Master of Technology

(2 Years)

DEPARTMENT OF ELECTRONICS ENGINEERING

Indian Institute of Technology (Indian School of Mines), Dhanbad, India.

M. Tech in Communication and Signal Processing

Date of last revision: **Approved by Senate/IIT(ISM) DHN/April 2019**

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Course Structure

M. Tech. in CSP| SEMESTER 1 | Core/Compulsory: 05 | Lab: 02

Course No.	Course Name	L	T	P	C
Semester - 1					
DC xxx	Advanced Communication Theory	3	0	0	9
DC xxx	Probability Theory and Linear Algebra	3	0	0	9
DC xxx	Mathematical and Simulation Techniques	3	0	0	9
DC xxx	Computer Communication Networks	3	0	0	9
DE 5xx	Advanced Optical Communication	3	0	0	9
DC xxx	Communication Systems Lab	0	0	3	3
DC xxx	Optical Communication Lab	0	0	3	3
	Total	15	0	6	51

M. Tech. in CSP| SEMESTER 2 | D Electives: 03 | Open Electives: 02 | Lab: 02

Course No.	Course Name	L	T	P	C
Semester -2					
DC xxx	D Elective 1	3	0	0	9
DC xxx	D Elective 2	3	0	0	9
DC xxx	D Elective 3	3	0	0	9
DE 5xx	Open Elective 1	3	0	0	9
DE 5xx	Open Elective 2	3	0	0	9
DC xxx	Advanced Signal Processing Lab	0	0	3	3
DC xxx	Computer Communication Lab	0	0	3	3
	Total	15	0	6	51

D Electives

1. Estimation and Detection Theory
2. Advanced Signal Processing
3. Wireless Communication Systems
4. Convex Optimization Techniques
5. Optical Networks

Open Electives

1. Wireless Sensor Networks

M. Tech. in CSP| SEMESTER 3 | Thesis

Course No.	Course Name	L	T	P	C
Semester - 3					
DC xxx	Thesis Unit 1	0	0	0	9
DC xxx	Thesis Unit 2	0	0	0	9
DC xxx	Thesis Unit 3	0	0	0	9
DC xxx	Thesis Unit 4	0	0	0	9
	Total	**0**	**0**	**0**	**36**

M. Tech. in CSP| SEMESTER 4 | D Electives/Open Electives (02) + Thesis

Course No.	Course Name	L	T	P	C
	Semester - 4				
DC xxx	D Elective 4/Open Elective 3	3	0	0	9
DC xxx	D Elective 5/Open Elective 4	3	0	0	9
DC xxx	Thesis Unit 5	0	0	0	9
DC xxx	Thesis Unit 6	0	0	0	9
	Total	**6**	**0**	**0**	**36**

Open Elective

1. Internet of Things

Detailed Syllabi

M. Tech in CSP

Semester 1

Theory (CORE): 05

Lab: 02

SEMESTER 1 | Subject: **Advanced Communication Theory** | **CORE** | L-T-P : 3-0-0

Course Philosophy:

- The students will gain advanced knowledge on the physical layer mechanism of the various communication technologies.

Learning Outcomes:

- This knowledge will be very much helpful for the students to do the research work in academia and various industries like Qualcomm, Samsung and Intel etc.

Course Structure (39 Lectures)

Module 1(7 Lectures)

Geometric representation of signals, Gram-Schmidt Orthogonalization, Maximum likelihood procedure for detection of a signal in a AWGN channel, Probability of symbol error, union bound on the probability of error. representation of narrowband noise, properties of its in-phase and quadrature components.

Module 2 (10 Lectures)

Advanced Digital Modulation techniques – QPSK, QAM, OQPSK, CPFSK, MSK, , GMSK, Power and bandwidth efficiency of different schemes. Noncoherent Orthogonal Modulation techniques.

Module 3 (12 Lectures)

Carrier phase and symbol timing synchronization techniques. Spread Spectrum Modulation – DSSS and FHSS systems, CDMA of DSSS, applications of spread spectrum systems. Multicarrier communication – OFDM, DMT and their real-life application.

Module 4 (10 Lectures)

Receivers for nonideal channel – signal distortion over a communication channel (linear distortion / distortion due to channel nonlinearities/multipath effects/fading), equalization techniques. Diversity techniques for reliable communication over a fading channel

Text: ● Proakis, John G., and Masoud Salehi. Digital communications. Vol. 4. New York: McGraw-hill, 2014.

Reference● Haykin, Simon S. Digital communications. New York: Wiley, 2010.

- Lathi, Bhagwandas P. Modern digital and analog communication systems. Oxford University Press, Inc., 2018. 5th ed.

SEMESTER 1 | Subject: **Probability Theory and Linear Algebra| CORE** | L-T-P : 3-0-0

Course Philosophy: This is a mathematical course which provides the knowledge about basic concepts of probability theory and linear algebra and its application to signal processing.

Learning Outcomes: • This basic course will make students to be strong enough in order to understand the advance courses like "Estimation and Detection Theory", "Advanced Signal Processing", " Wireless Communication System" etc.

Course Structure (39 Lectures)

Module 1 (6 Lectures)

Randomness in the real world, Mathematical model of probability theory, Axioms of probability theory.

Module 2 (11 Lectures)

Concept of Random Variables: Density Functions, Distribution Functions, Multidimensional Density Functions, Mean and Variance, Equality of Random Variables, Transformation of Variables, Conditional Probability Density, Conditional Expectation, Moments, Central Limit theorem. Random Processes: Stationary, non-stationary, WSS, White and Colored, Gaussian and Non Gaussian Processes, Correlation Function, Random Process through Linear Systems.

Module 3 (10 Lectures)

Introduction to Linear Algebra, Systems of Linear Equations; Vector spaces, Subspaces, Linear Dependence and Independence, Spanning Set and Basis.

Module 4 (12 Lectures)

Orthogonality, Eigen Values and Eigen Vectors; Matrixes and Subspaces Associated with a Matrix.

Text: • Linear Algebra and its Application, 4th edition By Gilbert Strang.2018

. • Probability, random variables, and stochastic processes", Tata McGraw-Hill Education, 2002, By Papoulis, Athanasios, and S. Unnikrishna Pillai.

Reference: 1. Linear Algebra Schaum's Outlines, 5th edition 2012. 2. Gallager, Robert G. Stochastic processes: theory for applications. Cambridge University Press, 2013.

SEMESTER 1 | Subject: Computer Communication Networks| CORE | L-T-P : 3-0-0

Course Philosophy:

- This course examines the science underpinning computer communications, such as the basic architectural principles of computer networking and specifically how the Internet works today. Covered topics include data representation, how errors in transmission can be detected and dealt with, the way information is routed over a large network, how congestion can be avoided, aspects of network security.

Learning Outcomes:

- Understanding of the most important principles of how computer communication works
- Understanding of protocols and ability to see it in an overall context of communication and the key security issues of computer communication
- Be able to explain the most important standards in the field of computer communication
- Assess different solutions for computer networks
- Be able to implement a simple object oriented distributed system.

Course Structure (39 Lectures)

Module 1: [12 Lectures]

Computer Communication Networks - overview and introduction, The ISO reference Model, Network Topologies. Basics of queuing models, Connectivity and Delay Analysis.

Module 2: [14 Lectures]

The Physical Layer, Data Link Layer Protocol with Case Studies, Point-to-Point Networks. Routing and Flow Control, Packet Communication Technology, Packet Broadcasting, Terrestrial Networks, Local Area Networks, Mixed Media and Large Scale Integrated Networks.

Module 3: [7 Lectures]

Transport and Session Layers, Presentation Layer Protocols and Data Link Layer Concepts of Distributed Systems, Computer Networks and a Distributed System.

Module 4: [6 Lectures]

Fibre Optic Network, Examples and Case Studies.

Text: **1**. Nader F. Mir, “Computer and Communication Networks”, Prentice Hall, Dec 2014.

Reference: **1**. Kurose, Ross: Computer Networking - A Top-Down Approach 5th edition, Pearson (2010). **2**. M Barry Dumas, Morris Schwartz, “Principles of Computer Networks and Communications”, Pearson Education, January 2012. **3**. William Stallings, “Data and Computer Communication”, 10th Edition, Pearson Education, 2013.

SEMESTER 1 | Subject: Advanced Optical Communication | CORE | L-T-P : 3-0-0

Course Philosophy:

- Recent years have seen an exponential increase in demand for large bandwidth and high data rate applications. This is driven by rapid advances in advance optical communications. A thorough grounding in advance optical communications is necessary to communication engineers to address future needs of high data rate communications. The topics covered include model analysis of optical fibers, impairments in optical fiber channel, lasers and photodiodes, optical amplifiers, digital optic fiber communications, WDM systems.

Learning Outcomes: At the end of the course, the student must be able to

- Understand basic principles of light propagation and modal analyses of optical fiber.
- Understand the basic operating principles of light sources, detectors.
- Fiber Nonlinearities.
- Understand coherent detection, Noises, Comparison of direct and coherent detection.
- Design optical link, power penalty etc

Course Structure (39 Lectures)

Module 1 [12 L]

Ray theory and Mode theory of optical fibers, linearly polarized modes. Fiber- SMF, MMF, Attenuation and Dispersion in fibers; Special fibers.

Module 2[9 L]

Brief overview of optical transmitter and optical receiver. Receiver Noise processes, BER measurement, Noise measurement for optical communication system, Optical Losses.

Module 3[4 L]

Optical Amplifiers, Optical Filters.

Module 4[4 L]

Fiber Nonlinearities: Kerr effects, SPM, XPM, FWM.

Module 5[6 L]

Coherent detection: fundamental concept, comparison of direct and coherent detection, Noises formulations, On-off keying, PSK, DPSK, FSK generation and detection.

Module 1[4 L]

Optical transmission Link design, Power budget and rise time budget. WDM

Text: **1**. Nader F. Mir, “Computer and Communication Networks”, Prentice Hall, Dec 2014.

Reference: **1**. Kurose, Ross: Computer Networking - A Top-Down Approach 5th edition, Pearson (2010). **2**. M Barry Dumas, Morris Schwartz, “Principles of Computer Networks and Communications”, Pearson Education, January 2012. **3**. William Stallings, “Data and Computer Communication”, 10th Edition, Pearson Education, 2013.

SEMESTER 1 | Subject: **Mathematical and Simulation Techniques** | **CORE** | L-T-P : 3-0-0

Course Philosophy:

The 5 modules of the course exposes the students to some of the popular tools required for optimization, mathematical analysis, modeling and design through simulations. Monte Carlo simulations find applications in IC design, communication engineering and quantum mechanics. Estimation theory as well signal transforms are being considered as elements of “machine learning”, it is highly relevant for researchers in pre-processing of data, feature extraction, and inferring parameters from data gathered from measurements or simulations, and is extremely important within communication and signal processing. Queuing theory Mathematical models for complex systems are rarely solvable analytically, and algorithms for numerical methods based on computational mathematics needs to be understood by researchers in many problem domains. Queuing theory provides a rich and useful set of mathematical models for the analysis and design of service process for which there is contention for shared resources and provides the student with a framework to compute performance metrics in networking and other similar problems. Several commercial software use the various modules forming a part of the course.

Course Structure (40 Lectures)

Module 1 (10 lectures)

Introduction to the course, Filtering techniques for signal estimation, Monte Carlo simulation method, Fast computation of Transforms, Tutorials.

Module 2 (10 lectures)

Root finding techniques, Review of Solution of ordinary and partial differential equations, Numerical methods for solution of differential equations, Numerical integration methods, Tutorials.

Module 3 (10 lectures)

Introduction to Finite element method, Boundary point method, Finite difference method, Discretization of differential equations, Tutorials.

Module 4 (10 lectures)

Introduction to Variational technique, Finite Difference Time Domain method, Mode matching method, Tutorials.

Module 5 (10 lectures)

Optimization Techniques, Queuing models.

** Out of 5 modules, any 4 modules may be floated

Text:

1. W. H. Press, S. A. Teukolsky, W. T. Vellerling and B. P.,Flannery.,"Numerical Recipes",Cambridge University Press.
2. Monson H Hayes, "Statistical Digital Signal Processing and Modeling",John Wiley & Sons

Reference:

1. B.S Grewal, "Higher Engineering Mathematics", 42nd Edition, Khanna Publishers 2012.
2. Erwin Kreyszig, "Advanced Engineering Mathematics", 10th Edition, John Wiley 2010.
3. David Kincaid and Ward Cheney, "Numerical Analysis: Mathematics of Scientific Computing", 3rd Edition, American Mathematical Society 2010

SEMESTER 1 | LAB: **Communication Systems Lab**| L-T-P : 0-0-3

Course Philosophy:

The goal of this lab is to provide knowledge about the real time communication through lots of experiments using PYTHON, SCILAB/MATLAB.

Learning Outcomes:

By the end of the course, the student must be able to:

- ❑ Do simulation in PYTHON, SCILAB/MATLAB
- ❑ Do Software Defined Radio (SDR) based real time communication.

Course Structure (40 Lectures) (Practical : 12 Lab Days | Exam : 01 Lab Days)

Unit I (2 Lab Days)

Frequency division multiplexing system. Time division multiplexing system.

Unit II (4 Lab Days)

PN sequence communication through baseband channels (LP, BP, HP) and eye pattern measurements. Digital modulations systems (ASK, FSK, PSK).

Unit III (6 Lab Days)

Carrier and clock recovery systems. Optimal Detection of the signal for AWGN channel and error calculation Optimal detection of the signal in presence of both ISI and AWGN. Introduction to Software Defined Radio (SDR).

SEMESTER 1 | LAB: : Optical Communication Lab | L-T-P : 0-0-3

Course Philosophy:

The goal of this lab is to provide knowledge about optical communication system through lots of experiments using optical trainer Kits and/or discrete component and simulation tools.

Learning Outcomes:

By the end of the course, the student must be able to:

- understand the various fiber optic and digital communication techniques
- Do simulation in Matlab and Photonics CAD

Course Structure (40 Lectures) (Practical : 12 Lab Days | Exam : 01 Lab Days)

Hardware-based Experiments (to be carried out using optical trainer Kits and/or discrete component)

(8 Lab Days)

1. Introduction and familiarization of different types of fiber and optical components.
2. Setting up a fiber optic analog link and digital link
3. Measurement of propagation and bending loss in optical fiber
4. Measurement of Numerical Aperture
5. Study the current-intensity relation of LED and LASER diode.
    1. Threshold current (b) Spectral bandwidth
6. Measurement of Quantum efficiency of Photodiode.
7. Study of PWM and PPM and their demodulation
8. Measurement of BER and eye pattern in optical fiber.
9. Study of non-linear effect in optical fiber.
10. Study of optical amplifiers.

Simulation –based Experiments (to be carried out in MATLAB/Photonic CAD Tool) (4 Lab Days)

1. Mode analysis in optical fiber.
2. Analysis of Dispersion in optical fiber.
3. Design and analysis of WDM link.
4. Study of BER and Q-factor using optical fiber.

Detailed Syllabi

M. Tech in CSP

Semester 2

Lab: 02

Theory (D Electives): 03

Theory (Open Elective): 02

SEMESTER 2 | LAB: Advanced Signal Processing Lab | L-T-P : 0-0-3

Course Philosophy:

- The Signal processing algorithms has to be designed using MATLAB/SCILAB.

Learning Outcomes:

By the end of the course, the student must be able to design various signal processing algorithms using MATLAB/SCILAB. Students are also able to do some Hardware experiments using DSP Starter Kits and/or FPGA.

Course Structure (Practical : 11 Lab Days | Exam : 01 Lab Days)

Unit I (3 Lab Days)

Simulation –based Experiments (Using MATLAB/SCILAB):

Random signals – generation, finding autocorrelation and power spectral density of signals e.g. cross-correlation between input and output in an LTI system.Design of Equi-ripple filters and comparison of their performance with FIR filters designed using windows.

Unit II (3 Lab Days)

Simulation –based Experiments (Using MATLAB/SCILAB):

Generation and detection of DTMF signals – using Goertzel's algorithm.

Wavelet analysis of a given signal. Study of LMS adaptive filters – their convergence, MSE, effect of step-size.

Unit III (5 Lab Days)

Hardware-based Experiments (to be carried out using DSP Starter Kits and/or FPGA):

1. Generation of signals and obtaining their spectrum.
2. Filtering the signals in real-time.

SEMESTER 2 | LAB: **Computer Communication Lab** | L-T-P : 0-0-3

Course Philosophy:

- To understand the working principle of various communication protocols.
- To analyze the various routing algorithms.
- To know the concept of data transfer between nodes

Learning Outcomes:

- Understand fundamental underlying principles of computer networking
- Understand details and functionality of layered network architecture.
- Apply mathematical foundations to solve computational problems in computer networking
- Analysing performance of various communication protocols.
- Compare routing algorithms and practice packet /file transmission between nodes.

Course Structure (Practical : 10 Lab Days | Exam : 01 Lab Days)

- Design of different topologies of communication networks **(1 Lab Day)**
- Aloha for data communication **(1 Lab Day)**
- Slotted Aloha for data communication **(1 Lab Day)**
- Realization of CSMA/CSMA-CD/CSMA-CA **(2 Lab Days)**
- IPv4 addressing **(1 Lab Day)**
- Minimum Spanning Tree using Kruskal's algorithm and Prim's algorithm **(1 Lab Day)**
- Dijikstra's shortest path algorithm **(1 Lab Day)**
- Hands on experiments on connectors and transmission media **(2 Lab Days)**

SEMESTER 2 | Subject: **Estimation and Detection Theory** | D ELECTIVE | L-T-P : 3-0-0

Course Philosophy:
This course deals with the various estimation and detection techniques that are used in signal processing.

Learning Outcomes: At the end of the course, the student must be able to do research in the designing of estimation framework for the various signal processing applications.

Course Structure (39 Lectures)

Module 1 (10 Lectures)

Gaussian variables and processes, Minimum variance unbiased estimation, Fisher information matrix, Cramer-Rao bound sufficient statistics, minimum statistics, complete statistics.

Module 2 (11 Lectures)

linear models; best linear unbiased estimation; maximum likelihood estimation, invariance principle; estimation efficiency. Bayesian estimation, risk functions, minimum mean square error estimation, maximum a posteriori estimation; Discrete-Time Linear Bayesian estimation, stochastic approximation.

Module 3 (10 Lectures)

signal detection and signal parameter estimation in discrete-time domain. Bayesian, minimax, and Neyman-Pearson detection; likelihood ratio, receiver operating characteristics, composite hypothesis testing. Locally optimum tests, detector comparison techniques, asymptotic relative efficiency.

Module 4 (8 Lectures)

Matched filter detector and its performance; detection under colored noise, detection under Non-Gaussian Noise, generalized matched filter; detection of sinusoid with unknown amplitude, phase, frequency and arrival time

Text: **1**. Kay, Steven M. "Fundamentals of statistical signal processing, volume i: Estimation theory PTR Prentice-Hall, Englewood Cliffs, 2010. **2**. .Kay, Steven M. "Fundamentals of statistical signal processing, Vol. II: Detection Theory." Signal Processing. Upper Saddle River, NJ: Prentice Hall, 2010. **Reference**: **1**. Levy, Bernard C. Principles of signal detection and parameter estimation. Springer Science & Business Media, 2008.

SEMESTER 2 | Subject: **Advanced Signal Processing**| D ELECTIVE | L-T-P : 3-0-0

Course Philosophy:
This course will provide the basic knowledge of discrete signal processing techniques.

Learning Outcomes: At the end of the course, the student must be able to
- apply these techniques in the research filed of wireless communication, Image Processing, Speech Processing, audio processing etc.

Course Structure (39 Lectures)

Module 1 (10 Lectures)

Introduction and evolution of wireless and mobile radio communication systems. The Cellular Concept-System Design Fundamentals, Frequency reuse, Handoff, Co-channel and Adjacent Interference. System Capacity, Improving Cell Capacity and Coverage, trunking, cell splitting, sectoring, micro-cell zone concept.

Module 2 (10 Lectures)

Mobile Radio Propagation, Large-scale Path Loss; free space propagation model, log-distance path loss model, shadowing, and coverage area. Small-scale fading and multipath; Doppler shift, multipath channel; delay spread and coherence bandwidth; Doppler spread and coherence time; flat fading and frequency-selective fading; fast fading and slow fading.

Module 3 (19 Lectures)

MIMO, OFDM, CDMA, Multi-user MIMO

Text:
1. Hayes, Monson H. Statistical digital signal processing and modeling. John Wiley & Sons, 2009.

Reference:
1. Oppenheim, Alan V., and Ronald W. Schafer. Discrete-time signal processing. Pearson Education, 2014.
2. Rao, Raghuveer M. Wavelet transforms: Introduction to theory and applications. Pearson Education India, 1998.

SEMESTER 2 | Subject: **Wireless Communication Systems** | D ELECTIVE | L-T-P : 3-0-0

Course Philosophy:
This course will provide the fundamental mechanism behind the wireless communication techniques (3G, 4G, 5G).

Learning Outcomes: At the end of the course, the student must be able to acquire knowledge on various wireless communication technologies which is very much helpful for academia research and Industries working in wireless communication technologies.

Course Structure (39 Lectures)

Module 1 (6 Lectures)

Discrete-time Random Signals, Digital Processing of Analog Signals, Oversampled A/D Conversion – with and without noise shaping.

Module 2 (16 Lectures)

Equiripple FIR Filters, Signal Modelling, Spectrum Estimation, Optimum Filtering – FIR and IIR filters, Wiener filter, Discrete Kalman Filter, Adaptive Filters - algorithms for adaptive filtering and typical applications

Module 3 (17 Lectures)

Wavelet Transform and its applications, Speech and Audio Signal Processing. Advanced Topics: Compressed sensing and its applications.

Text:

1. Rappaport, Theodore S. "Wireless communications: Principles and practice." (2002).
2. Goldsmith, Andrea. Wireless communications. Cambridge university press, 2005

Reference:

1. Tse, David, and Pramod Viswanath. Fundamentals of wireless communication. Cambridge university press, 2005.

SEMESTER 2 | Subject: Convex Optimization Techniques | D ELECTIVE | L-T-P : 3-0-0

Course Philosophy:
This is a mathematical course which is very much essential for the signal processing students in order to apply the optimization techniques in various research areas like wireless communication, wireless sensor network, image processing, big data processing etc.

Learning Outcomes: At the end of the course, the student must be able to frame the optimization problems in a specific format such that optimal solution can be found with minimum complexity.

Course Structure (39 Lectures)

Module 1 (15 lectures)

Background on linear algebra; Convex sets, functions, and problems; Examples of convex problems: LP, QCQP, SOCP; Duality, KKT conditions

Module 2 (15 lectures)

Geometric programming and applications; Linear and quadratic classification; Robust least squares and applications in signal processing; Semidefinite programming and applications in experiment design; Semidefinite relaxation and applications in MIMO detection

Module 3 (9 lectures)

integer programming; Numerical linear algebra, basics of interior point methods.

Text:

1. Boyd, Stephen, and Lieven Vandenberghe. Convex optimization. Cambridge university press, 2004.

Reference:

1. Convex Optimization in Signal Processing and Communications, D. P. Palomar, Y. C. Eldar. Cambridge Press, 2010.
2. IEEE Signal Processing Magazine- Special Issue on Advances in Convex Optimization, Vol. 27, No. 3, May 2010.
3. Dimitri P. Bertsekas, Convex Analysis and Optimization, Athena-Scientific, 2003

SEMESTER 2 | Subject: Optical Networks | D ELECTIVE | L-T-P : 3-0-0

Course Philosophy:

- An optical network is a type of data communication network built with optical fiber technology. It utilizes optical fiber cables as the primary communication medium for converting data and passing data as light pulses between sender and receiver nodes. The course will give the student in-depth understanding of the functionality of optical networks and how they may be implemented. How an optical network can work together with an IP-based network infrastructure for ensuring both high reliability and performance in access, metro and transport networks, is paid special attention.
- The topics covered includes building blocks for optical networks and systems, an introduction to optical components, principles and functionality in optical network elements as well as basic physical principles and properties and constraints in optical fiber transmission. Principles and the function of optical circuit switched networks, both network elements like reconfigurable add/drops and optical cross-connects as well as the principle of a wavelength routed optical network are covered. Finally, up-to-date research in optical packet switched node and network architectures is studied.

Learning Outcomes: A. Knowledge:

1) To get a basic understanding of physical properties of optical networks.
2) To get a profound understanding of protocols applied in optical networks
3) To get a profound understanding of optical switching methods and networking techniques, circuit, packet, hybrid, burst and flow.
4) To get a basic understanding of optical components and optical node design.
5) To be able to communicate, reason and creatively think about optical networks.
6) To be able to design optical networks, taking both physical transmission properties and optical networking constraints into account.
7) To be able to evaluate performance of optical packet switched nodes using discrete event simulation methods.

Course Structure (39 Lectures)

Module 1(L-6): Evolution of optical networking - Overview of Fibre optic LANs: Suitable topologies and MAC protocols, FDDI, DQDB, Gigabit Ethernet;

Module 2(L-6): Review of SONET/SDH and concepts of networking using IP-over-ATM-over-SONET/SDH architecture;

Module 3(L-7): WDM networks: Elements of WDM networks, Optical line terminals, Optical line amplifiers, Optical add/drop multiplexers (OADMs), Reconfigurable OADMs, Optical cross-connects

Module 4(L-7):

WDM backbone networks: Concepts of wavelength routing and lightpaths, Lightpath topology design, Routing and wavelength assignment, LP-based optimum design and heuristic algorithms, Wavelength conversion

Module 5(L-7):

Traffic grooming in wavelength-routed backbones; IP-over-WDM and GMPLS, Protection in SONET/SDH, Protection in WDM backbone networks - dedicated and shared schemes

Module 6(L-6):

Overview of Optical access networks: Hybrid fiber coax (HFC), Enhanced HFC, Fibre to the home (FTTH), Overview of Passive optical networks; Optical CDMA and Elastic Optical Network.

Text:1. Rajiv Ramaswami, Kumar N. Sivarajan and Galen H. Sasaki, “Optical Networks: A Practical Perspective” (Third Edition) The Morgan Kaufmann Series in Networking, David Clark, Series Editor, 2010

2. Biswanath Mukherjee, Optical WDM Networks, Springer, 2006

Reference: 1. P.E Green, Jr. ``Fiber Optic Networks," Prentice Hall; 1 edition (July 9, 1992).

2. G. P.Agarwal, ``Fiber-Optic Communication Systems," Wiley Pubisher (2015)

3. C. Siva Ram Murthy and Mohan Gurusamy, “WDM Optical Networks - Concepts Design and Algorithms”, Prentice-Hall PTR, 2002

4. López, Víctor, Velasco, Luis (Eds.) “Elastic Optical Networks: Architectures, Technologies, and Control”, Springer, 2016.

SEMESTER 1 | Subject: Wireless Sensor Networks | Open Elective | L-T-P : 3-0-0

Course Philosophy:

- This course is required to understand the basic WSN technology and supporting protocols, with emphasis placed on standardization basic sensor systems and provides a survey of sensor technology. This will also provide the understanding of the Sensor management, sensor network middleware, operating systems.

Learning Outcomes:

- Students are able to understand and explain the concept of ad-hoc and sensor networks, their applications and typical node and network architectures.
- Students are able to understand and explain protocol design issues (especially energy-efficiency) and protocol designs for wireless sensor networks.
- Students are able to critique protocol designs in terms of their energy-efficiency
- Students are able to set up and evaluate measurements of protocol performance in wireless sensor networks.

Course Structure (39 Lectures)

Module 1: [6 Lectures]

Introduction: Basics of wireless networks.

Module 2: [11 Lectures]

Wireless Sensor Networks: History, properties, medium access control, routing, energy efficiency, topology management, coverage, congestion and flow control, quality of service, resource allocation, scheduling, security, multimedia transmission, mobile sensor networks, applications.

Module 3: [11 Lectures]

Wireless Mesh Networks: Evolution, medium access control, channel assignment, routing, transport protocols, congestion control, scalability, mobility management, applications.

Module 4: [11 Lectures]

Vehicular Ad Hoc Networks: Introduction, applications and their classification, VANET communication stack, medium access control, routing, security, mobility models, vehicular sensor networks.

Text: **1**. Daniel Minoli, Taieb Znati Kazem Sohraby, “Wireless Sensor Networks: Technology, Protocols and Applications”, Wiley, 2010..

Reference:

1. H. Karl and A. Willig, “Protocols and Architectures for Wireless Sensor Networks”, Wiley Publishers, 2005.

2. Abbas Jamalipour Jun Zheng, “Wireless Sensor Networks: A Networking Perspective”, Wiley-Blackwell, 2009

Detailed Syllabi

M. Tech in CSP

Semester 4

Theory (D Electives/ Open Elective): 2

SEMESTER 4 | Subject: Internet of Things | Open Elective | L-T-P : 3-0-0

Course Philosophy:
The internet of things, or IoT, is a system of interrelated computing devices, mechanical and digital machines, objects, animals or people that are provided with unique identifiers (UIDs) and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction. The course introduces advanced concepts and methodologies of IoT to design, build and deploy IoT solutions. It also discusses various technologies and protocols used for communication including new generation IoT-friendly applications and physical layer protocols. Candidates will be able to get a.

Learning Outcomes: At the end of the course, the student must be able to
- ❑ Understand building blocks of Internet of Things and characteristics
- ❑ Understand of widely accepted IoT frameworks and standards
- ❑ Understand the application areas of IOT
- ❑ Build and deploy IoT solutions
- ❑ Realize the revolution of Internet in Mobile Devices, Cloud & Sensor Networks

Course Structure (37 Lectures)

Module 1 (7 lectures)
Introduction to IoT: Sensing, Actuation, Basics of Networking, Communication Protocols, Sensor Networks, Machine-to-Machine Communications.

Module 2 (8 lectures)
Interoperability in IoT, Introduction to Arduino Programming, Integration of Sensors and Actuators with Arduino

Module 3 (7 lectures)
Introduction to Python programming, Introduction to Raspberry Pi, Implementation of IoT with Raspberry Pi, Implementation of IoT with Raspberry Pi

Module 4 (7 lectures)
Introduction to SDN; SDN for IoT, Data Handling and Analytics, Cloud Computing

Module 5 (8 lectures)
Sensor-Cloud; Fog Computing, Smart Cities and Smart Homes, Connected Vehicles, Smart Grid, Industrial IoT, Case Study: Agriculture, Healthcare, Activity Monitoring.

Text:
1. Pethuru Raj and Anupama C. Raman, "The Internet of Things: Enabling Technologies, Platforms, and Use Cases", CRC Press, 2017
2. Arshdeep Bahga and Vijay Madisetti "Internet of Things: A Hands-on Approach", Universities Press, 2014

Reference:
1. Olivier Hersent, “The Internet of Things: Key Applications and Protocols”, Wiley Press, 2015
2. Adrian McEwen, “Designing the Internet of Things”, Wiley Publishers, 2013
3. Daniel Kellmereit, “The Silent Intelligence: The Internet of Things”, 2013