Detailed Syllabus
Lab-wise Breakup

Course Code	20M45EC111	**Semester: Odd**	**Semester 10th Session** 2021 -2022 **Month from** July to December
Course Name	Advanced Communication Systems Lab -1		
Credits	**3**	**Contact Hours**	**6**

Faculty (Names)	**Coordinator(s)**	Dr Juhi Gupta
	Teacher(s) (Alphabetically)	Dr Ashish Goel

COURSE OUTCOMES		**COGNITIVE LEVELS**
CO1	Understanding of Matlab applications to wireless communication technologies.	Understanding (C2)
CO2	Analyze wireless communication channel models and understand their applications	Analyzing (C4)
CO3	Applying the equalization techniques for communications systems.	Applying (C3)
CO4	Analyze and evaluate the spread spectrum communication system.	Evaluate (C5)
CO5	Evaluate the BER performance of M-ary digital modulation schemes over AWGN and fading Channels.	Evaluate (C5)

Module No.	**Title of the Module**	**List of Experiments**	**CO**
1.	Introduction to Matlab and its application	Introduction to MATLAB and its various applications.	CO1
2.	Wireless Communication Channel	To study and simulate Rayleigh and Rician distribution using two signals that follow normal distribution.	CO2
3.	Wireless Communication Channel	To study and simulate Propagation Path loss Models: Free Space Propagation, long distance and log normal.	CO2
4.	Wireless Communication Channel	To write a MATLAB program to calculate the median path loss for Outdoor Propagation – Okumura Model and Hata Model.	CO2
5.	Equalization in Communication Systems	To Study and analyze the process of Zero-forcing equalization process, when channel distorted input pulse is applied as an input.	CO3
6.	Equalization in Communication Systems	To study and simulate the effect of quantization levels on quantization error in anon-uniform PCM utilizing μ-law companding. Also analyze the effect of quantization levels on SQNR.	CO3
7.	Equalization in Communication Systems	To Study and analyze the process of minimum mean square equalization process, when channel distorted input pulse is applied as an input.	CO3
8.	Equalization in Communication	To Study and design an adaptive equalizer based on LMS algorithm for given number of taps and channel characteristic.	CO3

	Systems		
9.	Spread spectrum Communication Systems	To study and simulate the generation of Direct Sequence Spread Spectrum(DS-SS) Signal using PN Sequence and analyze frequency spectrum of DS-SS signal, when BPSK modulation is used for data transmission, and also determine the target distance (ranging).	CO4
10.	Spread spectrum Communication Systems	To study and demonstrate the performance of an FH-SS system that employs binary FSK and corrupted by worst-case partial band interference.	CO4
11.	Bandpass Digital Modulations	To simulate the BER performance of M-PSK system over AWGN Channel using Matlab.	CO5
12.	Bandpass Digital Modulations	To simulate the BER performance of M-QAM system over AWGN Channel using Matlab.	CO5

Evaluation Criteria

Components	**Maximum Marks**
Viva -1	20
Viva -2	20
D2D-	60
Total	**100**

Recommended Reading material: Author(s), Title, Edition, Publisher, Year of Publication etc. (Text books, Reference Books, Journals, Reports, Websites etc. in the IEEE format)

1.	John G. Proakis, "Digital Communication", McGraw Hill, 5th edition, 2013.
2.	Don Torrieri, " Principles of Spread-Spectrum Communication Systems ", Springer, 2015.
3.	H. Taub, D. L. Schilling and Gautam Saha, Principles of Communication Systems, 4th/ed, TMH, 2017

Detailed Syllabus

Lab-wise Breakup

Course Code	20M45EC112	**Semester: EVEN 2020**	**Semester 2 nd Session** 2021 -2022 **Month from** Jan to June
Course Name	Advanced Communication Systems Lab-2		
Credits	3	**Contact Hours**	6

Faculty (Names)	**Coordinator(s)**	
	Teacher(s) (Alphabetically)	

COURSE OUTCOMES		**COGNITIVE LEVELS**
CO1	Plan a communications system for a given environment in which it is to be deployed.	Apply Level (III)
CO2	Perform measurements with commercial equipment and understand the effects of radio channel on the OFDM signal as well as strategies to compensate them	Create Level (VI)
CO3	Use of MIMO technology in 5G communication	Evaluate Level (V)
CO4	Understand the different mode of optical fiber and to analyze the performance of optical communication system	Analyze (Level IV)

Module No.	**Title of the Module**	**List of Experiments**	**CO**
1.	Exp.1	To study atmospheric turbulence models in Free Space Optical Communication system and implement them using MATLAB	CO1
2.	Exp.2	To determine the channel capacity for AWGN and faded wireless channels	CO1
3.	Exp. 3	OFDM systems implementation using MATLAB	CO2
4.	Exp. 4	To obtain the PAPR analysis of multi-carrier signal and the performance of PAPR & BER with clipping and filtering Scheme.	CO2
5.	Exp. 5	To analyze the effect of carrier frequency offset (CFO) in OFDM system and evaluate the error performance of OFDM System for given normalized CFO.	CO2
6.	Exp 6	To analyze the effect of μ-law companding function on PAPR reduction in OFDM system and evaluate the error performance of OFDM System for given of μ.	CO2
7.	Exp.7	To simulate the channel capacity for MIMO system	CO3
8.	Exp.8	To analyze the performance of MIMO systems by using space time code technique.	CO3
9.	Exp 9	Determine the optical modes that exist for multimode step index fibers and investigate their performance on optical systems.	CO4
10.	Exp 10	Investigate the effect of loss on optical system performance and	CO4

		characterize the system with the power budget equation.	
11.	Exp 11	Investigate the effects of dispersion on optical systems.	CO4
12.	Exp 12	Investigate the characteristics of PIN Photodiode and plot its frequency response.	CO4

Evaluation Criteria Components	**Maximum Marks**
Viva -1	20
Viva -2	20
D2D	60
Total	**100**

Recommended Reading material: Author(s), Title, Edition, Publisher, Year of Publication etc. (Text books, Reference Books, Journals, Reports, Websites etc. in the IEEE format)	
1.	Aditya K Jagannatham, Principles of Modern Wireless Communication Systems Theory and Practice, TMH, 2/e, 2017
2.	Yong Soo Cho, Jaekwon Kim, Won Young Yang, Chung-Gu Kang , MIMO-OFDM Wireless Communications with MATLAB, Wiley, 2013
3.	Gerd Keiser, Optical Fiber Communications, 3rd Edition, McGraw-Hill International edition, 2000.

Detailed Syllabus

Lecture-wise Breakup

Course Code	**20M41EC117**	**Semester:** ODD **(specify Odd/Even)**	**Semester: 1 Session: 2020-21** **Month from July to Dec**
Course Name	**ADVANCED DIGITAL COMMUNICATION SYSTEMS**		
Credits	3	**Contact Hours**	3
Faculty (Names)	**Coordinator(s)**	Dr. Ashish Goel	
	Teacher(s) (Alphabetically)	Dr. Ashish Goel	

COURSE OUTCOMES- At the completion of the course, students will be able to		**COGNITIVE LEVELS**
C112.1	Understanding of line coding schemes and study of various issues related to ISI,	Understanding Level (C2)
C112.2	Understand and analyse the Optimum filter realization for digital signals	Analyzing Level (C4)
C112.3	Understand the concepts of digital modulation techniques and evaluate their probability of error and bandwidth efficiency.	Evaluating Level (C5)
C112.4	Understanding of symbol and carrier synchronization and various equalization schemes.	Understanding Level (C2)
C112.5	Analyse different types of spread spectrum techniques.	Analyzing Level (C4)

Module No.	**Title of the Module**	**Topics in the module**	**No. of Lectures for the module**
1.	**Waveform Coding and Baseband Shaping for Data Transmission**	Overview of wave form coding scheme, Companding scheme for PCM system, Signal to Quantization Noise Ratio of Companded PCM system. Line codes and Power Spectral Density of line coding schemes, Intersymbol Interference: Ideal solution, Practical Solution and Correlative Coding. Eye pattern.	10
2.	**Optimal Reception of Digital Signals**	Baseband Signal Receiver, Peak signal to RMS Noise output Voltage Ratio, Probability of error, Optimum Threshold: Maximum Likelihood Detector and Bayes' Receiver, Optimal receiver design:	8

		calculation of the optimum filter transfer function, Optimum filter realization using Match filter, Probability of error of Matched filter, Optimum filter realization using Correlator	
3.	**Digital Modulation Techniques**	Digital modulation formats, M-ray modulation techniques: Modulation, Demodulation, Power spectra, Bandwidth efficiency, symbol error probabilities. Channel capacity theorem for M-ary modulation formats. Minimum Shift keying: Effect of side lobes, MSK as FSK, Signal Space representation of MSK, Phase continuity in MSK, generation and reception of MSK, GMSK.	10
4.	**Synchronization and Equalization**	Synchronization: Phase Jitter in Symbol Synchronization, Carrier synchronization. Equalization: Maximum–Likelihood Sequence Estimation (MLSE), Linear equalization, Decision -feedback equalization, Reduced complexity ML detectors	7
5.	**Spread Spectrum Signals for Digital Communication**	Model of spread spectrum digital communication system, Spreading code sequences; generation and properties: PN Sequence, Gold Code, Walsh Hadamard Code. Direct sequence spread spectrum signals; Frequency hopped spread spectrum signals, FDMA, TDMA, CDMA, Time hopping SS, Synchronization of SS systems.	7
		Total number of Lectures	**42**

Evaluation Criteria

Components	**Maximum Marks**
T1	20
T2	20
End Semester Examination	35
TA	25(Attendance, Performance. Assignment/Quiz)
Total	**100**

Recommended Reading material: Author(s), Title, Edition, Publisher, Year of Publication etc. (Text books, Reference Books, Journals, Reports, Websites etc. in the IEEE format)	
1.	John G. Proakis, "Digital Communication", McGraw Hill, 5th edition, 2013.
2.	H. Taub, D. L. Schilling and Gautam Saha, Principles of Communication Systems, 4th/ed, TMH, 2017
3.	S.Haykin, Digital Communication Systems ,John Wiley & Sons, 2013
4.	Don Torrieri, " Principles of Spread-Spectrum Communication Systems ", Springer, 2015.

Detailed Syllabus

Lecture-wise Breakup

Course Code	18M22EC116/ 17M11EC118	**Semester Odd 2018** **(specify Odd/Even)**	**Semester I** **Session** July 2020 –December 2021
Course Name	ADVANCED DIGITAL SIGNAL PROCESSING		
Credits	3	**Contact Hours**	3

Faculty (Names)	**Coordinator(s)**	Dr. Vineet Khandelwal
	Teacher(s) (Alphabetically)	NIL

COURSE OUTCOMES At the end of the semester, students will be able to		**COGNITIVE LEVELS**
CO1	Recall the principles of various transform techniques like Z, Chirp Z, Hilbert, Discrete Fourier transform and Fast Fourier Transform.	Applying (Level III)
CO2	Demonstrate the ability to apply different methods to design and analyze digital FIR (Finite Impulse Response) and IIR (Infinite Impulse Response) filters with its structural realization.	Analyzing (IV)
CO3	Analyze Multirate signal processing and examine its application.	Analyzing (Level IV)
CO4	Comprehend different methods for designing adaptive filters and examine its application	Analyzing (Level IV)

Module No.	**Title of the Module**	**Topics in the Module**	**No. of Lectures for the module**
1.	**Review of Digital Signal Processing**	Review of discrete–time sequences and systems, Linear Shift Invariant (LSI) systems. Causality and Stability Criterion, FIR & IIR representations, Z-Transform, Discrete Fourier Transform (DFT), Fast Fourier Transform (FFT) algorithms using decimation in time	9

		and decimation in frequency techniques, Chirp Z-Transform, Hilbert Transform and applications	
2.	**Design of IIR and FIR Filters**	Digital filter specifications, selection of filter type, and filter order, FIR filter design; using windowing Techniques, Fourier Series and frequency sampling method, Design of IIR Filters Using Butterworth, Chebyshev and Elliptic Approximations, Frequency Transformation Techniques; approximation of derivatives, Impulse invariant method, Bilinear transformation, Structures for IIR Systems – Direct Form I & II, Cascade, Parallel, Lattice & Lattice-Ladder Structures, Structures For FIR Systems – Direct , Cascade, Parallel, Lattice & Lattice ladder Structures.	11
3.	**Multirate Digital Signal Processing**	Decimation & Interpolation, Sampling rate conversion, Identities, polyphase decomposition, General polyphase framework for Decimator and Interpolator, Multistage decimator and Interpolator, Efficient transversal structure for Decimator and Interpolator, FIR and IIR structure for Decimator, Filter design for FIR decimator and Interpolator, Application of Multirate Signal processing.	16
4.	**Adaptive Filters**	Introduction. Application of adaptive filters, Adaptive Direct-form FIR filters Adaptive Lattice-Ladder filters.	6
		Total number of Lectures	42

Evaluation Criteria

Components	**Maximum Marks**
T1	20
T2	20
End Semester Examination	35
TA	25 (…)
Total	**100**

Recommended Reading material: Author(s), Title, Edition, Publisher, Year of Publication etc. (Text books, Reference Books, Journals, Reports, Websites etc. in the IEEE format)

1.	J.G. Proakis & D.G. Manolakis, "Digital Signal Processing, Principles, Algorithms and Applications", PHI ,3rd Edition
2.	John G. Proakis, Charles M. Rader, Fuyun Ling, Chrysostomos L. Nikias, Mark Moonen and Ian K. Proudler, Algorithms for Statistical Signal Processing, Pearson Education Inc., 2002
3.	P.P. Vaidyanathan, "Multirate Systems and Filter Banks", PHI, 2010

Detailed Syllabus
Lecture-wise Breakup

Course Code	17M12EC125	**Semester** : Odd 2019 **(specify Odd/Even)**	**Semester** IInd **Session** 2019 -2020 **Month from July – Dec. 2019**
Course Name	Detection and Estimation Theory		
Credits	3	**Contact Hours**	3

Faculty (Names)	**Coordinator(s)**	Dr. Vikram Karwal
	Teacher(s) (Alphabetically)	Dr. Vikram Karwal

COURSE OUTCOMES		**COGNITIVE LEVELS**
CO1	The course aims to familiarize student with stochastic processes and its properties.	Understanding Level (C2)
CO2	The course helps students to analyze probabilistic models and estimate the parameters of the model parameters.	Analyze Level (C4)
CO3	The course helps students evaluate the observations of the noise-corrupted functions and determine the best estimate of the state.	Evaluating Level (C5)
CO4	The course helps student compute the optimality criteria to quantify best estimates or detection decisions and limits on performance.	Applying Level (C3)

Module No.	**Title of the Module**	**Topics in the Module**	**No. of Lectures for the module**
1.	Review of random variables	Distribution and density functions, moments, independent, uncorrelated and orthogonal random variables; Vector-space representation of random variables, Schwarz Inequality, Orthogonality principle in estimation, Central limit theorem, Random Process, stationary process, autocorrelation and autocovariance functions, Spectral representation of random signals, Wiener Khinchin theorem, Properties of power spectral density, Gaussian Process and white noise	6
2.	Parameter estimation theory	Principal of estimation and applications, Properties of estimates, unbiased and consistent estimators, MVUE, CR bound, Efficient estimators; Criteria of estimation: the methods of maximum likelihood and its properties; Baysean estimation: Mean Square error and MMSE, Mean Absolute error, Hit and Miss cost function and MAP estimation	8

3.	Estimation of signal in presence of White Gaussian Noise(WGN)	Linear Minimum Mean-Square Error(LMMSE) Filtering: Wiener Hoff Equation FIR Wiener filter, Causal IIR Wiener filter, Noncausal IIR Wiener filter, Linear prediction of signals, Forward and Backward Predictions, Levinson Durbin Algorithm, Lattice filter realization of prediction error filters	8
4.	Complexity Computations	Principle and Application, Steepest Descent Algorithm, Convergence characteristics; LMS algorithm, convergence, excess mean square error, Leaky LMS algorithm; Applications of Adaptive filters; RLS algorithm, derivation, Matrix inversion Lemma, Initilization, tracking of nonstationarity.	8
5.	Kalman Filtering	Principle and application, Scalar Kalman filter, Vector Kalman filter	4
6.	Detection Theory	Hypothesis testing, Bayesian, Neyman-Pearson and Minimax detetion, Composite Hypothesis testing, Generalized LRT, Sequential and Distributed Detection, Non-parametric detection, Detection in Gaussian noise	9
		Total number of Lectures	**43**

Evaluation Criteria

Components	**Maximum Marks**
T1	20
T2	20
End Semester Examination	35
TA	25 (5 Assignment, 5 Quiz, 5 Class Participation, 10 Attendance)
Total	**100**

Recommended Reading material: Author(s), Title, Edition, Publisher, Year of Publication etc. (Text books, Reference Books, Journals, Reports, Websites etc. in the IEEE format)

1.	An Introduction to Signal Detection and Estimation by H. Vincent Poor, Springer, 1994
2.	Linear Estimation by Thomas Kailath, Ali H sayed, Babak Hassibi, Prentice Hall, 2000
3.	Fundamentals of Statistical Signal Processing: Detection theory by Steven M Kay, Pearson, 2010
4.	Fundamentals of Statistical Signal Processing: Estimation theory by Steven M Kay, Pearson, 2010

Detailed Syllabus

Lecture-wise Breakup

Subject Code	**20M41EC119**	**Semester: EVEN (specify Odd/Even)**	**Semester** : 2 **Session** 2020 -21 **Month from** Jan **to** June
Subject Name	**MIMO-OFDM for Wireless Communications**		
Credits	3	**Contact Hours**	3

Faculty (Names)	**Coordinator(s)**	1. Dr. Ashish Goel
	Teacher(s) (Alphabetically)	

COURSE OUTCOMES		**COGNITIVE LEVELS**
C117.1	To understand OFDM system with its impairments.	Understanding (C2)
C117.2	To understand and analyze the various performance parameters of OFDM system.	Analyzing (C4)
C117.3	To understand and analyze the performance of MIMO systems	Analyzing (C4)
C117.4	To understand the Single Carrier Frequency Division Multiplexing System	Understanding (C2)

Module No.	**Subtitle of the Module**	**Topics in the module**	**No. of Lectures for the module**
1.	Introduction	Basic principles of orthogonality, Single carrier vs. multi carrier systems, orthogonal frequency-division multiplexing (OFDM): Block diagram, modulation, demodulation, frequency spectrum, need of cyclic prefix. synchronization, peak-to-average power ratio, effect of HPA on OFDM signal,	7
2.	PAPR and PAPR Reduction Schemes	PAPR of Base band and Bandpass OFDM signal, PDF & CCDF of PAPR, Need of PAPR reduction , PAPR reduction techniques: Clipping, Iterative clipping and filtering, Companding schemes, Selective mapping (SLM), Partial transmit sequence (PTS), Tone Reservation (TR), Tone Injection, Active Constellation Extension (ACE).	12
3.	Inter Carrier Interference (ICI) and ICI cancellation Schemes	Effect of Frequency offset, ICI Cancellation Schemes: ICI self cancellation, Symmetric ICI Self-Cancellation Scheme , ICI conjugate cancellation etc.	8

4.	Multiple-input multiple-output (MIMO) Systems	MIMO System model, antenna diversity, MIMO detection algorithms: MIMO Zero-Forcing Receiver, MIMO MMSE Receiver, Singular Value Decomposition of MIMO Channel, MIMO capacity, Space-time coding. V-BLAST, MIMO Beamforming	12
5.	Single Carrier Frequency Division Multiplexing (SC-FDMA)	SC-FDMA, Transmitter and Receiver, Subcarrier Mapping, Advantages and disadvantages	3
		Total number of Lectures	**42**

Evaluation Criteria

Components	**Maximum Marks**
T1	**20**
T2	**20**
End Semester Examination	**35**
TA	**25(Attendance, Performance. Assignment/Quiz)**
Total	**100**

Project based learning: Here, students will learn latest 4G wireless communication technologies, starting from the basics process of modulation, demodulation and its impairment. These schemes are of utmost importance to understand the concepts of current and future generations of communication system and to design the same . Student will be able to design the physical layer of 4G communication and to analyze its implementations issues. Students can perform the some simulation on Matlab to analyze the same. Understating of these techniques will further help to work in any core communication industry.

Recommended Reading material: Author(s), Title, Edition, Publisher, Year of Publication etc. (Text books, Reference Books, Journals, Reports, Websites etc. in the IEEE format)

1.	Aditya K Jagannatham, Principles of Modern Wireless Communication Systems Theory and Practice, TMH, 2/e, 2017
2.	Yong Soo Cho, Jaekwon Kim, Won Young Yang, Chung-Gu Kang , MIMO-OFDM Wireless Communications with MATLAB, Wiley, 2013
3.	T. Jiang and Y.Wu, "An Overview: Peak-to-average power ratio reduction techniques for OFDM signals", IEEE Transactions on Broadcasting, vol. 54, no. 2, pp. 257–268, Jun. 2008.
4.	Y. Zhao, S.G. Häggman , "Intercarrier interference self-cancellation scheme for OFDM mobile communication systems" , IEEE Transactions on Communications, 49(7), pp .1185-1191, 2001.
5.	Hyung G. Myung, "Introduction to single carrier FDMA", In Proceedings of 2007 15th European Signal Processing Conference, Poznan, Poland, pp. 2144-48.
6.	Journal articles i.e. IEEE, Springer, NPTEL video lectures.