - Classification. Stationary, WSS and ergodic random process. Auto-correlation function-properties, Gaussian random process, Engineering Applications of Random processes.

Unit 4 08 hrs

Linear Algebra: Introduction to vector spaces and sub-spaces, definitions, illustrative example. Linearly independent and dependent vectors- Basis-definition and problems. Linear transformations-definitions, Matrix form of linear transformations - Illustrative examples, Computation of eigen values and eigen vectors of real symmetric matrices - Given's method.

Unit 5 08 hrs

Computational Graph Theory: Graph enumerations and optimization: DFS-BFS algorithm, shortest path algorithm, min-spanning tree and max-spanning tree algorithm, basics of minimum cost spanning trees, optimal routing trees, optimal communication trees, network flow algorithms

Text Books:

1. S L Miller and D C Childers, “Probability and random processes: application to signal processing and communication”, Academic Press / Elsevier 2004.
2. David C. Lay, “Linear Algebra and its Applications”, 3rd Edition, Pearson Education, 2003.
3. GeirAgnarsson and Raymond Greenlaw “Graph Theory- Modeling, Applications and Algortihms”, Pearson Education, 2007.

Reference books:

1 A. Papoulis and S U Pillai, “Probability, Random variables and stochasticprocesses”, McGraw Hill 2002
2 Roy D. Yates and David J. Goodman, Probability and Stochastic Processes: A friendlyintroduction for Electrical & Computer Engineers/
3. MIT Open courseware, Introduction to Linear Algebra, Course 20.06
4 NausingDeo, “Graph Theory with applications to Engineering and ComputerScience”, Prentice Hall of India, 1999.

MOOC / e-resources:

MIT Opencourseware:

https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-041-probabilistic-systems-analysis-and-applied-probability-fall-2010/
NPTEL course by IIT Delhi and IIT Madras:
https://nptel.ac.in/courses/111/102/111102111/
https://nptel.ac.in/courses/111/106/111106112/
https://nptel.ac.in/courses/111/101/111101115/

Course Code	1MTDC02	Course Title	Radiating systems
Credits	04	L-T-P	3-0-1
CIE	50 Marks(100% weightage)	SEE 100	100 Marks (50% weightage)

Prerequisites: Basic knowledge of Electromagnetic Fields and waves,comprehensive knowledge of performance parameters of antenna and radiation mechanisms

CO1	To provide comprehensive knowledge of different design and performance parameters of antenna and analyse their performance based on the radiation mechanisms and design different types of antenna arrays.	PO3
CO2	Apply analytical & numerical approach to understand different types of antennas arrays	PO3
CO3	Understanding the concept of Computational Electromagnetics	PO3
CO4	Usage of modern computational tools in electromagnetic scattering, propagation, and radiation.	PO1,PO2
CO5	Ability to provide critical analysis of current research topics in the domain of antennas and prepare a technical document and present the same.	PO1,PO2

Unit 1 07 Hrs

Arrays: Array factor for linear arrays, uniformly excited equally spaced Linear arrays, pattern multiplication, directivity of linear arrays, non- uniformly excited -equally spaced linear arrays, phased arrays

Unit 2 08 Hrs

Resonant Antennas : Infinitesimal dipole, finite-length dipole, dipoles for mobilecommunication, Microstrip Patch Antennas: Basic characteristics ,feeding methods, methods of analysis, design of rectangular and circular patch antennas. Printed antennas for wireless communication

Unit 3 08 Hrs

Smart Antennas :Angle-of-Arrival Estimation; Methods,Fixed Weight Beam forming;Adaptive Beam forming.

Space Antennas-Antennas for Satellite Communications

Wearable Antennas: A Review of Materials, Structures, and Innovative Features forAutonomous Communication and Sensing

Unit 4 08 Hrs

Antennas for underwater communication

Antennas for Visible Light Communication:Design and Analysis of Optical ReceivingAntenna for LED, Multifunctional Metamaterial Designs for Antenna Applications: Introduction to metamaterials, Metamaterials for Antenna applications, Antennas for 5G Communication

Unit 5 08 Hrs

Computational Electromagetics: Classification,General Method of Moments (MoM) for the solution of integro-differential equations,Pocklington's integral equation, integral equations and Kirchhoff's Networking Equations.

Text Books:

1. C. A. Balanis: "Antenna Theory Analysis and Design", John Wiley, 2012
2. Kraus: "Antennas", McGraw Hill, TMH, 3rd/4th Edition
3. Jordan, E.C. and Balmain, K.G., "Electromagnetic Waves and Radiating Systems", 2nd Ed., Prentice-Hall of India.
4. Stutzman and Thiele, "Antenna Theory and Design", 2ndEd, JohnWiley and Sons Inc
5. Introduction to Smart Antennas, Constantine A. Balanis, Panayiotis I. Ioannides, Morgan ; Claypool Publishers, 2007

REFERENCE BOOK

1. John D Kraus R J Marhefka and Ahmed S Khan "ANTENNAS AND WAVE PROPAGATION", Tata McGraw Hiill India, 2006, Fourth Edition

E Books:

1. Introduction to Smart Antennas, Constantine A. Balanis,
2. (https://doi.org/10.2200/S00079ED1V01Y200612ANT005) Wearable antennas https://ieeexplore.ieee.org/document/8681039
3. Antennas for underwater communication https://ieeexplore.ieee.org/document/7928763
4. Antennas for Satellite Communications - Space Antenna https://onlinelibrary.wiley.com/doi/10.1002/9781119945147.ch12
5. LED antennas https://ieeexplore.ieee.org/document/8937517
6. Meta materials for Antenna design https://upcommons.upc.edu/bitstream/
7. 5G Antennas https://www.microwavejournal.com/articles/30563-

MOOCs:

1. https://www.classcentral.com/course/swayam-antennas-7924
2. https://www.coursera.org/lecture/satellite-communications/antennas-BQhQ6
3. https://nptel.ac.in/courses/108/101/108101092/

Lab exercises:

It can be implemented using hardware / any open source software/ Licensed software like EmPro / Adavnced Design System

1) Evaluation of performance parameters of any Radiator
2) Design of Arrays
3) Design of Antennas for VLC
4) Introduce the students to basic principles of antennas, propagation and coverage

estimations in a wireless communication environment. The scope is to observe the cell size variation according to basic parameters that are met in a cellular system. These include 1. Transmit power of the base station 2. Antenna heights of base station and mobile user terminal 3. Antenna pattern of base station and mobile user terminal 4. Antenna orientation of the base station and mobile user terminal

5) Change the antenna parameter at the transmitter to be $3\lambda/2$ dipole and perform the measurements. Record the observations

6) S parameters measurement of an Antenna

7) Design of a rectangular microstrip patch antenna for operating frequency 1.88GHz with εr =4.4, h=31 mils; transformer coupled microstrip feed. (HFSS)

8) To calculate the resonant frequency and estimate the VSWR of an antenna.

Course Code	1MTDC03	Course Title	Wireless Networks
Credits	04	L-T-P	3-1-0
CIE	50 Marks(100% weightage)	SEE 100	100 Marks (50% weightage)

Prerquisites: Basics of Wireless Networking, Computer Networks

COURSE OUTCOMES

CO1	To develop the concept of wireless systems in the context of networks.	PO3
CO2	To Learn the concepts of Sensor networks with its Protocol Design	PO3
CO3	Able to understand building blocks of Internet of Things, their characteristics and to understand the application areas of IOT ·	PO3
CO4	Ability to provide critical analysis of current research topics in the domain of Wireless Networks and prepare a technical document and present the same.	PO 2

Unit 1 07 Hrs

Introduction: Wireless Body Area Networks, Wireless Personal Area Networks, Wireless Local Area Networks: Network components, design requirements, architecture, standards, protocols.

Unit 2 07 Hrs

Wireless Sensor networks- Introduction, Hardware and Software, Sensor Taxonomy, WN Operating Environment, Issues in Ad Hoc Wireless Networks, Medium Access Schemes, Routing, Transport Layer Protocols,Self Organization,Security, Addressing and Service Discovery, Energy management,Scalability

Unit 3 09 Hrs

Sensor Network Architecture Data Dissemination,Flooding and GossipingData gathering Sensor Network Scenarios , Design Principles for WSNs- Gateway Concepts, Need for gateway, WSN to Internet Communication, WSN Tunneling.

MAC Protocols for Sensor Networks, Location Discovery,Quality of Sensor Networks, Evolving Standards Other Issues, Low duty cycle and wake up concepts

Unit 4 08 Hrs

IoT: Introduction, State of the art, Reference Model and architecture, IoT reference Model - IoT Reference Architecture, Functional View, Information View, Deployment and Operational View, Other Relevant architectural views. Real-World Design Constraints, Technical Design constraints, Data representation and visualization, Interaction and remote control

Unit 5 08 Hrs

Case Study & Advanced IoT Applications: IoT applications in home automation,cities,environment,energy, retail, logistics,agriculture, industry, Use of Big Data and Visualization in IoT, Industry 4.0 concepts.

Text Books:

1. S. S. Manvi, M. S. Kakkasageri, "Wireles and Mobile Network concepts and protocols", Wiley.
2. WaltenegusDargie,ChristianPoellabauer, "Fundamentals of Wireless Sensor Networks:Theory and Practice"
3. Holger Karl and Andreas Wiilig, "Protocols and Architectures for Wireless Sensor Networks" John Wiley & Sons Limited 2008. 2. I.F .
4. Akyildiz and Weillian, "A Survey on Sensor Networks",IEEE Communication Magazine, August 2007.
5. Vijay Madisetti, ArshdeepBahga, "Internet of Things: A Hands-On Approach"

Reference Books:

1. "Wireless Communication Networks and Systems, Global Edition", Cory Beard, William Stallings, Pearson, 2016

2.ItiSaha Mishra, "Wireless communication and networks 3G and beyond ", MGH, 2009

3. P. Nicopolitidis, M. S. Obaidat, etal., "Wireless Networks", Wiley, 2009.

E books:

1. Analysis and Design of Next generation Software architectures, Arthur M Langer
2. An Introduction to IoT

NPTEL/MOOC:

1. https://www.bbvaopenmind.com/en/iot-implementation-and-challenges/

2.https://www.ftc.gov/system/files/documents/reports/federal-trade-commission-staff-reportnovember-2013-workshop-entitled-internet-things-privacy/150127iotrpt.pdf

Course Code	1MTDC05	Course Title	Advanced Digital Communications
Credits	03	L-T-P	3-0-0
CIE	50 Marks(100% weightage)	SEE 100	100 Marks (50% weightage)

Prerequisites: Signals and Systems

Course Outcomes

CO1	Acquire a scholarly knowledge of the different signalling and digital modulation techniques and to compare them in terms of their constellations, power spectra and bandwidth etc.	PO1,3
CO2	Perform characterization of AWGN channels, bandlimited channels and fading multipath channels, and a critical analysis of communication systems and receiver design techniques over different channels.	PO1,3
CO3	Plan and execute basic and advanced simulations exercises related to digital communications in lab.	PO1,3
CO4	Execute a group study of one advanced topic in digital communication (through IEEE journal papers).	PO1
CO5	Prepare a technical documentation and presentation for the study performed by theteam.	PO2

Unit 1 10 Hrs

Signal Representation / Modulation techniques – Low pass representation of bandpass signals, Representation of digitally modulated Signals, Modulation Schemes without memory (Band Limited Schemes - PAM, BPSK, QPSK, MPSK, MQAM, Power Limited Schemes – FSK, MFSK, DPSK, DQPSK), modulation schemes with memory (Basics of CPFSK and CPM), Transmit PSD for Modulation Schemes, Vector and AWGN Channels, Optimum Coherent Detection for power limited and Bandlimited schemes

Unit 2 07 Hrs

Tx over Bandlimited Channels: Bandlimited channel characterization, signaling through band limited linear filter channels, Sinc, RC, Duobinary and Modified Duobinarysignalling schemes

Unit 3 08 Hrs

Fading – Large scale, small scale; Statistical characterization of multipath channels – Delay and Doppler spread, classification of multipath channels, scattering function; Binarysignalling over frequency non selective Rayleigh fading channel.

Unit 4 08 Hrs

Receiver design techniques: Optimum receiver for channel with ISI and AWGN.Linear Equalizers: Zero forcing Equalizer, MSE and MMSE, Baseband and Passband Linear Equalizers, Diversity techniques for performance improvement with binary signalling on freq flat slow fading channels – power combining and Maximal ratio combining

Unit 5 06 Hrs

Spread spectrum signals for digital communication: Model of spread spectrum digital communication system, Direct sequence spread spectrum signals, some applications of DS spread spectrum signals, generation of PN sequences, Frequency hopped spread spectrum signals, Time hopping SS, Synchronization of SS systems.

TEXT BOOKS:

1. John G. Proakis, MasoudSalehi, "Digital Communications, 5e, Pearson Education(2014),ISBN:978-9332535893
2. Bernard Sklar;Digital Communications: Fundamentals and Applications: Fundamentals; Applications, 2e Pearson Education(2009),ISBN:978-8131720929
3. Simon Haykin; Digital Communications Systems,1e, Wiley(2014), ISBN:978- 8126542314

MOOC / e-resources:

MIT podcasts by world renowned Prof Gallager:
https://podcasts.apple.com/us/podcast/principles-of-digital-communications-i/id341597796
NPTEL course by IIT Kharagpur and IIT Delhi:
https://nptel.ac.in/courses/117/105/117105144/
https://nptel.ac.in/courses/108/102/108102120

Course Code	**1MTDC06**	**Course Title**	**Research Methodology**
Credits	**02**	**L-T-P**	**2-0-0**
CIE	**50 Marks(100% weightage)**	**SEE 100**	**100 Marks (50% weightage)**

COURSE OUTCOMES

CO 1	Ability to write and present a substantial technical report/document	PO 2
CO 2	Able to demonstrate a degree of mastery over the area of specialization	PO 3

Module 1:

Meaning and sources of research problem, , Objectives and Characteristics of research – Errors in selecting research problem, Research methods Vs Methodology - Types of research-Criteria of good research – Developing a research plan.

Module 2:

Investigations of a research problem - Selecting the problem - Necessity of defining the problem – Data collections-analysis- Importance of literature review in defining a problem - Survey of literature -Necessary instrumentations.

Module 3:

How to write paper-conference articles-poster preparation, thesis report writing, inclusion of references, journal reviewing process, journal selection process, filling about journal template, developing effective research proposal- plagiarism-research ethics

Module 4:
Nature of Intellectual property, IPRs- Invention and Creativity - Importance and Protection of Intellectual Property Rights (IPRs) – procedure for grant of patents and patenting under PCT-types of patents-technological research and innovation- international cooperation on IP.

Module 5:
A brief summary of : Patents-Copyrights-Trademarks, patent rights-licensing and transfer of technology-patent databases-case studies on IPR-Geographical indications-new developments in IPR-protection of IPR rights

TEXT BOOKS:
1. Garg, B.L., Karadia, R., Agarwal, F. and Agarwal, U.K., 2002. An introduction to Research Methodology, RBSA Publishers.
2. Kothari, C.R., 1990. Research Methodology: Methods and Techniques. New Age International. 420p.
3. Anderson, T. W., An Introduction to Multivariate Statistical Analysis, Wiley Eastern Pvt., Ltd., New Delhi
4. Sinha, S.C. and Dhiman, A.K., 2002. Research Methodology, EssEss Publications. 2
5. Subbarau NR-Handbook of Intellectual property law and practise- S Viswanathan Printers and Publishing Private Limited 1998.

I SEMESTER
PROGRAM ELECTIVE SYLLABUS

Course Code	**1MTDC07**	**Course Title**	**Error Control Coding**
Credits	**03**	**L-T-P**	**3-0-0**
CIE	**50 Marks(100% weightage)**	**SEE 100**	**100 Marks (50% weightage)**

Prerequisites: Linear Sysytems, Probability Theory

COURSE OUTCOMES

CO1	Apply various error control coding techniques for various telecommunication and data storage systems.	PO3
CO2	Design &Analyse various error control schemes using principles and techniques developed to identify bottlenecks.	PO3
CO3	Proficiency in knowledge development on the specific topic of error control coding using open literature to keep up to date with new advancements.	PO3

Unit 1 07 Hrs
Linear block codes: Generator and parity check matrices, Encoding circuits, Syndrome and error detection, Minimum distance considerations, Standard array and syndrome decoding,

decoding circuits, Hamming codes, Reed-Muller codes, Golay codes, Product codes and interleaved codes.

Unit 2 08 Hrs

Cyclic codes: Introduction, Generator and parity check polynomials, Encoding using multiplication circuits, Systematic cyclic codes – Encoding using feedback shift register circuits, generator matrix for cyclic code, Syndrome computing and error detection, Meggitt decoder, Error trapping decoding, Cyclic hamming codes, Shortened cyclic codes.

Unit 3 08 Hrs

Majority Logic decodable codes: One -step majority logic decoding, One-step majority logic decodable codes, Two-step majority logicdecoding, Multiple-step majority logic decoding.

Unit 4 08 Hrs

Convolution codes: Encoding of convolutional codes, Structural properties, Distance properties, Viterbi decoding algorithm for decoding, Soft output Viterbi algorithm, Stack and Fano sequential decoding algorithms, Majority logic decoding.

Unit 5 08 Hrs

Applications of Block codes and convolution codes.

TEXT BOOKS:

1. Shu Lin and Daniel J. Costello. Jr, "Error control coding", Pearson, Prentice Hall, 2nd edition, 2004.
2. Blahut. R. E, "Theory and practice of error control codes", Addison Wesley, 1984.

E Books:

1. Understanding Error Control Coding, Sanvicente, Emilio

Course Code	**1MTDC08**	**Course Title**	**Optical Communication and Networks**
Credits	**03**	**L-T-P**	**3-0-0**
CIE	**50 Marks(100% weightage)**	**SEE 100**	**100 Marks (50% weightage)**

Prerequisites: Sound knowledge on basic optics, optical communication, Electromagnetic Fields and waves

Course Outcomes:

CO1	To gain knowledge on design of the latest generation of transmission systems and networks, and the factors limiting the system performance	PO 3
CO2	Ability to execute a group study of one advanced topic in Optical communication (through IEEE journal papers) prepare a technical documentation and present the same	PO 2
CO3	To gain knowledge of the free space optics engineering	PO 3

Unit 1 07 Hrs

Transmission System Engineering: system model, power penalty, Transmitter, Receiver, Optical amplifiers, cross talk, dispersion, fiber non-linearities, wavelength stabilization, Overall Design considerations.

Unit 2 08 Hrs

Optical Networks: Client layers of optical layer, SONET/SDH, multiplexing, layers, frame structure, ATM functions, adaptation layers, Quality of service and flow control

Unit 3 08 Hrs

WDM Network Elements: Optical line terminal optical line amplifiers, optical cross connectors, WDM network design, cost tradeoffs, LTD and RWA problems, Routing and wavelength assignment, Introduction to DWDM & CWDM

Unit 4 08 Hrs

Control and Management: Network management functions, management frame work, Information model, management protocols, layers within optical layer performance and fault management, impact of transparency, optical trace, Alarm management, configuration management, optical safety

Unit 5 08 Hrs

Fundamentals of FSO Technology: Introduction, Fiber Vs FSO, The Role of FSO in the Network, How FSO Works: An Overview (Block Diagram), factors affecting FSO, Integration of FSO in Optical Networks, Benefits of Next-Generation Optical Networking, Classifying the Global Optical Network, Driving FSO from the Edge, FSO in Metropolitan Optical Networks

TEXT BOOKS:

1. Rajiv Ramswami, N Sivaranjan, Galen H Sasaki, "Optical Networks – A Practical Perspective", 3rd Edition, M. Kauffman Publishers.
2. John M. Senior, "Optical Fiber Communications", Pearson edition, 2000.
3. Gerd Keiser, "Optical Fiber Communication", MGH, 2008.
4. Heinz, Phd. Willebrand, "Free Space Optics," Sam's, 1st Ed., 2001.

E Books:

1. Optical Communication and Networks eBook: Bandyopadhyay, M.N

MOOC/NPTEL:

1. . http://nptel.iitm.ac.in/courses/117101002.html
2. http://www.optics.arizona.edu/academics/course/opti-632.html
3. https://optiwave.com/resources/academia/free-fdtd-download

Course code	20ECDCPEFG	Course Title	Fifth Generation Networks
Credits	03	L-T-P	3-0-0
CIE	50 Marks(100% weightage)	SEE 100	100 Marks (50% weightage)

Prerequisites: Basic knowledge of Wireless networks , Network layers

Course Outcomes

CO1	Understand 5G Technology advances and their benefits	PO3
CO2	To provide comprehensive knowledge of 5G architecture and the key RF, PHY, MAC and air interface	PO3
CO3	Insight about Device to device communication and millimeter ve communication.	PO3
CO4	Ability to provide critical analysis of current research topics in the domain of antennas and prepare a technical document and present the same.	PO2

Unit 1 07 Hrs

An Overview of 5G requirements, Regulations for 5G,Spectrum Analysis and Sharing for 5G, The 5G wireless Propagation Channels: Channel modeling requirements, propagation scenarios and challenges in the 5G modeling, Channel Models for mmWave MIMO Systems.

Unit 2 08 Hrs

5G Architecture and Millimeter wave communication

5G Architecture: Software Defined Networking – Network Function Virtualization – Basics about RAN Architecture –High-Level Requirements for 5G Architecture – Functional Architecture and 5G Flexibility – Physical Architecture and 5G Deployment Millimeter Wave Communication: Channel Propagation – Hardware Technologies for mmW Systems, Deployment Scenarios – Architecture and Mobility – Beamforming – Physical layer Techniques

Unit 3 08 Hrs

Machine type and D2D communication Device-to-device (D2D) and machine-to-machine (M2M) type communications – Extension of 4G D2D standardization to 5G, radio resource management for mobile broadband D2D, multihop and multi-operator D2D communications.

Unit 4 08 Hrs

5G radio access technologies Access Design Principles for Multi-user Communications – Multi-carrier with Filtering ,Nonorthogonal Schemes for Efficient Multiple Access – Radio Access for

Dense Deployments – Radio Access for V2X Communication – Radio Access for Massive Machine-type Communication.

Unit 5 08 Hrs

Massive Multiple-input Multiple –output systems

Millimeter-wave Communications – spectrum regulations, deployment scenarios, beamforming, physical layer techniques, interference and mobility management, Massive MIMO propagation channel models, Channel Estimation in Massive MIMO, Massive MIMO with Imperfect CSI, Multi-Cell Massive MIMO, Pilot Contamination, Spatial Modulation (SM)

REFERENCE BOOKS

1) Asif Oseiran, Jose F.Monserrat and Patrick Marsch, "5G Mobile and WirelessCommunications Technology", Cambridge University Press, 2016.

2) Jonathan Rodriquez, "Fundamentals of 5G Mobile Networks", Wiley, 2015

3) Patrick Marsch, Omer Bulakci, Olav Queseth and Mauro Boldi, "5G SystemDesign – Architectural and Functional Considerations and Long Term Research",Wiley, 2018

4) Martin Sauter "From GSM From GSM to LTE–Advanced Pro and 5G: AnIntroduction to Mobile Networks and Mobile Broadband", Wiley-Blackwell.

5) Athanasios G.Kanatos, Konstantina S.Nikita, Panagiotis Mathiopoulos, "NewDirections in Wireless Communication Systems from Mobile to 5G", CRC Press.

6) Theodore S.Rappaport, Robert W.Heath, Robert C.Danials, James N.Murdock"Millimeter Wave Wireless Communications", Prentice Hall Communications.

E Books:

1. https://www.nokia.com/networks/portfolio/radio-access-networks-ran/
2. https://www.eric

https://www.huawei.com/minisite/hwmbbf16/insights/5G-Nework-Architecture-Whitepaper-en.pdfsson.com/en/reports-and-papers/white-papers/5g-systems

MOOCs:

1. https://www.udemy.com/course/5g-mobile-networks-modern-wireless-communication-technology/
2. https://www.classcentral.com/course/swayam-evolution-of-air-interface-towards-5g-12957

Course Code	**20ECDCGEED/ 20ECELGEED**	**Course Title**	**Estimation and Detection Techniques**
Credits	**03**	**L-T-P**	**3-0-0**
CIE	**50 Marks(100% weightage)**	**SEE 100**	**100 Marks (50% weightage)**

Prerequisites: Fourier transform, signals and systems, probabilities and random processes.

COURSE OUTCOMES

CO1	Acquire the concepts of detection theory, estimation theory and binary/composite hypothesis testing	PO3
CO2	Apply different techniques to perform detection of deterministic / random signals in the presence of noise	PO3
CO4	Ability to independently reproduce the results of the research paper in the domain	PO1

Unit 1 07 Hrs

Introduction: The mathematical detection problem, Binary hypothesis testing, Bayesian test, Minimax test, MAP criteria, Bayes' risk, Neyman-Pearson theorem

Unit 2 08 Hrs

Detection of deterministic and random signals: Detection of known signals in noise, Matched filter, Performance evaluations, Estimator Correlator for random signals

Unit 3 08 Hrs

Composite Hypothesis Testing: Bayesian approach, GLRT. Sinusoidal detection with unknown phase/ amplitude/ frequency

Unit 4 08 Hrs

Sequential Detection of Multiple Hypotheses, Signal detection with unknown noise parameters – white Gaussian noise case

Unit 5 08 Hrs

Fundamentals of estimation theory: Formulation of the General Parameter Estimation Problem, Relationship between Detection and Estimation, Types of Estimation, Minimum variance unbiased estimation.

TEXT BOOKS:

1. Harry L. Van Trees, "Detection, Estimation, and Modulation Theory, Part I," John Wiley & Sons, 2004.
2. Steven M.kay, "Fundamentals of Statistical signal processing, volume-1: Estimation theory". Prentice Hall 1993.
3. Steven M.kay, "Fundamentals of Statistical signal processing, volume-2: Detection theory". Prentice Hall 1993
4. A.Papolis and S.Unnikrishna Pillai, "Probability, Random Variables and stochastic processes, 4e". The McGraw-Hill 2002.

EBooks:

1. An Introduction to Signal Detection and Estimation, Poor, H. Vincent

Course Code	20ECDCPESC	Course Title	Advanced Satellite Communication
Credits	03	L-T-P	3-0-0
CIE	50 Marks(100% weightage)	SEE 100	100 Marks (50% weightage)

Prerequisites: Basics of digital and satellite communication

Course Outcomes

CO1	To explore the orbital mechanics, space craft sub-systems, satellite link design, Satellite applications.	PO3
CO2	Analyze the technical details behind the satellite link and its real time applications	PO3
CO3	Ability to independently develop a solution to a defined practical problem	PO1

Unit 1 07 Hrs

Introduction and Satellite Access: Orbits of Satellite: Low - medium - geo-synchronous - angle period - returning period - orbital spacing - delay transponder - earth stations - antennas and earth coverage - altitude and eclipses; Multiple Access: Demand assigned FDMA - spade system - TDMA - satellite switched TDMA - CDMA.

Unit 2 08 Hrs

Space Segment and Earth Segment: Space Segment: Power supply - altitude control - station keeping - thermal control - TT and C subsystem - transponders; Earth Segment: Receive only home TV system - outdoor unit, indoor unit - master antenna TV system - community antenna TV system.

Unit 3 08 Hrs

Satellite Link Design and VSAT Systems: Link Design: System noise temperature and G/T ratio - design of downlinks - uplink design - C/N - error control for digital satellite link; VSAT Systems: Network architectures - access control protocols - earth station engineering - antennas - link margins - system design procedure.

Unit 4 08 Hrs

Antennas for Satellite: Multibeam antennas, On board beam switching.

Unit 5 08 Hrs

Applications of Satellite communication: Direct to Home, Intelsat, GSAT

TEXT BOOKS:

1. Timothy Pratt and Charles W. Bostain, "Satellite Communications", 2nd Edition, Wiley, 2012.
2. D. Roddy, "Satellite Communication", 4th Edition (Reprint), McGraw Hill, 2009.
3. Wilbur L. Pritchard, Hendri G. Suyderhoud and Robert A. Nelson, "Satellite Communication Systems Engineering", Prentice Hall/ Pearson, 2007
4. Tri T. Ha, "Digital Satellite Communication", 2nd Edition, McGraw Hill, 1990.
5. Brian Ackroyd, "World Satellite Communication and Earth Station Design", BSP Professional Books, 1990.
7. Communication Satellites By Donald H. Martin
8. Satellite Communications Network Design andAnalysis,By Kenneth Y. Jo

e-resources:

1. http://advancedengineering.umd.edu/node/2320
2. http://ece564web.groups.et.byu.net
3. http://personal.stevens.edu/~yyao/syllabus-674.html
4. http://staff.um.edu.mt/carl.debono/lectures.html

Course Code	**20ECDCPESD**	**Course Title**	**Software Defined Radio**
Credits	**03**	**L-T-P**	**3-0-0**
CIE	**50 Marks(100% weightage)**	**SEE 100**	**100 Marks (50% weightage)**

Prerequisites:

Course Outcomes

CO1	Complete understanding of SDR Architecture	PO3
CO2	Insight into system design from RF perspective	PO3
CO3	Understand the concept of smart antenna systems.	PO3
CO4	Ability to use modern tools for the design & implementation of an end to end communication System.	PO2

Unit 1 07 Hrs

Introduction: – Software Defined Radio- SDR concepts & history,- Characteristics and Benefits of Software Radio – Design Principles of a Software Radio, Ideal SDR architecture, SDR Based End-to-End Communication.

Unit 2 08 Hrs

Analog to digital and digital to analog conversion Parameters of ideal data converters; Parameters of practical data converters;Techniques to improve data converter performance; Common ADC and DAC architectures.

Unit 3 08 Hrs

RF System Design – The purpose of the RF Front-End, Dynamic range: The principal challenge of receiver design. RF receiver front-end topologies, Enhanced flexibility of the RF Chain with Software Radios, Importance of the components to overall performance,

Unit 4 08 Hrs

Transmitter architectures and their Issues, noise and distortion in the RF Chain, ADC and DAC distortion.

Unit 5 08 Hrs

Smart Antennas Using Software Radio- Introduction- 3G smart Antenna Requirements,, Smart Antenna Architectures- Optimum Combining/ Adaptive Arrays- DOA Arrays- Beam Forming for CDMA- Downlink Beam Forming.Introduction and Concept of Cognitive Radio

TEXT BOOKS:

1. Jeffrey H Reed, "Software Radio: A Modern Approach to Radio Engineering", PEA Publication, 2002.
2. Paul Burns, "Software Defined Radio for 3G", Bartech House, 2002.
3. Markus Dillinger, "Software Defined Radio: Architectures, Systems and Functions", 2003.
4.Telecommunication Breakdown by C. Richard Johnson Jr., William A. Sethares, 2003, Prentice Hall.
5.Cognitive Radio Networks by Wyglinski, Alexander M. Nekovee, Maziar, Hou, Y. Thomas, 2010,Elsevier.

II SEMESTER

PROGRAM CORE

Course code	**2MTDC01**	**Course Title**	**Advanced Wireless Communication**
Credits	**04**	**L-T-P**	**3-0-1**
CIE	**50 Marks(100% weightage)**	**SEE 100**	**100 Marks (50% weightage)**

Prereq uisite : Basic knowledge of Cellular concept and Wireless concepts

Course outcomes

CO1	Acquire knowledge about wireless II/O models for real time channels	PO3
CO2	A ility to analyze the need of diversity and performance factors of ading multipath channels and MIMO systems.	PO3
CO3	To implement the current research topics in Wireless communication, reparation of technical documentation and presentation of the work one	PO2

CO4	Ability to independently formulate and analyze the design of wireless etwork models using simulator.	PO1

Unit 1 08 Hrs

Wireless channel: Multipath &fading of channels, Physical modeling for wireless channels, input/output model of wireless channel

Unit 2 08 Hrs

Point –to-point communication

- Detection : Coherent and non -coherent detection in a fading channel
- Diversity: Introduction, Micro diversity, Micro diversity Time diversity, Antenna diversity, Frequency diversity

Unit 3 07 Hrs

Capacity of wireless channels: AWGN channel capacity, resources of AWGN channel, Linear time invariant Gaussian channels, capacity of fading channels – slow & fast fading channels.

Unit 4 08 Hrs

MIMO Systems: Introduction, MIMO system, Capacity in slow fading and fast fading channels, MIMO Based system architecture, Antenna considerations for MIMO, MIMO channel modeling, measurement, and Capacity.

Unit 5 08H rs

Visible light communication: Security issues in visible light communication systems,Visible light communication: Applications, architecture, standardization and research challenges

References Books:

1 David Tse, P. Viswanath, "Fundamentals of wireless communication", Cambridge, 2006.
2 Andreas Molisch, "Wireless communications", Wiley, 2009
3 Wireless Communications: Principles and Practice, By T. S. Rappaport , Prentice Hall
4 William C Y Lee, "Mobile Communication Engineering Theory and applications", TMGH, 2008
5 UpenDalal, "Wireless communication", Oxford, 2009

E Books:

https://ocw.mit.edu/courses/electrical-engineering-and-computer-science

https://lifi.co/visible-light-communication/
https://www.sciencedirect.com/science/article/pii/S2405896315008149

https://www.sciencedirect.com/science/article/pii/S2352864816300335
https://www.fraunhofer.de/en/research/fields-of-research/communication-knowledge/broadband-communications/visible-light-communication.html

MOOCs:

https://www.udemy.com/course/introduction-to-wireless-communications

https://www.coursera.org/learn/wireless-communications
https://nptel.ac.in/courses/117/105/117105132/

Course Code	20ECDCGCAD	Course Title	Advanced Digital Signal Processing
Credits	04	L-T-P	3-1-0
CIE	50 Marks(100% weightage)	SEE 100	100 Marks (50% weightage)

Prerequisites: Signals and Systems

Course Outcomes

CO1	Ability to acquire the theoretical knowledge of advanced DSP, including FIR/IIR filter design, multirate DSP and adaptive filters	PO 1,3
CO2	Ability to analyse and apply the theoretical concepts of DSP to real life problems of practical and numerical nature.	PO 1,3
CO3	Ability to select an IEEE journal paper covering a contemporary application of DSP, conduct appropriate literature survey pertaining to the topic, and solve and assimilate the selected paper..	PO1
CO4	Ability to create a standard documentation and presentation of the study performed by their team	PO2

Unit 1 08 Hrs

Introduction: Overview of signals and systems, The concept of frequency in continuous time and discrete time signals, Sampling of continuous time signals, Analog to digital and digital to analog conversion. Discrete Fourier transform: The DFT / IDFT pair, Properties of DFT, Linear filtering methods based on the DFT, applications in Communication engineering.

Unit 2 09 Hrs

Design of digital filters: General considerations, design of FIR filters, windowing and frequency sampling methods, Design of IIR filters from analog filters, impulse invariance and bilinear transformation methods.

Unit 3 08 Hrs

Multirate digital signal processing: decimation by a factor D, Interpolation by a factor sampling rate conversion by a factor I/D, Engineering applications of multirate signalprocessing, digital filter banks, QMF filters.

Unit 4 06 Hrs

Filter Implementation techniques: Polyphase structure, Multistage implementation of sampling rate conversion, Adaptive filters: concept and applications, Adaptive direct form FIR filters, The LMS algorithm (without proof).

Unit 5 08 Hrs

Wavelet Transforms: The origin of Wavelets, Wavelets and other reality transforms, continuous Wavelet and Short Time Fourier Transform, Mathematical preliminaries,Properties of wavelets. Discrete Wavelet Transform: Haar scaling functions, Haar waveletfunction, Daubechies Wavelets.

Text Books:

1. S. K. Mitra;Digital signal processing: A computer based approach", 3rd edition, TMH, India, 2007.
2. E.C. Ifeachor, and B. W. Jarvis;Digital signal processing: A Practitioner approach, Second Edition, Pearson Education, India, 2002,
3. Proakis, and Manolakis,;Digital signal processing", 3rd edition, Prentice Hall, 1996
4. Insight into Wavelets- from Theory to Practice", K.P Soman, Ramachandran, Resmi-PHI Third Edition-2010.

MOOC / e-resources:

Podcasts by MIT:
https://podcasts.apple.com/us/podcast/digital-signal-processing/id481803782
NPTEL from IIT Bombay and IIT Madras:
https://nptel.ac.in/courses/117/101/117101001/
https://nptel.ac.in/courses/108/106/108106151/

A note on Tutorial conduction: Topic wise conceptual and numerical problem solving.
Detailed Study of a research paper from related IEEE journals.

Course Code	**20ECDCPCNA**	**Course Title**	**Wireless Communication Networks Analytics**
Credits	**04**	**L-T-P**	**3-1-0**
CIE	**50 Marks(100% weightage)**	**SEE 100**	**100 Marks (50% weightage)**

Prerequisites: Strong grasp of descriptive and inferential statistics.

Course Outcomes:

CO1	Study concepts, applications and development of data science in the communication industry	PO3
CO2	Use concept of ML and data mining for studying problems in telecommunication networks.	PO3
CO3	Achieve adequate perspectives of data analytics in various applications like	PO3

	recommender systems, social media applications etc.	
CO4	Select an IEEE paper, conduct literature survey on the chosen topic ,document the survey and present.	PO2

Unit 1 07 Hrs

Introduction, Methodologies of Analytics for Telecom, Regression Methods, ClassificationMethods, Clustering Methods, Forecasting Methods, Neural Network and Deep Learning

Unit 2 08 Hrs

Trending LTE Network Performance, Network Performance Forecasting Strategy, Relationship Between Network Resources and Performance Indicators, Forecasting Network Resources, Application for RRC Connection Setups Evaluation, Trending Device Readiness and Device Return Rate

Unit 3 08 Hrs

Evaluating VoLTE Voice Quality in LTE Networks, POLQA in Assessment of Voice Quality, CrowdMi Methodology, Technical Details on CrowdMi, CrowdMi Prototyping a and Trial, Profiling Wireless Resource Usage for Mobile Apps

Unit 4 08 Hrs

Analytics Assisted Self-Optimization in LTE Networks, SON (Self-Organizing Network), APP-SON, APP-SON Architecture, APP-SON Algorithm

Unit 5 08 Hrs

Telecommunications Data and Marketing, Topics in Telecom Marketing, General Construction of a Social Network, Network Measures, Modelling Consumer Behaviours within a Network

Text Books:

1. Mining Over Air: Wireless Communication Networks Analytics, Ye Ouyang, Mantian Hu, Alexis HuetZhongyuan Li, Springer International Publishing AG, part of Springer Nature 2018.

EBooks:

1. Data Science Specialization — JHU (Coursera)
2. Introduction to Data Science — Metis.
3. Applied Data Science with Python Specialization — UMich (Coursera)
4. Dataquest.
5. Statistics and Data Science MicroMasters — MIT (edX)
6. CS109 Data Science — Harvard.

II SEMESTER
PROGRAM ELECTIVE SYLLABUS

Course Code	**20ECDCPEWR**	**Course Title**	**Advanced Techniques for Wireless Reception**
Credits	**03**	**L-T-P**	**3-0-0**
CIE	**50 Marks(100% weightage)**	**SEE 100**	**100 Marks (50% weightage)**

Prerequisites: Fundamentals of Wireless techniques in receiver side of wireless communication , Signal processing techniques

Course Outcomes

CO1	Evaluate the performance of wireless signaling environment	PO3
CO2	Apply mathematical formulation to find Optimum detection of wireless signal	PO3
CO3	Develop signal processing algorithms for wireless signal reception.	PO3
CO4	Ability to independently develop a solution to a defined practical problem	PO1

Unit 1 07 Hrs

Blind Multiuser Detection Wireless signalling environment: Basic receiver signal processing for wireless reception- matched filter/raked receiver, equalization and MUD. Linear receiver for synchronousCDMA- decorrelating and MMSE detectors. Blind MUD, direct and subspace methods.

Unit 2 08 Hrs

Group Blind MUD : Linear group blind MUD for synchronous CDMA, Non-linear group blind multiuser detectors for CDMA-slowest descent search. Group blind multiuser detection in multipath channels- Linear group blind detectors**.**

Unit 3 08 Hrs

Space-Time MUD: Adaptive array processing in TDMA systems-Linear MMSE combining, sub-space based training algorithm and extension to dispersive channels. Optimal space time MUD. Linear space time MUD Linear MUD via iterative interference cancellation, single user space-time detection and combined single user/multiuser linear detection**.**

Unit 4 08 Hrs

NBI Suppression: Linear predictive techniques-linear predictive methods. Non-linear predictive techniques-ACM filter, Adaptive non-linear predictor, Non-linear interpolating filters and HMM based methods.

Unit 5 08 Hrs

Signal Processing for Wireless Reception: Bayesian signal processing- Bayesian framework, batch processing Versus adaptive processing, Monte-Carlo methods. Signal processing for fading channels. Coherent detection in fading channels based on EM algorithm. Decision feedback

differential detection in fading channels-Decision feedback differential detection in flat channels, Decision feedback space-time differential decoding.

Text Books:

1. X.Wang and H.V.Poor," Wireless Communication Systems," Pearson,2004
2. ItiSahaMisra, "Wireless Communications and Networks,"Tata McGraw Hill, 2009.

Hyperlinks:

1. docwiki.cisco.com/wiki/WirelessTechnologies
2. http://dl.acm.org/citation.cfm?id=1593080

Course Code	**20ECDCPECN**	**Course Title**	**Communication Networking Systems**
Credits	**03**	**L-T-P**	**3-0-0**
CIE	**50 Marks(100% weightage)**	**SEE 100**	**100 Marks (50% weightage)**

Prerequisites: Knowledge in Telecommunication Networks

Course Outcomes

CO1	Apply the concepts of Computer Networks and Network Models for Data Communication.	PO3
CO2	Analyze existing network protocols and networks.	PO3
CO3	Analyze and exemplify current QoS architectures and mechanisms, the QoS support challenges in future networks	PO3
CO4	Ability to identify the future opportunities and challenges associated with next generation networks and prepare a technical document.	PO2

Unit 1 06 Hrs

Introduction: Performance and architectural issues in packet and circuit switching

Unit 2 09 Hrs

Packet queues and delay analysis: Little's theorem, Birth-and-death process, queueing disciplines, Markovian FIFO queueing systems, Non- Markovian and self-similar models, networks of queues.

Unit 3 08 Hrs

QoS and Resource Allocation: Integrated services QoS, Differentiated services QoS, Resource Allocation

Unit 4 08 Hrs

Networks in Switch Fabrics: Characteristics and features of switch fabrics, Crossbar switch fabrics, Blocking switch fabrics, Non-blocking switch fabrics, Concentration and Expansion switch fabrics, Shared memory switch fabrics.

Unit 5 08 Hrs

Routing: Engineering issues: Algorithms for shortest path routing; Dijkstra's algorithm, Bellman ford alorithmg, Routing protocols- Distance Vector Protocols, Link state protocols

Textt Books::

1. Communication Networking – An analytical approach, Anurag Kumar, D. Manjunath, Joy Kuri, Morgan Kaufman Publishers, 2005.
2. Computer and Communication Networks, Nader F Mir, Pearson Education, 2009
3. Computer Networks and Internets,Douglas E Comer, 6th Edition

E Resources:

1. https://nptel.ac.in/courses/117/101/117101050/
2. http://www.ifp.illinois.edu/~angelia/ge330fall09_dijkstra_l18.pdf
3. https://www.ciscopress.com/articles/article.asp?p=24090&seqNum=3

Course Code	**20ECDCPELT**	**Course Title**	**Long Term Evolution Networks**
Credits	**03**	**L-T-P**	**3-0-0**
CIE	**50 Marks(100% weightage)**	**SEE 100**	**100 Marks (50% weightage)**

Prerequisites: Basic understanding of mobile telecom network technologies like GSM, CDMA and WCDMA .

Course Outcomes

CO1	Identify the motivations and goals for 4G networks and summarize the basic concepts of LTE Air Interface	PO3
CO2	Sketch the high-level architectures of the evolved LTE Radio network	PO3
CO3	Walk through a typical LTE call from power-up to service setup to disconnect	PO3
CO4	Ability to prepare a technical document and make an oral presentation to provide the evolution of technology in the domain	PO2

Unit 1 07 Hrs

OFDM and OFDMA for LTE : OFDM -Introduction , History of OFDM Development, OFDM Orthogonal Multiplexing Principle, Peak-to- Average Power Ratio and Sensitivity to Nonlinearity , Sensitivity to Carrier Frequency Offset and Time-Varying Channels . Timing Offset and Cyclic Prefix Dimensioning, OFDMA- Introduction - Parameter Dimensioning, Physical Layer Parameters for LTE , Conclusion .

Unit 2 08 Hrs

Transmit diversity and MIMO Spatial Multiplexing: Transmit diversity-Transmit diversity schemes , Downlink transmission chain , Code word to layer mapping , Transmit diversity precoding

Unit 3 08 Hrs

MIMO spatial multiplexing- MIMO capacity , Code words and layer mapping , Downlink MIMO transmission chain , MIMO precoding , CDD-based precoding, Open-loop spatial multiplexing

Unit 4 08 Hrs

Network architecture and protocols : Network architecture, QoS and bearer service , architecture , Layer 2 structure ,Protocol states and states transitions , Seamless mobility support, Multicast broadcast system architecture.

Unit 5 08 Hrs

Channel structure and bandwidths: Channel bandwidths, UE radio access capabilities , Frame and slot structure , Frame structuretype 2, Downlink distributed transmission , Uplink hopping , Uplink power control , Downlink power control.

Dataflow and Call flow in LTE: Message flow- IMS registration and attach procedure, VOLTE system architecture- Call flow between legacy network to LTE, call flow within LTE system.

Text Books:

1. Farooq Khan- "LTE for 4G mobile broadband" – Cambridge University press 2009
2. StefaniaSesia, IssamToufik, Matthew Baker "LTE-Long Term Evolution –From Theory to Practice " Wiley, 2009

Reference Books:

1**.** Steven M.kay, "Fundamentals of Statistical signal processing, volume-2: Detection theory", Prentice Hall 1993
2.A. Papolis and S.Unnikrishna Pillai, "Probability, Random Variables and stochastic processes, 4e". The McGraw-Hill 2002.

Resources :

1.Nokia Documents on LTE

Course Code	**20ECDCPEMT**	**Course Title**	**Multimedia Compression Techniques**
Credits	**03**	**L-T-P**	**3-0-0**
CIE	**50 Marks(100% weightage)**	**SEE 100**	**100 Marks (50% weightage)**

Prerequisites: Basics of signals and systems and information theory

COURSE OUTCOMES

CO1	demonstrate a sound knowledge of the mathematical concepts and algorithms behind the compression of multimedia signals of various types	PO3

CO2	Analyse contemporary standards used for compression of different classes of multimedia signals	PO2,3

Unit 1 07 Hrs

Introduction to Multimedia – components of multimedia- Introduction to Multimedia: components of multimedia, Graphics/image data types, Fundamental Concepts in Video, analog and digital video, Basics of Digital Audio, Storage requirements for multimedia applications, Need for Compression, Taxonomy of compression techniques, popular file formats

Unit 2 08 Hrs

Data Compression: Adaptive methods, Huffman Coding, simple and adaptive, Arithmetic coding, simple and Adaptive, Dictionary Methods, LZW algorithm, illustrative examples

Unit 3 08 Hrs

Audio Compression: Speech compression, waveform codecs, source codecs, hybrid codecs, Shorten compressor, MPEG-1 audio layers

Unit 4 08 Hrs

Image Compression: Image Transforms, orthogonal transforms, DCT, JPEG, progressive image compression, JBIG, JBIG2 standards, Vector quantization, Differential lossless compression, DPCM Wavelet based compression, Filter banks, DWT, Multiresolution decomposition, SPIHT and EZW Coders, JPEG 2000 standard

Unit 5 08 Hrs

Video Compression: Video signal components – Video compression techniques – MPEG Video Coding– Motion Compensation – H.261 , H.263 Standard , .MPEG4 and H.264 codecs .

Reference books:

1. Mark S.Drew and Ze-Nian Li, "Fundamentals of Multimedia," PHI, 1st Edition, 2008.
2. David Salomon, "Data Compression – The Complete Reference," Springer Verlag New York Inc., 3rd Edition, 2008.
3. L. Hanzo, P. J. Cherriman and J. Streit, "Video Compression and Communications From Basics to H.261, H.263, H.264, MPEG4 for DVB and HSDPA-Style Adaptive Turbo-Transceivers," Second Edition, IEEE Communications Society, John Wiley & Sons Ltd, 2007.
4. Peter Symes, "Digital Video Compression," McGraw Hill Pub., 2004.
5. Mark Nelson, "Data compression," BPB Publishers, New Delhi, 1998.

MOOC / e-resources:

NPTEL course by IIT Kharagpur: https://nptel.ac.in/courses/117/105/117105083/

Course Code	20ECDCPESS	Course Title	Communication System Security
Credits	03	L-T-P	3-0-0
CIE	50 Marks(100% weightage)	SEE 100	100 Marks (50% weightage)

Prerequisites: Network security, Crytography

Course Outcomes

CO1	Identify the factors driving the need for network security and the physical points of vulnerability in simple networks	PO3
CO2	Study the various Mechanisms and Protocols that are available to Establish Protected Communications	PO3
CO3	Be able to identify and present real world security attacks on networks and document the same	PO2

Unit 1 07 Hrs

Introduction -Information Security Objectives and Protection Mechanisms, Trust Model, Threat Model, Communication System Security

Unit 2 08 Hrs

Security Mechanisms and Protocols- Security Infrastructure: Infrastructure Support, Authentication Server, Certificate Authority, Key Generation and Distribution Server, Signing Server.

Establish Protected Communications: Mutual Authentication, Cryptographic Algorithm Negotiation, Protected Communications.

Unit 3 08 Hrs

Wireless Security- Network Access Authentication: Basic Concepts in Access Authentication, Authentication and Key Agreement (AKA) in 3G and LTE, Authentication, Authorization, and Accounting (AAA), Extensible Authentication Protocol (EAP).

Unit 4 08 Hrs

Wireless Network Security: Special Aspects of Wireless Protection, UMTS and LTE Air Link Protection, IEEE 802.11 Security Solutions.

Unit 5 08 Hrs

System Security- Introduction to Trusted Platform, Principles and Basic Mechanisms, Technologies and Methodologies.

Text Books:

1. Lidong Chen Guang Gong, "Communication System Security", CRC Press, A Chapman & Hall Book, 2012

2. SumitGhosh**,** "Principles of Secure Network Systems Design", Springer; 2002 edition

Reference Books:

1. Behrouz A. Ferouzan, "Cryptography & Network Security", Tata Mc Graw Hill, 2007. 2. Man Young Rhee, "Internet Security: Cryptographic Principles", "Algorithms and Protocols", Wiley Publications, 2003.
2. William Stallings, Cryptography and Network Security, 6th Edition, Pearson Education, March 2013.
3. Charles Pfleeger, "Security in Computing", 4th Edition, Prentice Hall of India, 2006
Bruce Schneier and Neils Ferguson, "Practical Cryptography", First Edition, Wiley Dreamtech India Pvt Ltd, 2003.
4. Douglas R Simson "Cryptography – Theory and practice", First Edition, CRC Press, 1995.

NPTEL:
1. https://nptel.ac.in/content/syllabus_pdf/106106199.pdf

Course Code	**20ECDCPEGR**	**Course Title**	**Green Radio Communication Networks**
Credits	**03**	**L-T-P**	**3-0-0**
CIE	**50 Marks(100% weightage)**	**SEE 100**	**100 Marks (50% weightage)**

Prerequisites: Fundamentals of computer communication and wireless networks.

Course Outcomes

CO1	Analyze the importance of reducing energy consumption, CO_2 emissions and inculcate green concepts for energy efficient approaches while designing next generation wireless networks.	PO3
CO2	Design new green radio architectures and radio techniques to reduce the overall energy consumption.	PO3
CO3	Ability to prepare a technical document to provide critical analysis of impact on environment of the hazards of e-waste	PO2

Unit 1 10 Hrs

Introduction: Fundamental Tradeoffs on the Design of Green Radio Networks: Insight from Shannon's capacity formula - impact of practical constraints - latest research and directions; Algorithms for Energy Harvesting Wireless Networks: Energy harvesting technologies - PHY and MAC layer optimization for energy harvesting wireless networks.

Unit 2 10 Hrs

Green Modulation and Coding: Modulation: Green modulation and coding schemes in energy constrained wireless networks - energy consumption of uncoded scheme - energy consumption analysis of LT coded modulation

Unit 3 10 Hrs

Co-operative Techniques: Co-operative Techniques for Energy Efficient Wireless Communications: Energy efficiency metrics for wireless networks – co-operative networks - optimizing the energy efficiency performance of co-operative networks - energy efficiency in co-operative base stations.

Unit 4 09Hrs

Base Station Power Management Techniques: Base Station Power Management Techniques for Green Radio Networks: Opportunistic spectrum and load management for green radio networks - energy saving techniques in cellular wireless base stations - power management for base stations in a smart grid environment.

References Books:

1. Ekram Hossain, Vijay K. Bhargava and Gerhard P. Fettweis, "Green Radio Communication Networks", Cambridge University Press, 2012.
2. F. Richard Yu, Yu, Zhang and Victor C. M. Leung "Green Communications and Networking", CRC press, 2012.
3. Mazin Al Noor, "Green Radio Communication Networks Applying Radio-Over-Fibre Technology for Wireless Access", GRIN Verlag, 2012.
4. Mohammad S. Obaidat, AlaganAnpalagan and Isaac Woungang, "Handbook of Green Information and Communication Systems", Academic Press, 2012.
5. Jinsong Wu, SundeepRangan and Honggang Zhang, "Green Communications: Theoretical Fundamentals, Algorithms and Applications", CRC Press, 2012.
6. Mazin Al Noor, "WiMAX Improvements in Green Radio Communications Utilizing Radio-Over- Fiber", GRIN Verlag, 2012.
7. Ramjee Prasad and Shingo Ohmori, Dina Simunic, "Towards Green ICT", River Publishers, 2010.

E Resources:

1.http://www.comsoc.org/webcasts/view/wireless-green-networking
2.http://home.ku.edu.tr/~nwcl/green.html
3. http://mypage.zju.edu.cn/en/honggangzhang/607861.html

Open Elective

Course Code	**20ECDCOEQR**	**Course Title**	**Quality and Reliability of Engineering systems**
Credits	**04**	**L-T-P**	**4-0-0**
CIE	**50 Marks(100% weightage)**	**SEE 100**	**100 Marks (50% weightage)**

Prerequisites: Basics of Probability Engineering

Course Outcomes

CO1	Understand the concepts of quality control, improvement and management and design for quality.	PO3
CO2	Understand the concepts of reliability and carry out reliability data analysis	PO3

CO3	Learn fundamentals of reliability management and risk assessment and get acquainted with various reliability prediction and evolution methods.	PO2

Unit 1 07 Hrs

Introduction: Definition and Importance of Quality and Reliability

Concepts of Reliability: Causes of failure, Life characteristic pattern, Modes of failure, Measures of Reliability, Derivation of the Reliability Function, Reliability Specifications.

Unit 2 08 Hrs

Failure Analysis Technique: Failure investigation, Data collections, Data forms, Data Sources, Reliability Analysis, Use of Probability distributions, Calculation of performance parameters, Survival curves and their Calculation, Calculation of failure rate, application of Weibull Distribution.

Unit 3 08 Hrs

System Reliability & Modelling: Types of Systems, Series, Parallel, Series-Parallel, and Parallel-Series system, Standby Systems, Types of Standby redundancy. Reliability of different systems, nature of reliability problems in electronic equipment, selection of components.

Unit 4 08 Hrs

Simulation & Reliability Prediction: Generation of Random Numbers, Generation of random observations from a probability distribution, Applicability of Monte-Carlo Method, Simulation languages.

Unit 5 08 Hrs

M**aintainability and Availability**: Objectives of maintenance, designing for optimum maintainability and measure of maintainability Availability: Uptime ratio, down time ratio and system availability **Quality Reliability and Safety**: Reliability and Quality Control, Quality Circles, Safety factor, increasing safety factors and Case Studies.

Text Books:

1. A.K.Govil, " Reliability Engineering", TMH, 1983
2. B.S.Dhillion," Reliability Engineering in Systems Design and Operation", Van No strand Reinhold Co., 1983

REFERENCES:

1. A.E.Green and A.J.Bourne ,"Reliability Technology", Wiley-Interscience, 1972

III Semester
Program Elective Syllabus

Course Code	20 ECDCPEMW	Course Title	RF and Microwave Circuits
Credits	03	L-T-P	2-1-0
CIE	50 Marks(100% weightage)	SEE 100	100 Marks (50% weightage)

Prerequisites:

Course Outcomes

CO1	Analyse the component level basics at high frequencies	PO3
CO2	Design passive circuits and analyze the importance of matching networks	PO3
CO3	Design active circuits taking into account stability and noise consideration.	PO3
CO4	Conceptualize the role of Mixers and MMICs in practical systems	PO3
CO5	Ability to independently formulate and analyze the design of RF systems through the usage of modern tools.	PO1

Unit 1 07 Hrs

Wave propagation in network: RF and Microwave circuit design, Introduction to components basics, Analysis of simple circuit phasor domain, RF impedance matching, High frequency parameters, Formulation of S-parameters, Properties, transmission matrix, Generalized S-parameters.

Unit 2 07 Hrs

Basic consideration in active networks : Stability consideration, gain consideration, Noise consideration, design of amplifiers, oscillators and detector: Introduction, Types of amplifier, Design of different types of amplifiers, Design of transistor oscillators, Detector losses, detector design.

Unit 3 06 Hrs

Mixers & Phase shifters : Mixer types, Conversion loss for SSB mixers, Phase shifters

Unit 4 06 Hrs

RF and microwave IC design: MICs, MIC materials, Types of MICs

Text Books:

1. Matthew M. Radmanesh, "RF and Microwave Electronics Illustrated", Pearson Education edition, 2004.
2. Reinhold Ludwig, and Pavel Bretchko,"RF circuit design theory and applications", Pearson Education edition, 2004.

Reference Book:

1.D K Mishra, “RF Circuit Design”, John Wiley, Intl.

Course Code	20ECDCPCNC	Course Title	Network on Chip
Credits	04	L-T-P	3-0-0
CIE	50 Marks(100% weightage)	SEE 100	100 Marks (50% weightage)

Prerequisites: Advanced Computer Architecture

Course Outcomes:

CO1	Understand the concept of network - on - chip	P O 3
CO2	Learn router architecture designs	P O 3
CO3	Study fault tolerance network - on - chip	P O 3

Unit 1 07 Hrs

INTRODUCTION TO NoC – OSI layer rules in NoC - Interconnection Networks in Network-on-Chip Network Topologies - Switching Techniques - Routing Strategies - Flow Control Protocol Quality-of-Service Support

Unit 2 08Hrs

Architecture Design: Switching Techniques and Packet Format - Asynchronous FIFO Design -GALS Style of Communication - Wormhole Router Architecture Design - VC Router Architecture Design – Adaptive Router Architecture Design.

Unit 3 08Hrs

Routing Algorithm: Packet routing-Qos, congestion control and flow control – router design – network link design – Efficient and Deadlock-Free Tree-Based Multicast Routing Methods - Path-Based Multicast Routing for 2D and 3D Mesh Networks- Fault-Tolerant Routing Algorithms - Reliable and Adaptive Routing Algorithms

Unit 4 08Hrs

Test And Fault Tolerance Of NoC: Design-Security in Networks-on-Chips-Formal Verification of Communications in Networks-on Chips Test and Fault Tolerance for Networks-on-Chip Infrastructures-Monitoring Services for Networks-on Chips.

Unit 5 08Hrs

Three-Dimensional Integration Of NoC:Three-Dimensional Networks-on-Chips Architectures. – A Novel Dimensionally-Decomposed Router for On-Chip Communication in 3D Architectures - Resource Allocation for QoS On-Chip Communication – Networks-on-Chip Protocols-On-Chip Processor Traffic Modeling for Networks-on Chip

REFERENCES:

1. ChrysostomosNicopoulos, Vijaykrishnan Narayanan, Chita R.Das" Networks-on - Chip , Architectures Holistic Design Exploration", Springer.

2. Fayezgebali, Haythamelmiligi, HqhahedWatheq E1-Kharashi "Networks-on-Chips theory and practice CRC press.
3. Konstantinos Tatas and Kostas Siozios "Designing 2D and 3D Network-on-Chip Architectures", 2013
4. Palesi, Maurizio, Daneshtalab, Masoud "Routing Algorithms in Networks-on-Chip" 2014
5. SantanuKundu, Santanu Chattopadhyay "Network-on-Chip: The Next Generation of System on-Chip Integration",2014 CRC Press

Course Title: Internship

COURSE CODE	**20ECDCPCIN**	**COURSE TITLE**	**Internship**
CREDITS	**09**	**L-T-P**	**0-0-9**
CIE	**50 Marks(100% weightage)**	**SEE 100**	**100 Marks (50% weightage)**

CO1	Able to develop a sound theoretical and practical knowledge of new technologies.
CO2	Able develop domain specific problem solving and critical thinking skills
CO3	Able to develop individual responsibility towards their internship goal as well as participate as an effective team member
CO4	Gain exposure to professional work culture & practices
CO5	Able to develop effective presentation & communication skills, and create proper documentation of the work

Course Title: Project work (I-phase)

COURSE CODE	20ECDCPWP1	COURSE TITLE	PROJECT WORK(I-Phase)
CREDITS	08	L-T-P	0-0-8
CIE	50 Marks(100%	SEE 100	100 Marks (50% weightage)

Course outcomes:Phase-2

CO1	To identify the research gaps in the selected domain leading to problem formulation through the knowledge gained with the awareness of impact of technology on the Society and their ethical responsibilities.	PO3
CO2	Able to state a research problem, apply research methods, tools for data collection, analyse and interpret research data.	PO1
CO3	To comprehend and Communicate their research with professionalism.	PO2

Course Title: Technical Seminar

COURSE CODE	20ECDCSR01	COURSE TITLE	TECHNICAL SEMINAR
CREDITS	02	L-T-P	0 – 0 – 2

COURSE OUTCOMES

CO1	Identify the problem through literature survey by applying in-depth knowledge of the chosen domain
CO2	Analyse, synthesize and conceptualize the identified problem
CO3	Communicate clearly, write effective reports and make effective presentations following the professional code of conduct and ethics
CO4	Comprehensively study the domains and reflect the same towards the future enhancements of the work

IV Semester

COURSE CODE	20ECDCSR02	COURSE TITLE	TECHNICAL SEMINAR
CREDITS	02	L-T-P	0 – 0 – 2
CIE	50 Marks(100%	SEE 100	100 Marks (50% weightage)

COURSE OUTCOMES

CO1	Identify the problem through literature survey by applying in depth knowledge of the chosen domain
CO2	Analyse, synthesize and conceptualize the identified problem
CO3	Communicate clearly, write effective reports and make effective presentations following the professional code of conduct and ethics
CO4	Comprehensively study the domains and reflect the same towards the future enhancements of the work

PROJECT WORK (PHASE 2)

COURSE CODE	20ECDCPWP2	COURSE TITLE	PROJECT WORK(II-Phase)
CREDITS	20	L-T-P	0-0-20
CIE	50 Marks(100%	SEE 100	100 Marks (50% weightage)

COURSE OUTCOMES –Phase-2

	COURSE OUTCOMES(Phase-2)	
CO1	Carryout a research project independently by applying their knowledge to propose optimal solution for the formulated problem.	PO3
CO2	Design, implement using appropriate tool and critically analyse the proposed solution.	PO1
CO3	Communicate their research clearly and professionally, leading to publications/patent.	PO2