E.G.S. PILLAY ENGINEERING COLLEGE (Autonomous)

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NAGAPATTINAM – 611002

M.E. COMMUNICATIONSYSTEMS

R2024 - FIRST YEAR CURRICULUM

SEMESTER II

Sl. No	Course Code	Course Title	Category	Periods per week			Credits	Total contact periods
				L	T	P	C	
1	2402CO201	Microwave integrated Circuits (Regular/NPTEL)	PCC	3	0	0	3	3
2	2402CO202	Advanced wireless communication	PCC	3	0	0	3	3
3	2402CO203	Advanced Digital Signal Processing	PCC	3	0	0	3	3
4	2403CO009	Wireless Sensor Networks (Professional Elective – II)	PEC	3	0	0	3	3
5	2403CO011	Mobile Adhoc Networks (Professional Elective – III)	PEC	3	0	0	3	3
6		Audit Course - II	AC	2	0	0	0	2
Laboratory Courses								
7	2402CO204	Wireless Communication and Networks Laboratory	PCC	0	0	4	2	4
8	2404CO205	Mini Project/Internship with seminar	EEC	0	0	4	2	4
TOTAL				**11**	**0**	**8**	**19**	**25**

2402CO201	MICROWAVE INTEGRATED CIRCUITS (REGULAR/NPTEL)	L	T	P	C
		3	0	0	3

PREREQUISITE:

1. Microwave Engineering
2. Linear Integrated Circuits

COURSE OBJECTIVES:

1. To understand the fundamentals of RF radio system design
2. To understand the various components that constitute an RF radio system for wireless Communications
3. To know the basic analysis techniques needed for evaluating the performance of an RF radio system for Wireless applications

COURSE OUTCOMES:

On the successful completion of the course, students will be able to

CO1:	Identify the concept of CMOS physics, transceiver specifications and architectures.
CO2:	Explain about the RF filter, oscillator and mixer.
CO3:	Dissect the concept of microwave circuits.
CO4:	Classify the different matching networks and amplifiers.
CO5:	Design the microwave IC and measurement techniques.

COs Vs POs MAPPING:

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	-	-	-	-	-	-	-	-	3
CO2	3	3	2	-	-	-	-	-	-	-	-	3
CO3	3	3	2	-	-	-	-	-	-	-	-	3
CO4	3	3	2	-	-	-	-	-	-	-	-	3
CO5	3	3	2	-	-	-	-	-	-	-	-	3

COs Vs PSOs MAPPING:

COs	PSO1	PSO2
CO1	3	-
CO2	3	-
CO3	3	-
CO4	3	-
CO5	3	-

COURSE CONTENTS:

MODULE I	CMOS PHYSICS, TRANSCEIVER SPECIFICATIONS AND ARCHITECTURES	9 Hours

CMOS: Introduction to MOSFET Physics – Noise: Thermal, shot, flicker, popcorn noise transceiver Specifications: Two port Noise theory, Noise Figure, THD, IP2, IP3,Sensitivity, SFDR, Phase noise - Specification distribution over a communication link Transceiver Architectures: Receiver: Homodyne, Heterodyne, Image reject, Low IF Architectures – Transmitter: Direct up conversion, Two step up conversion.

MODULE II	**INTRODUCTION TO RF FILTER, OSCILLATOR AND MIXER**	**9 Hours**
Overview –basic resonator and filter configuration-special filter realization-filter implementation. Basic oscillator model-high frequency oscillator configuration-basic characteristics of mixer- phase locked loops-RF Directional Couplers - hybrid couplers –detector and demodulator circuits.		
MODULE III	**INTRODUCTION TO MICROWAVE CIRCUITS**	**9 Hours**
Definitions – Frequency Bands – Lumped versus Distributed Circuits - Behavior of finite length transmission lines – General Characteristics of PC Boards – Transmission Lines on PC Boards – Passives made from Transmission Lines – Resonators - Combiners, Splitters and Couplers		
MODULE IV	**MATCHING NETWORKS AND AMPLIFIERS**	**9 Hours**
Circuit Representation of two port RF/Microwave Networks: Low Frequency Parameters, High Frequency Parameters, Transmission Matrix, ZY Smith Chart, Design of Matching Circuits using Lumped Elements, Matching Network Design using Distributed Elements, Amplifiers: Stability considerations in active networks – Gain Consideration in Amplifiers – Noise Consideration in active networks – Broadband Amplifier design – Low Noise Amplifier Design.		
MODULE V	**MICROWAVE IC DESIGN AND MEASUREMENT TECHNIQUES**	**9 Hours**
Microwave Integrated Circuits – MIC Materials- Hybrid versus Monolithic MICs – Multichip Module Technology - Fabrication Techniques, Miniaturization techniques, Introduction to SOC, SOP, Test fixture measurements, probe station measurements.		
		TOTAL: 45 HOURS

REFERENCES:

1. *T. Lee, "Design of CMOS RF Integrated Circuits", Cambridge, 2004*
2. *B.Razavi, "RF Microelectronics", Pearson Education, 1997.*
3. *Jan Crols, Michiel Steyaert, "CMOS Wireless Transceiver Design", Kluwer Academic Publications, 1997*
4. *B. Razavi, Design of analog CMOS Integrated Circuits", McGraw Hill,2001*
5. *D. Robertson &S. Lucy szyn, "RFIC and MMIC Design and Technology", IEE Circuits, Devices and Systems series 13, London, UK, 2001*

2402CO202	ADVANCED WIRELESS COMMUNICATION	L	T	P	C
		3	0	0	3

PREREQUISITE:

1. Communication theory
2. Wireless Communication

COURSE OBJECTIVES:

1. To learn the concepts of wireless communication.
2. To know about the various propagation methods, Channel models, capacity calculations multiple antennas and multiple user techniques used in the mobile communication

COURSE OUTCOMES:

On the successful completion of the course, students will be able to

CO1:	Explain the wireless channel propagation and model.
CO2:	Classify the capacity of various wireless channels.
CO3:	Dissect the concept of diversity in wireless communication.
CO4:	Compare the different MIMO communications.
CO5:	Identify the concept of multi user systems.

COs Vs POs MAPPING:

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	-	-	-	-	-	-	-	-	3
CO2	3	3	2	-	-	-	-	-	-	-	-	3
CO3	3	3	2	-	-	-	-	-	-	-	-	3
CO4	3	3	2	-	-	-	-	-	-	-	-	3
CO5	3	3	2	-	-	-	-	-	-	-	-	3

COs Vs PSOs MAPPING:

COs	PSO1	PSO2
CO1	-	3
CO2	-	3
CO3	-	3
CO4	-	3
CO5	-	3

COURSE CONTENTS:

MODULE I **WIRELESS CHANNEL PROPAGATION AND MODEL** **9 Hours**

Propagation of EM signals in wireless channel – Reflection, diffraction and Scattering-free space, two ray. Small scale fading- channel classification- channel models – COST -231 Hata model, Longley-Rice Model, NLOS Multipath Fading Models: Rayleigh, Rician, Nakagami, Composite Fading –shadowing Distributions, Link power budget Analysis.

MODULE II **CAPACITY OF WIRELESS CHANNELS** **9 Hours**

Capacity in AWGN, capacity of flat fading channel, capacity of frequency selective fading channels.

MODULE III	**DIVERSITY**	**9 Hours**
Realization of independent fading paths, Receiver Diversity: selection combining, Threshold Combining, Maximum-ratio Combining, Equal gain Combining. Transmitter Diversity: Channel known at transmitter, channel unknown at the transmitter		
MODULE IV	**MIMO COMMUNICATIONS**	**9 Hours**
Narrowband MIMO model, Parallel decomposition of the MIMO channel, MIMO channel capacity, MIMO Diversity Gain: Beam forming, Diversity-Multiplexing trade-offs, Space time Modulation and coding : STBC,STTC, Spatial Multiplexing and BLAST Architectures.		
MODULE V	**MULTI USER SYSTEMS**	**9 Hours**
Review of Multiple Access Techniques, Scheduling, power control, Uplink and Downlink channel capacity, multiuser diversity, MIMO-MU systems.		
		TOTAL: 45 HOURS

REFERENCES:

1. *Andrea Goldsmith, Wireless Communications, Cambridge University Press, 2007.*
2. *Harry R. Anderson, - Fixed Broadband Wireless System Design‖ John Wiley - India, 2003. Education 2009.*
3. *Andreas.F. Molisch, - Wireless Communications‖, John Wiley - India, 2006.*
4. *Simon Haykin& Michael Moher, - Modern Wireless Communications‖, Pearson Education, 2007.*
5. *Rappaport. T.S., - Wireless communications‖, Pearson Education, 2003.*
6. *Gordon L. Stuber, - Principles of Mobile Communication‖, Springer International Ltd., 2001.*
7. *UpenaDalal, —Wireless Communication — Oxford Higher*

2402CO203	ADVANCED DIGITAL SIGNAL PROCESSING	L	T	P	C
		3	0	0	3

PREREQUISITE:

1. Signals and Systems
2. Digital Signal Processing

COURSE OBJECTIVES:

1. To explore the concepts of multi rate signal processing and multi rate filters.
2. To explore the concepts of multi rate filters.
3. To know about Linear and Prediction concepts.
4. To study the adaptive filters and its applications.
5. To learn fundamental concepts on signal processing in power spectrum estimation.

COURSE OUTCOMES:

On the successful completion of the course, students will be able to

CO1:	Design and implement decimator and interpolator.
CO2:	Design multi rate filter bank and acquires knowledge of how a multi rate system work
CO3:	Compute different linear prediction techniques.
CO4:	Explain about LMS and RLS adaptive filters for signal enhancement, channel equalization.
CO5:	Construct different Power spectrum estimation methods and solutions

COs Vs POs MAPPING:

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	-	-	-	-	-	-	-	-	3
CO2	3	3	3	-	-	-	-	-	-	-	-	3
CO3	3	3	3	-	-	-	-	-	-	-	-	3
CO4	3	3	3	-	-	-	-	-	-	-	-	3
CO5	3	3	3	-	-	-	-	-	-	-	-	3

COs Vs PSOs MAPPING:

COs	PSO1	PSO2
CO1	-	-
CO2	-	-
CO3	-	-
CO4	-	-
CO5	-	-

COURSE CONTENTS:

MODULE I MULTIRATE DIGITAL SIGNAL PROCESSING 9 Hours

Introduction-Sampling and Signal Reconstruction-Sampling rate conversion – Decimation by an integer factor – interpolation by an integer factor –Sampling rate conversion by a rational factor – poly-phase FIR structures – FIR structures with time varying coefficients - Sampling rate conversion by a rational factor-Multistage design of decimator and interpolator.

MODULE II	**MULTIRATE FIR FILTER DESIGN**	**9 Hours**
Design of FIR filters for sampling rate conversion –Applications of Interpolation and decimation in signal processing –Filter bank implementation –Two channel filter banks-QMF filter banks –Perfect Reconstruction Filter banks – tree structured filter banks - DFT filter Banks – M-channel filter banks-octave filter banks.		
MODULE III	**LINEAR ESTIMATION AND PREDICTION**	**9 Hours**
Linear prediction- Forward and backward predictions, Solutions of the Normal equations- Levinson-Durbin algorithms. Least mean squared error criterion -Wiener filter for filtering and prediction, FIR Wiener filter and Wiener IIR filters, Discrete Kalman filter.		
MODULE IV	**DESIGN OF ADAPTIVE FILTERS**	**9 Hours**
FIR Adaptive filters - Newton's steepest descent method – Adaptive filters based on steepest descent method - LMS Adaptive algorithm – other LMS based adaptive filters- RLS, Exponentially weighted RLS - Sliding window RLS – Simplified IIR Application: channel equalization, noise cancellation, prediction.		
MODULE V	**POWER SPECTRAL ESTIMATION**	**9 Hours**
Estimation of spectra from finite duration observations of a signal –The Period gram-Use of DFT in Power spectral Estimation –Non-Parametric methods for Power spectrum Estimation – Bartlett. Welch and Blackman–Tukey methods –Comparison of performance of Non – Parametric power spectrum Estimation methods –Parametric Methods - Relationship between auto correlation and model parameters, Yule-Walker equations, solutions using Durbin's algorithm,AR, MA, ARMA model based spectral estimation.		
		TOTAL: 45 HOURS

REFERENCES:

1. *H. Monson Hayes, Statistical Digital Signal Processing and Modeling, John Wiley and Sons, Inc., 2008.*
2. *G.. John Proakis and G. DimitrisManolakis, Digital Signal Processing, Pearson Education, 2006.*
3. *P.P.Vaidyanathan, Multirate Systems and Filter Banks, Pearson Education, 2008.*
4. *N.J.Filege, Multirate Digital Signal Processing, John Wiley and Sons, 2000.*
5. *G..JohnProakis, Algorithms for Statistical Signal Processing, Pearson Education, 2002.*
6. *Sophoncles J. Orfanidis, Optimum Signal Processing, McGraw Hill, 2007.*

2403CO009	WIRELESS SENSOR NETWORKS	L	T	P	C
		3	0	0	3

PREREQUISITE:

1. Computer Networks
2. Wireless Communication
3. Embedded Systems and IoT
4. Sensor Networks and Data Processing

COURSE OBJECTIVES:

1. To make students understand the basics of Wireless sensor Networks.
2. To familiarize with learning of the Architecture of WSN.
3. To understand the concepts of Networking and Networking in WSN.
4. To study the design consideration of topology control and solution to the various problems.
5. To introduce the hardware and software platforms and tool in WSN.

COURSE OUTCOMES:

On the successful completion of the course, students will be able to

CO1:	1. Understand challenges and technologies for wireless networks
CO2:	2. Understand architecture and sensors
CO3:	3. Describe the communication, energy efficiency, computing, storage and transmission
CO4:	4. Establishing infrastructure and simulations K
CO5:	5. Explain the concept of programming the in WSN environment

COs Vs POs MAPPING:

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	3	-	-	3	3	-	3	3
CO2	3	3	3	3	3	-	-	3	3	-	3	3
CO3	3	3	3	3	3	-	-	3	3	-	3	3
CO4	3	3	3	3	3	-	-	3	3	-	3	3
CO5	3	3	3	3	3	-	-	3	3	-	3	3

COs Vs PSOs MAPPING:

COs	PSO1	PSO2	PSO3
CO1	-	-	3
CO2	-	-	3
CO3	-	-	3
CO4	-	-	3
CO5	-	-	3

COURSE CONTENTS:

MODULE I **OVERVIEW OF WIRELESS SENSOR NETWORKS** **9 Hours**

Single Node Architecture Hardware Components Network Characteristics unique constraints and challenges, Enabling Technologies for Wireless Sensor Networks Types of wireless sensor networks.

MODULE II **ARCHITECTURES** **9 Hours**

Network Architecture Sensor Networks Scenarios Design Principle, Physical Layer and Transceiver Design Considerations, Optimization Goals and Figures of Merit, Gateway Concepts, Operating Systems and

Execution Environments introduction to Tiny OS and nesC Internet to WSN Communication.		
MODULE III	**NETWORKING SENSORS**	**9 Hours**
MAC Protocols for Wireless Sensor Networks, Low Duty Cycle Protocols And Wakeup Concepts – SMAC, BMAC Protocol, IEEE 802.15.4 standard and ZigBee, the Mediation Device Protocol, Wakeup Radio Concepts, Address and Name Management, Assignment of MAC Addresses, Routing Protocols Energy Efficient Routing, Geographic Routing.		
MODULE IV	**INFRASTRUCTURE ESTABLISHMENT**	**9 Hours**
Topology Control, Clustering, Time Synchronization, Localization and Positioning, Sensor Tasking and Control.		
MODULE V	**SENSOR NETWORK PLATFORMS AND TOOLS**	**9 Hours**
Sensor Node Hardware – Berkeley Motes, Programming Challenges, Node level software platforms, Node level Simulators, State centric programming.		
		TOTAL: 45 HOURS

REFERENCES:

1. Holger Karl & Andreas Willig, "Protocols And Architectures for Wireless Sensor Networks", John Wiley, 2005.

2. Feng Zhao & Leonidas J.Guibas, "Wireless Sensor Networks An Information Processing Approach", Elsevier, 2007.

3. Waltenegus Dargie , Christian Poellabauer, "Fundamentals of Wireless Sensor Networks Theory and Practice", John Wiley & Sons Publications, 2011

4. Kazem Sohraby, Daniel Minoli, & Taieb Znati, "Wireless Sensor Networks Technology, Protocols, and Applications", John Wiley, 2007.

5. Anna Hac, "Wireless Sensor Network Designs", John Wiley, 2003

2403CO011	MOBILE ADHOC NETWORKS	L	T	P	C
		3	0	0	3

PREREQUISITE:

1. Computer Networks
2. Wireless Communication
3. Mobile Communication
4. Network Routing and Protocols

COURSE OBJECTIVES:

1. Understand the basics of Ad-hoc & Sensor Networks
2. Describe various fundamental and emerging protocols of all layers
3. Report the issues pertaining to major obstacles in establishment and efficient management of Ad-hoc and sensor networks
4. Restate the nature and applications of Ad-hoc and sensor networks
5. Discuss various security practices and protocols of Ad-hoc and Sensor Networks

COURSE OUTCOMES:

On the successful completion of the course, students will be able to

CO1:	Identify different issues in wireless ad hoc and sensor networks
CO2:	Report different protocols developed for ad hoc and sensor networks
CO3:	Restate the security threats in ad hoc and sensor networks
CO4:	Discuss a Sensor network environment for different type of applications
CO5:	Restate importance of MAC & TCP in networks

COs Vs POs MAPPING:

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	3	-	-	-	-	-	3	3
CO2	3	3	3	3	3	-	-	-	-	-	3	3
CO3	3	3	3	3	3	-	-	-	-	-	3	3
CO4	3	3	3	3	3	-	-	-	-	-	3	3
CO5	3	3	3	3	3	-	-	-	-	-	3	3

COs Vs PSOs MAPPING:

COs	PSO1	PSO2	PSO3
CO1	-	-	3
CO2	-	-	3
CO3	-	-	3
CO4	-	-	3
CO5	-	-	3

COURSE CONTENTS:

MODULE I **MAC & TCP IN AD HOC NETWORKS** **9 Hours**

Fundamentals of WLANs – IEEE 802.11 Architecture - Self configuration and Auto configuration-Issues in Ad-Hoc Wireless Networks – MAC Protocols for Ad-Hoc Wireless Networks – Contention Based Protocols - TCP over Ad-Hoc networks-TCP protocol overview - TCP and MANETs – Solutions for TCP over Ad-Hoc Networks

MODULE II	**ROUTING IN AD HOC NETWORKS**	**9 Hours**
Routing in Ad-Hoc Networks- Introduction-Topology based versus Position based Approaches-Proactive, Reactive, Hybrid Routing Approach-Principles and issues – Location services - DREAM – Quorums based location service – Grid – Forwarding strategies – Greedy packet forwarding – Restricted directional flooding-Hierarchical Routing- Issues and Challenges in providing QoS.		
MODULE III	**MAC, ROUTING & QOS IN WIRELESS SENSOR NETWORKS**	**9 Hours**
Introduction – Architecture - Single node architecture – Sensor network design considerations – Energy Efficient Design principles for WSNs – Protocols for WSN – Physical Layer : Transceiver Design considerations – MAC Layer Protocols – IEEE 802.15.4 Zigbee – Link Layer and Error Control issues - Routing Protocols – Mobile Nodes and Mobile Robots - Data Centric & Contention Based Networking – Transport Protocols & QOS – Congestion Control issues – Application Layer support.		
MODULE IV	**SENSOR MANAGEMENT**	**9 Hours**
Sensor Management - Topology Control Protocols and Sensing Mode Selection Protocols - Time synchronization - Localization and positioning – Operating systems and Sensor Network programming – Sensor Network Simulators		
MODULE V	**SECURITY IN AD HOC AND SENSOR NETWORKS**	**9 Hours**
Security in Ad-Hoc and Sensor networks – Key Distribution and Management – Software based Anti-tamper techniques – water marking techniques – Defense against routing attacks - Secure Adhoc routing protocols – Broadcast authentication WSN protocols – TESLA – Biba – Sensor Network Security Protocols – SPINS		
		TOTAL: 45 HOURS

REFERENCES:

1. *Adrian Perrig, J. D. Tygar, "Secure Broadcast Communication: In Wired and Wireless Networks", Springer, 2006*
2. *Carlos De MoraisCordeiro, Dharma Prakash Agrawal "Ad Hoc and Sensor Networks: Theory and Applications (2nd Edition), World Scientific Publishing, 2011*
3. *C.Siva Ram Murthy and B.S.Manoj, "Ad Hoc Wireless Networks – Architectures and Protocols", Pearson Education, 2004*
4. *C.K.Toh, "Ad Hoc Mobile Wireless Networks", Pearson Education, 2002*
5. *ErdalÇayırcı ,ChunmingRong, "Security in Wireless Ad Hoc and Sensor Networks", John Wiley and Sons, 2009.*

2402CO204	WIRELESS COMMUNICATION AND NETWORKS LABORATORY	L	T	P	C
		0	0	4	2

PREREQUISITE:

1. Computer Networks Lab
2. Wireless Communication Lab

COURSE OBJECTIVES:

1. To study the network simulators for implementation of different layered protocols
2. To Implement MAC and Routing algorithms
3. To perform simulation and analysis of various network protocols, Mobility model

COURSE OUTCOMES:

On the successful completion of the course, students will be able to

CO1:	Develop characteristics of analog and digital channels in communication systems.
CO2:	Design the wireless medium access mechanisms.
CO3:	Test the performance of routing protocols.
CO4:	Design the IP and TCP traffic in static and mobile adhoc network.
CO5:	Develop the code for Wimax technique.
CO6:	Simulate the different routing algorithm.

COs Vs POs MAPPING:

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	3	-	-	3	3	-	3	3
CO2	3	3	3	3	3	-	-	3	3	-	3	3
CO3	3	3	3	3	3	-	-	3	3	-	3	3
CO4	3	3	3	3	3	-	-	3	3	-	3	3
CO5	3	3	3	3	3	-	-	3	3	-	3	3
CO6	3	3	3	3	3	-	-	3	3	-	3	3

COs Vs PSOs MAPPING:

COs	PSO1	PSO2
CO2	-	3
CO3	-	3
CO4	-	3
CO5	-	3
CO6	-	3

LIST OF EXPERIMENTS:

1. Design and Implementation of wired network in open source simulator and performance analysis
2. Simulation of Distance Vector and Link state routing in NS2
3. Simulation of a multicast routing mechanism in NS2
4. Simulation and Performance analysis of IEEE 802.11 networks based on Throughput, PDR, Average End to End delay and Jitter
5. Simulation of IEEE 802.11 networks with Mobility and performance comparison based on Throughput, PDR, Average End to End Delay and Jitter
6. Simulation and Performance analysis of IEEE 802.16 WiMAX networks

7. Design and Simulation of Handover mechanism in WiMAX systems and performance analysis based on Packets sent and received
8. Simulation and Performance analysis of Table Driven routing protocol in Mobile Ad Hoc Networks
9. Simulation of On-Demand Routing Protocols in Mobile Adhoc networks and Performance comparison with Table Driven Protocols
10. Simulation of a security attack in Wireless Networks and analysis of performance degradation
11. Performance analysis of secure routing mechanism in Wireless Networks and study on network performance in the presence of an attack
12. Design and simulation of Wireless Sensor Networks using Zigbee and performance analysis based on battery model
Mini Project • Design of Vehicular Ad Hoc Network and performance analysis based on different Mobility conditions
• Design of Wireless sensor networks for a specific application of Patient Health Monitoring
• Performance analysis and comparison of Battery aware models in Wireless Networks
• Performance evaluation of Medium Access Control in Heterogeneous wireless networks
• Design and simulation of GSM network and their performance analysis
TOTAL: 30 HOURS

REFERENCES:

1. *K.Nandakumar, R.Anandaraj, "Power Electronics and Drives Laboratory Manual", 2018*
2. *G.K Dubey, "Fundamentals of Electrical Drives", 2nd Edition, Narosa Book Distributors, 2013.*
3. *R. Krishnan, "Electric Motor Drives: Modeling, Analysis and Control", 1st Edition, Pearson Education, 2015.*
4. *Bimal K. Bose, "Modern Power Electronics and AC Drives", 1st Edition, Pearson Education, 2015.*
5. *https://nptel.ac.in/courses/108/104/108104140/*
6. *https://in.mathworks.com/matlabcentral/fileexchange?q=electrical+drives*
7. *https://ied-nitk.vlabs.ac.in/*
8. *https://em-coep.vlabs.ac.in/List%20of%20experiments.html*