SAVITRIBAI PHULE PUNE UNIVERSITY

FACULTY OF ENGINEERING

SYLLABUS FOR
M.E. ELECTRICAL (Power Electronics and Drives)
(2017 course)

WITH EFFECT FROM YEAR 2017-2018

Structure for M.E.(Electrical) Power Electronics and Drives 2017 Course

SEMESTER I

CODE	SUBJECT	TEACHING SCHEME	EXAMINATION SCHEME					CREDITS
		Lect./ Pr	Paper		TW	Oral/presentation	Total	
			In Semester Assessment	End Semester Assessment				
503301	Linear Systems Theory And Design	4	50	50	-	-	100	4
503302	Modelling and Analysis of Electrical Machines	4	50	50	-	-	100	4
503303	Power Converters-I	4	50	50	-	-	100	4
503304	Research Methodology	4	50	50	-	-	100	4
503305	Elective I	5	50	50	-	-	100	5
503306	Lab Practice I	4	-	-	50	50	100	4
Total		**25**	**250**	**250**	**50**	**50**	**600**	**25**

SEMESTER II

CODE	SUBJECT	TEACHING SCHEME	EXAMINATION SCHEME					CREDITS
		Lect./Pr	Paper		TW	Oral/presentation	Total	
			In Semester Assessment	End Semester Assessment				
503307	AC and DC Drives	4	50	50	-	-	100	4
503308	Power Converters-II	4	50	50	-	-	100	4
503309	Advanced Control Systems	4	50	50	-	-	100	4
503310	Elective II	5	50	50	-	-	100	5
503311	Lab Practice II	4	-	-	50	50	100	4
503312	Seminar I	4	-	-	50	50	100	4
Total		**25**	**200**	**200**	**100**	**100**	**600**	**25**

SEMESTER III

CODE	SUBJECT	TEACHING SCHEME	EXAMINATION SCHEME					CREDITS
			Paper		TW	Oral/presentation	Total	
		Lect./ Pr	In Semester Assessment	End Semester Assessment				
603301	Special Applications of Power Electronics	4	50	50	-	-	100	4
603302	Energy management and power quality	4	50	50	-	-	100	4
603303	Elective III	5	50	50	-	-	100	5
603304	Seminar II	4	-	-	50	50	100	4
603305	Project Stage I	8	-	-	50	50	100	8
Total		**25**	**150**	**150**	**100**	**100**	**500**	**25**

SEMESTER IV

CODE	SUBJECT	TEACHING SCHEME	EXAMINATION SCHEME				CREDITS
		Lect./ Pr	Paper	TW	Oral/presentation	Total	
603306	Seminar III	5	-	50	50	100	5
603307	Project Work Stage II	20	-	150	50	200	20
Total		**25**	**-**	**200**	**100**	**300**	**25**

Evaluation of Seminars and Project in different semesters would be carried out as per rules and regulations of ME programs under faculty of engineering effective from June 2017.

List of Elective Subjects

Note: Select any one subject from module I and one subject from module II for each Elective.

503305 Elective-I (5 credits)		**503310 Elective-II (5 credits)**		**603303 Elective-III (5 credits)**	
Module I (credits=4)	Module II (credit=1)	Module I (credits=4)	Module II (credit=1)	Module I (credits=4)	Module II (credit=1)
1)DSP and its Applications	1) Project Management	1) Industrial drives And Automation	1) Electric Vehicles	1)Artificial Intelligence Based Electrical drives	1) Artificial Intelligent tools
2) Data Acquisition and Signal conditioning	2) IPR and Patent Law	2)Embedded systems	2) Fundamentals of Cyber Security	2) Industrial Automation And Control	2) Intelligent Sensors and instrumentation
3) Optimisation Techniques	3) Technical communication	3) FACTS	3)Disaster Management	3) Energy Storage Systems	3) Human Rights
4) Wind And Solar Systems	4) Smart Grid Technologies	-	4) Communication protocols in SCADA System	4) High voltage DC Transmission (HVDC)	4) Green building design

EXAMINATION SCHEME GUIDELINES

A) Compulsory subjects: Credits 4

Total marks: 100

To be done at Institute Level		**University Exam**	
In semester assessment Units 1 – 4		**End semester assessment**	
Class tests	30 Marks	Units 1- 4	18 Marks
Assignments / PPT/ Mini Project	20 Marks	Unit 5	16 Marks
		Unit 6	16 Marks
Total	50 Marks	Total	50 Marks

B) Elective subjects: Credits 5

Total marks: 100

Module 1 (Credits – 4)			
In semester assessment Units 1-4		**End semester assessment**	
Class tests	15 Marks	Units 1 & 2	12 Marks
Assignments/PPT presentations	10 Marks	Units 3 & 4	14 Marks
		Unit 5	12 Marks
		Unit 6	12 Marks
Total	25 Marks	Total	50 Marks

Module 2 (Credit – 1)	
In semester assessment	Units 1-2
Class tests / Assignments/Presentations	25 Marks

B.O.S.
Electrical Engineering

Semester I

503301: LINEAR SYSTEMS THEORY & DESIGN

Teaching Scheme
04 Hours/Week
Credits: 04

Examination Scheme
In semester Assessment: 50
End semesters Assessment: 50

Course Objectives:

The students will be able to understand:

1. Basic linear algebra, vectors and vector space concept, matrix algebra.

2. Analysis of statistical data and normal distribution.

3. Data in graphical representation.

Course Outcomes:

The students will be able to:

CO1. Analyze and represent data in various form.

CO2. Apply knowledge of linear system theory to design various power electronics systems.

Unit I: Vectors
Vector algebra, Geometry of vector, Dot and cross product of vectors, Orthogonal vectors.(08 Hrs)

Unit II: Vector Space
Linear dependence and independence, Spanning sets and dimensions, Linear transformations, Change of basis. (08 Hrs)

Unit III: Matrix Algebra
Basic definitions and rules of matrices, Special matrices, Eigen values and Eigen vectors, Diagonalization of matrices, orthogonal symmetrical matrices, Skew matrices. (08 Hrs)

Unit IV: Statistical Data Analysis
Types of measured quantity- discrete & continuous distributed quantities, Histogram, Central tendency of data, Median and mean value of data, Measures of dispersion, Standard deviation. (08 Hrs)

Unit V: Normal Distribution
Gaussian distribution and its properties, Area under normal distribution, Standardized normal distribution, Central limit theorem, significant test, Chi-square test. (08 Hrs)

Unit VI: Graphical Representation of data
Equation of approximate curves, Determination of parameters in linear relationships: Graphical method, Method of sequential differences, Method of extended differences, method of least squares. (06 Hrs)

Reference Books

1) Peter V.O'Neil, Cengage Learning, Canada , "Advanced Engineering Mathematics"
2) B.C. Nakra, K.K. Chaudhry, "Instrumentation, Measurement & Analysis", Tata McGraw Hill, 2004
3) Chi-T Song Chen, "Linear Systems Theory and Design", 3rd Edition, Oxford University Press NewYork, 1999.

503302: MODELING AND ANALYSIS OF ELECTRICAL MACHINES

Teaching Scheme
4 Hours / Week
Credits : 4

Examination Scheme
In Semester Assessment: 50
End Semester Assessment: 50

Course Objectives:
The students will be able to understand:

1. Various linear and non-linear models for analysis of steady-state and dynamic machine performance estimation.
2. Concepts of representing transfer function model of a DC machine.
3. Importance of 3-phase to 2-phase conversion.
4. The representation of 3-phase induction motor in various reference frames
5. Modelling of 3-phase synch. Motor in 2- axis representation.
6. Linearization of machine equations.

Course Outcome:
After completion of course students will be able to

CO1.Apply the various linear and non-linear models for analysis of steady-state and dynamic machine performance estimation.
CO2. Have an appreciation of the simplifying assumptions associated with the various modelling techniques.
CO3.Determine the dynamic model of an induction machine and determination of torque.
CO4. Determine the torque developed in a salient pole synchronous machine using the Park's transformation and identify contribution of saliency torque-damping torque and excitation torque.
CO5.Apply the modelling techniques to novel or other machine technologies

Unit I: Generalized Machine Theory:
Elements of generalized circuit theory, basic electrical machine, conventions used, Kron's primitive machine, leakage flux in machines with more than two windings, voltage equations, matrix form, torque equations, power in AC circuits. (08 Hrs)

Unit II: Linear Transformations in Machines:
Linear Transformations in machines: Power invariance, transformations from displaced brush axis, transformations from 3-phase to 2-phase, transformation from rotating axes to stationary axes, Transformed impendence matrix. (08 Hrs)

Unit III: DC Machine:
Separately excited DC motor-steady state and transient state analysis, sudden application of inertia load, transfer function of separately excited DC motor, mathematical model of dc series motor, shunt motor. (08Hrs)

Unit IV: Modelling of three phase Induction machine

Generalized model in arbitrary frame, Voltage, torque equations, Induction motor models-stator reference frame model, rotor reference frame model, synchronously rotating reference frame model, equations in flux linkages, per unit model, dynamic simulation. (08 Hrs)

Unit V: Modelling of Synchronous Machines

Introduction, voltage equations and torque equation in machine variables, stator voltage equations in arbitrary and rotor reference frame variables, Park's equations, rotor angle, per unit system, analysis of steady state operation. (08 Hrs)

Unit VI: Alternative forms of Machine equations

Linearization of machine equations, Small displacement stability: Eigen values, Eigen values of typical induction machine and synchronous machine. Performance prediction of -Induction machine, synchronous machine with stator electric transients neglected (08Hrs)

Text Books:

1. R. Krishnan, "Electric Motor Drives - Modeling, Analysis & Control", PHI Learning Private Ltd, 2009.
2. P.C.Krause, Oleg Wasynczuk, Scott D.Sudhoff, "Analysis of Electrical Machinery and Drive Systems", IEEE Press ,John Wiley and Sons
3. P.S.Bimbra, "Generalized Theory of Electrical Machines", Khanna Publications,.

Reference Books:

1. Chee-Mun Ong, "Dynamic Simulation of Electric Machinery using Matlab / Simulink", Prentice Hall, 1998.
2. Matrix Analysis of Electric machines,N.N.Hancock,Pergamon Press.
3. Matrix Analysis of Electric machines by Mukhopadhyay

503303: POWER CONVERTERS - I

Teaching Scheme
4 Hours / Week
Credits: 4

Examination Scheme
In Semester Assessment: 50
End Semester Assessment: 50

Course Objective:
The students will be able

1. To explain working of different solid state devices.
2. To analyze and comprehend the various operating modes of different configurations of power converters.

Course Outcomes: Students will have

CO1. Understanding of solid state devices.

CO2.Understand the operating principles and models of different types of power electronic converters

CO3. Calculate performance parameters and analyze output waveforms of various converters under different loading conditions

Unit I: SOLID STATE DEVICES

Power semiconductor devices: SCR -MOSFET– IGBT – Integrated Gate-Commutated thyristor (IGCTs) – MOS-controlled thyristors (MCTs): Characteristics, Features, ratings, applications and comparison of their features. (08Hrs)

Unit II: AC - DC CONVERTERS

1-phase and 3-phase Full controlled bridge converters with RLE loads- continuous and discontinuous modes of operation, freewheeling diodes, Effect of source inductance on commutation, Harmonic analysis of source current, Twelve pulse converters (08Hrs)

Unit III: DC - DC CONVERTERS

Buck, boost, buck-boost and Cuk converter topologies- continuous and discontinuous modes of operation, Filter circuits, Multilevel Boost converters (08Hrs)

Unit IV: DC -AC CONVERTERS

General topology of 1-phase and 3-phase voltage source Inverters, Voltage Control Techniques, Current source inverters, Selection of switching frequency & switching device. (08Hrs)

UNIT-V: AC-AC CONVERTERS –I (VOLTAGE CONTROLLERS)

Single phase AC voltage controllers with RLE loads, AC voltage controllers with PWM Control , Three Phase AC Voltage Controllers with star and delta Connected RLE loads ,Effects of source and load inductances ,Applications ,numerical problems. (08Hrs)

UNIT-VI: AC-AC CONVERTERS –II (CYCLO-CONVERTERS)

Single phase to single phase cyclo-converters: analysis of midpoint and bridge Configurations, Three phase to three phase cyclo-converters: Analysis of Midpoint and bridge configurations, Limitations, Advantages, Applications, numerical problems. (08Hrs)

Text Books:

1. Rashid M.H., "Power Electronics Circuits, Devices and Applications ", Prentice Hall India, Second Edition, New Delhi.

2. “Power Electronics: Converters, Design and Applications”, Ned Mohan, Undeland, Robbins. John Wiley and Sons, 2004.

3. V. R. Moorthi,, “Power Electronics Devices, Circuits and Industrial applications”, Oxford University Press

Reference Books:

1. M.D.Singh and Khanchandani, “Power Electronics”, Tata McGraw-Hill Education
2. VedamSubramanyam,“Power Electronics”, Tata McGraw Hill.
3. B.K.Bose“Modern Power Electronics and AC drives”, Pearson Education Inc., 2002.
4. Erickson Robert W. DraganMaksimović, “Fundamentals of Power Electronics”, Springer Publication,
5. Philip T. Krein, “Elements of Power Electronics”, Oxford University Press.

503304: RESEARCH METHODOLOGY

Teaching Scheme
4 Hours / Week
Credits: 4

Examination Scheme
In Semester Assessment: 50
End Semester Assessments: 50

Course Objectives:

1. To develop understanding of the basic framework of research and identify various sources of information for literature review.
2. To identify various sources of data collection and analyze the same .
3. An ability to prepare technical document using LATEX .
4. To develop an understanding of the ethical issues related to research.
5. To enable students to differentiate between different types of technical papers.
6. To develop this skill of report writing and preparing a research proposal .

Course Outcome :

At the end of the course, the students should be able to:

CO1. Understand some basic concepts of research and its methodologies
CO2. Select and define appropriate research problem and its parameters
CO3. Demonstrate knowledge and understanding of data analysis
CO4. Prepare research proposal and write a research thesis using LATEX follow research ethics

Unit I:
Research -Definition, Characteristics, Need and Objectives. Research Formulation – Defining and formulating the research problem ,Selecting the problem , Necessity of defining the problem Importance of literature review in defining a problem – Literature review – Primary and secondary sources – reviews, treatise, monographs-patents .Critical literature review – Identifying gap areas from literature review (08 Hrs)

Unit II:
Data Collection and analysis:- Observation and Collection of primary and secondary data - Methods of data collection, processing operations, types of analysis, statistics in research, measures of central tendency, measures of dispersion, measures of asymmetry, measures of relationships, simple regression analysis, multiple correlation and regression, partial correlation. (08 Hrs)

Unit III:
Report/Thesis preparation using LATEX Important parts of reports like abstract, results, conclusion. Supplementary parts like list of symbols, list of tables, annexure, references etc. Making title page, writing mathematical equations, including graphics, making tables and writing references using LaTex/ MiKTeX.(08 Hrs)

Unit IV:
Ethical issues– Copy right – royalty - Intellectual property rights and patent law – Trade Related aspects of Intellectual Property Rights – Reproduction of published material – Plagiarism - Citation and acknowledgement - Reproducibility and accountability (08 Hrs)

Unit V:
Types of technical papers - Journal papers, Conference papers, Survey papers, Poster papers, Review papers Comparison, Structure of a survey, conference and journal paper, Organization and flow of thesis/ Project report, Research proposal: preparation, budgeting, presentation, funding agencies for engineering research

(08 Hrs)

Unit VI:
Reporting and thesis writing – Structure and components of scientific reports - Types of report – Technical reports and thesis – Significance – Different steps in the preparation – Layout, structure and Language of typical reports – Illustrations and tables - Bibliography, referencing and footnotes - Oral presentation – Planning – Preparation –Practice – Making presentation – Use of visual aids - Importance of effective communication (08 Hrs)

Text Books :
1. Kothari, C.R., Research Methodology: Methods and Techniques. New Age International
2. Garg, B.L., Karadia, R., Agarwal, F. and Agarwal, U.K., An introduction to Research Methodology,
RBSA Publishers.
3. Suresh Sinha, Anil K Dhiman, Research Methodology, ESS Publications,Volumes 2
4. Day R.A., How to Write and Publish a Scientific Paper, Cambridge University Press
5. Wadehra, B.L. Law relating to patents, Trade Marks, copyright designs and geographical indications. Universal Law Publishing.
6. Leslie Lamport, ' Latex: A document preparation system' Addison Wesley, Reading, Massachusetts,
second edition, 1994, ISBN 0-201-52983-1.
7. Caroline Whitbeck , Ethics in engineering practice and Research , Cambridge University Press .

Reference Books:
1. Louis Cohen, Lawrence Manion and Keith Morrison, Research Methods in Education, 7th Edition,
Cambridge University Press, ISBN – 978-0415-58336-7
2. Anthony, M., Graziano, A.M. and Raulin, M.L., Research Methods: A Process of Inquiry, Allyn and
Bacon.
3. Ranjit Kumar, Research Methodology: A Step by Step Guide for Beginners, 2nd Edition, APH Publishing Corporation.
4. Leedy, P.D. and Ormrod, J.E., Practical Research: Planning and Design, Prentice Hall.
5. Fink, A., Conducting Research Literature Reviews: From the Internet to Paper. Sage Publications.
6.Satarkar S.V., Intellectual Property Rights and Copy Right. ESS Publications.
7.Meenakshi Raman and Sangeeta Sharma , Technical Communication Principles and Practice ,2nd Edition , Oxford University

503305: (ELECTIVE- I)

CODE	TEACHING SCHEME	EXAMINATION SCHEME					CREDITS
		Paper		TW	Oral / Presentation	Total	
503305	Lect/week	In semester Assessment	End Semester Assessment				
	5	50	50	-	-	100	5

Code No.	Modules of 4 credit (Select any one)	Code No.	Modules of 1 credit (Select any one)
503305 M1(i)	DSP and its applications	503305 M2(i)	Project Management
503305 M1(ii)	Data Acquisition and Signal conditioning	503305 M2(ii)	IPR and Patent Law
503305 M1(iii)-	Optimisation Techniques	503305 M2(iii)	Technical communication
503305 M1(iv)-	Wind And Solar Systems	503305 M2(iv)	Smart Grid Technologies

503305 M1(i): ELECTIVE-I -Module 1 : DSP AND ITS APPLICATIONS

Teaching Scheme
Lectures: 4 Hrs./Week
Marks Credits: 4

Examination Scheme
In-Semester Examination : 25 Marks
End Semester Examination: 50 Marks

Course Objectives:
The student will be able to understand

1. Various signals and systems used in digital signal processing.
2. Time and frequency domain concepts and the associated mathematical tools those are fundamental to all DSP techniques.
3. Various sampling techniques and different types of filters .
4. Different applications of DSP.

Course Outcomes:
The student will be able to

CO1. Transform analog signal to digital signal.
CO2. Implement the appropriate type of design methods for FIR filter .
CO3. Know different types of IIR filter structures and their implementations
CO4. Implement DFTs using Fast Fourier Transforms.

Unit I: Discrete Signals and systems
Sampling of continuous time signals, quantization, aliasing, Sampling Theorem, Elementary discrete-time signals, classification, sequence operations, Discrete-time systems and Classification, impulse response, linear convolution and its properties, Z transform: basics, properties, inverse Z transform using power series and partial fraction. (08Hrs)

Unit II: Frequency response of discrete time systems
Discrete-time systems described by difference equations, Analysis of LTI discrete systems using z transform, frequency response of first order and second order systems, transfer function, steady state and transient response. (08Hrs)

Unit III: Frequency analysis of discrete time signals
The Fourier series for discrete-Time periodic signals (only concept), The Fourier transform of discrete-time a periodic signals (only concept), Discrete Fourier Transform, Properties: periodicity, linearity, and symmetry properties, Circular convolution, Linear convolution using circular convolution, Fast Fourier Transform: Radix 2 DIT and DIF algorithms. (08Hrs)

Unit IV: IIR filters

Advantages and disadvantages of digital filter over analog filters, classification of digital filters: FIR and IIR, design of analog low pass Butterworth filter, Chebyshev filter, design of IIR filters from analog filters using bilinear transformation, impulse invariance. Realization of IIR filters: direct form I, direct form II, cascade and parallel. (08Hrs)

Unit V: FIR filters

Comparison between FIR and IIR filters, symmetric and anti-symmetric FIR filters, design of linear phase FIR filters using windows method(Rectangular and Hamming Window only), Realization of FIR filters by direct form, cascade form and parallel form. (08Hrs)

Unit VI: Applications of DSP

Application of DSP in rotating Electric Machines - speed control and condition Monitoring, Application of DSP in transmission line protection, Transformer protection. Harmonic analysis. (08 Hrs)

Text Books:

1. Proakis J.G. and Manolakis D.G., Digital Signal Processing, PHI, New Delhi.
2. Oppenhein A.V. and Schafer R. W., Digital Signal Processing. PHI, New Delhi.
3. Digital Signal Processing by P.Ramesh Babu, Scitech publications.

Reference Books:

1. Litan – Digital signal processing. Elsevier Publications
2. Mitra S., "Digital Signal Processing: A Computer Based Approach", Tata McGraw-Hill,1998,
3. S.W.Smith, Scientist and Engineers Guide to Digital Signal Processing ,California Technical Publications, California,1999.

503305 M1(ii):ELECTIVE-I Module1:
DATA ACQUISITION AND SIGNAL CONDITIONING

Teaching Scheme
Lectures: 4 Hrs./Week
Credits: 4

Examination Scheme
In-Semester Examination : 25 Marks
End Semester Examination:50 Marks

Course Objectives:
The student will be able to understand

1. Various transducers and data acquisition
2. Various signal conditioning and filtering, sampling techniques.
3. Various signal conversion, transmission and interfacing methods.
4. Different software design strategies.

Course Outcomes:
The student will be able to

CO1. Use the knowledge of transducers
CO2. Implement the appropriate type of method of signal conditioning, filtering and sampling
CO3. Use different methods of signal conversion, transmission and interfacing
CO4. Implement software design strategies.

Unit I : Transducers &Data Acquisition
Data Acquisition Systems(DAS)- Introduction . Objectives of DAS . Block Diagram Description of DAS- General configurations - Single and multichannel DAS-Transducers for the measurement of motion, force, pressure, flow, level, dc and ac voltages and currents (CTs, PTs for supply frequency as well as high frequency, Hall Effect Current Sensors, High Voltage Sensors, Optosensors, Rogowski Coil, Ampflex Sensors etc.) (08 Hrs)

Unit II: Signal Conditioning
Requirements - Instrumentation amplifiers: Basic characteristics. Chopped and Modulated DC Amplifiers-Isolation amplifiers - Optocouplers - Buffer amplifiers .Noise Reduction Techniques in Signal Conditioning- Transmitters. Optical Fiber Based Signal Transmission-Piezoelectric Couplers- Intelligent transmitters. (08 Hrs)

Unit III: Filtering and Sampling
Review of Nyquist.s Sampling Theorem-Aliasing . Need for Prefiltering-First and second order filters - classification and types of filters - Low -pass, High-pass, Band-pass and Band-rejection and All Pass: Butterworth, Bessel, Chebyshev and Elliptic filters. Opamp RC Circuits for Second Order Sections-Design of Higher Order Filters using second order sections using Butterworth Approximation-Narrow Bandpass and Notch Filters and their application in DAS. Sample and Hold Amplifiers . (08Hrs)

Unit IV: Signal Conversion and Transmission

Analog-to-Digital Converters (ADC)-Multiplexers and demultiplexers - Digital multiplexer. A/D Conversion . Conversion Processes, Speed, Quantization Errors. Successive Approximation ADC . Dual Slope ADC . Flash ADC . Digital-to-Analog Conversion (DAC) . Techniques, Speed, Conversion Errors, Post Filtering- Weighted Resistor, R-2R, and Weighted Current type of DACs-Multiplying Type DAC-Bipolar DACs- Data transmission systems-Schmitt Trigger-Pulse code formats- Modulation techniques and systems-Telemetry systems. (08 Hrs)

Unit V: Digital Signal Transmission and Interfacing

DAS Boards-Introduction. Study of a representative DAS Board, Interfacing Issues with DAS Boards, I/O vs Memory Addressing, Software Drivers, Virtual Instruments, Modular Programming Techniques for Robust Systems, Bus standard for communication between instruments - GPIB (IEEE-488bus) - RS-232C- USB-4-to-20mA current loop serial communication systems. Communication via parallel port . Interrupt-based Data Acquisition. (08 Hrs)

Unit VI: Software Design Strategies

Hardware Vs Software Interrupts-Foreground/ background Programming Techniques- Limitations of Polling Circular Queues. (08 Hrs)

Text Books:

1. Ernest O Doeblin., "Measurement Systems: Application and Design", McGraw Hill (Int. edition) 1990, ISBN 0-07-100697-4
2. George C.Barney, "Intelligent Instrumentation", Prentice Hall of India Pvt Ltd., New Delhi, 1988.
3. Ibrahim, K.E., "Instruments and Automatic Test Equipment", Longman Scientific & Technical Group Ltd., UK, 1988.

Reference Books:

1. John Uffrenbeck, "The 80x86 Family, Design, Programming, and Interfacing", Pearson Education , Asia,
2. Bates Paul, "Practical digital and Data Communications with LSI", Prentice Hall of India, 1987.
3. G.B. Clayton, Operational Amplifiers., Butterworth and Co,
4. A.K Ray et. Al,Advanced Microprocessors and Peripherals., Tata McGrawHill,

Oliver Cage, .Electronic Measurements and Instrumentation, McGraw-Hill, (Int. edition) 1975, ISBN 0-07-085544 -7.

503305 M1(iii): ELECTIVE-I -Module 1: OPTIMIZATION TECHNIQUES

Teaching Scheme
4 Hours/ Week
Credits:4

Examination Scheme
In semester Assessment :25 Marks
End semester Assessment : 50 Marks

Course Objective
Student will be able to understand

1. Concept of optimization
2.Different optimization Techniques
3.Application of optimization to engineering problem

Course Outcome
At the end of course student will be able to

CO1. Classify different optimization techniques
CO2. Apply optimization techniques to simple and moderate system
CO3. Use modern methods of optimization.

Unit I
Introduction to Optimization:
Introduction Historical Development Importance of optimization techniques Engineering Applications of Optimization Definition-classification of optimization problems, unconstrained and constrained optimization, constrained surface, Objective function , Optimization Techniques
(8Hrs)

Unit II
Classical Optimization Techniques:
Single-Variable Optimization, Multivariable Optimization with No Constraints, Multivariable Optimization with Equality Constraints, Lagrange's method of multipliers Multivariable Optimization with Inequality Constraints , Karush-Kuhn-Tucker conditions
(8Hrs)

Unit III
Linear Programming:
Statement of an LP problem, Simplex method, Dual simplex method.
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(8Hrs)

Unit IV
Non-linear Programming I:
One-dimensional minimization: Unimodal function, Unrestricted search, Exhaustive search, Dichotomous search, Interval halving method, Fibonacci method, Direct root methods: Newton-Raphson and Quasi Newton methods, secant method.
(8Hrs)

Unit V

Non-linear Programming II:

Unconstrained Optimization Techniques: Direct Search Methods: Random search methods, Grid search method, Univariate method, Powell's method, Indirect search method: Gradient of a function Steepest Descent (Cauchy) Method

(8Hrs)

Unit VI

Modern Methods of Optimization:

Genetic algorithms, simulated annealing, fuzzy optimization, neural-network based methods, Particle swarm optimization.

(8Hrs)

Text Books :

1. Singiresu S. Rao, Engineering Optimization: Theory and Practice, John Wiley & Sons
2. R. L., Addison , Optimization Methods for Engineering Design, Fox, Wesley, 2001.

Reference Books:

1. Deb Multi-objective optimization using evolutionary algorithms, Wiley Publications.
2. J S Arora, Introduction to Optimum Design, Mc-Graw Hill.
3. Kaddah, S.S, "Genetic algorithm based optimal operation for photovoltaic systems under different fault criteria", Proceedings of IEEE Power Systems Conference, 2006.

503305 M1(iv): ELECTIVE-I -Module 1: : WIND AND SOLAR SYSTEMS

Teaching Scheme
04 Hours/Week
Credits: 04

Examination Scheme
In semester Assessment: 25 Marks
End semesters Assessment: 50 Marks

Course Objectives:
The students will be able to understand:

1. Basic engineering processes.
2. Design and analysis of the performance parameters of wind and solar generation system.

Course Outcomes:
The students will be able to:

CO1. Analyze and represent renewable system data in various form.

CO2. Perform basic assessment and design of a renewable electrical energy system for a given application

CO3. Determine the requirements for interconnecting a renewable electrical energy system to the utility electric power grid

Unit 01: Wind Energy Fundamentals
Wind Energy Basics, Wind Speeds and scales, Terrain, Roughness, Wind Mechanics, Power Content, Atmospheric Boundary Layers, and Turbulence. [08 Hrs]

Unit 02: Wind turbines types
Vertical Axis Type, Horizontal Axis, Constant Speed Constant Frequency, Variable speed Variable Frequency, Up Wind, Down Wind, Stall Control , Pitch Control, Gear Coupled Generator type, Direct Generator Drive /PMG/Rotor Excited Sync Generator [08 Hrs]

Wind Turbine Technology & Components
1) Gear Coupled Generator Type [Constant Speed] 2) Direct Coupled Generator Type [Variable Speed Variable Frequency. Doubly Fed Induction Generator and Power Control [08 Hrs]

Unit 3: Modern Wind Turbine Control & Monitoring System

Details of Pitch System & Control Algorithms, Protections used & Safety Consideration in Wind turbines, Wind Turbine Monitoring with Error codes, SCADA & Databases: Remote Monitoring and Generation Reports, Operation & Maintenance for Product Life Cycle, Balancing technique (Rotor & Blade), FACTS control & LVRT & New trends for new Grid Codes. [08 Hrs]

Unit 04: SOLAR CELL FUNDAMENTALS

Photovoltaic effect - Principle of direct solar energy conversion into electricity in a solar cell. Semiconductor properties, energy levels, basic equations. Solar cell, p-n junction, structure. I-V characteristics of a PV module, maximum power point, cell efficiency, fill factor, effect of irradiation and temperature. [08 Hrs]

Unit 05: CLASSIFICATION OF PV SYSTEMS AND COMPONENTS

Classification - Central Power Station System, Distributed PV System, Stand alone PV system, grid Interactive PV System, small system for consumer applications, hybrid solar PV system, concentrator solar photovoltaic. System components - PV arrays, inverters, batteries, charge controls, net power meters. PV array installation, operation, costs, reliability. [08 Hrs]

Unit 06: PV SYSTEM APPLICATIONS

Building-integrated photovoltaic units, grid-interacting central power stations, stand-alone devices for distributed power supply in remote and rural areas, solar cars, aircraft, space solar power satellites. [08 Hrs]

Text Books:

1) Remus Teodorescu, "Grid Converters for Photovoltaic and Wind Power Systems" ,Marco Liserre

2) Renewable and Efficient Electric Power Systems - G. M. Masters

Reference Books:

1) Michael Boxwell, "Solar Electricity Handbook - 2015 Edition"

2) Krauter, Stefan C. W. , "Solar Electric Power Generation - Photovoltaic Energy Systems" Springer Pub.

3) Heinrich Haberlin,"Photovoltaics System Design and Practice by Wiley Pub.

4) A. K. Mukerjee,Nivedita Thakur, "Photovoltaics System Analysis And Design", PHI LEARNING

5) Bin Wu, Yongqiang Lang, NavidZargari, Samir Kouro, " Power Conversion and Control of Wind Energy Systems", IEEE – Wiley Pub

6) Tony Burton, Nick Jenkins, David Sharpe, Ervin Bossanyi, "Wind Energy Handbook, 2nd Edition" Wiley Pub

7) Sathyajith, Mathew, "Wind Energy . Fundamentals, Resource Analysis and Economics",Spinger Pub

503305 M2(i) -ELECTIVE-I -Module 2:PROJECT MANAGEMENT

Teaching Scheme
Lectures: 1 Hr/Week
Credit: 1

Examination Scheme
In-Semester Examination: 25 Marks

Course Outcome:
At the end of this course student is able to
CO1: Prepare the project scheduling using different techniques and able to plan, manage and control the project quality.
CO2: Measure, assess and manage the project risk with the help of different techniques.

Unit 1
Project Scheduling: Gantt chart and its application, AOA (Activity on Arrow diagram), AON (Activity on Node) Diagram, Precedence diagramming methods (PDM), Critical Path Method (CPM), Programme Evaluation and Review Technique (PERT), GERT (Graphical Evaluation and Review Technique), Resource allocation, Line of Balancing and crashing the network.
Project Quality Management: The processes of project quality management, Quality planning, assurance and control, Quality of procured items, Techniques of quality assurance and control, project execution and control, International Project Management. (9Hrs)

Unit 2
Project Risk Management: Introduction, Managing risks in projects, Measurement and assessment of risk, Sources of risks. Risk: - Adjusted discount rate method, certainly equivalent method, correlation coefficient, portfolio risks, diversible& non-diversible risks, CAPM (Capital Asset pricing model) case studies of project management, computer aided project management. (5Hrs)

Text Books:
1. K. Nagarajan, "Project Management", 5th Edition, New Age International Publishers, 2010.
2. Prasanna Chandra, "Projects: planning, analysis, selection, implementation and review", 4th Edition, Tata McGraw Hill Publishing Co. Ltd, New Delhi, 1995.
3. Rosy Burke, "Project Management: planning and control technique", Wiley India, 2003
4. S. Chaudhary, "Project Management", Tata McGraw Hill, 1988.

Reference Books:
1. J. R. Meredith, S. J. Mantel, "Project Management: A managerial approach", Wiley India, 2010
2. John M. Nicholas, Herman Steyn, "Project Management", 3rd Edition, Elsevier Inc., 2008
3. Samuel Mantel, Jr. J. R. Meredith, S. M. Scafer, M. M. Sutton, M. R. Copalan, "Project Management" 1st Edition, 2011

503305 M2(ii) -ELECTIVE-I -Module 2: IPR AND PATENT LAW

Teaching Scheme
Lectures: 1 Hr/Week
Credit: 1

Examination Scheme
In-Semester Examination : 25 Marks

Course Outcome:
At the end of this course student is able to

CO1: Define intellectual property and distinguish between different types of IPR with legal requirements.
CO2: Describe laws of IPR in different countries and international.

Unit1:
Intellectual property, History, Types(Seven types of Intellectual Property Right**s**) viz.
Patent, Industrial Designs, Trademark, Copyright, Geographical Indication, Integrated Circuit Layout, Trade Secrets.
Patents and standards: History of patent law, History of Indian Patent System, Utility model Procedures: Patent application, Patent infringement and enforcement, Patent licensing, Patent prosecution. Criteria of patentability, Rights granted for IP owners. Legal requirements: Patentable subject matter, Novelty, Utility (patent), Inventive step and nonobviousness, Industrial applicability, Person skilled in the art, Prior art, Inventor ship, Sufficiency of disclosure, Unity of invention**,** Intellectual property brokering, Intellectual property education, Intellectual property infringement, Intellectual property valuation**.** (7 Hrs)

Unit:2
CEN and CENELEC Patent Policy, CEN-CENELEC Guidelines for Implementation of the Common IPR Policy on Patents, Declaration of patents. Copyright: CEN-CENELEC copyright policy, piracy. Industrial design rights Trademarks: Geographical indication, Protected designation of origin, Trade dress. Other types**:** Database right, Fashion law, Indigenous intellectual property, Industrial design rights (or registered designs), Intellectual rights to magic methods, Internet domain name, Know how, Mask work (or Integrated circuit layout design protection), Open-source software, Orphan drug rights, Personality rights, Plant breeders' rights Patent law by region or country: Indian patent law, Australian patent law, Canadian patent law, Patent law of the People's Republic of China, European patent law, Japanese patent law, United States patent law.
(7 Hrs)

Text Books:
1) Intellectual Property Rights – Prabuddha Ganguli, Tata McGraw Hill publishing Company Ltd.
2) Satarkar S.V., Intellectual Property Rights and Copy Right. ESS Publications.

References:
www.cen.eu
www.cenelec.eu
www.cencenelec.eu

http://ipindia.nic.in/
http://ipindia.nic.in/ipr/patent/patents.htm
http://www.ipaustralia.gov.au/ (Australian Intellectual property)
http://guides.slv.vic.gov.au/
http://www.cipo.ic.gc.ca (Canadian patent office)
http://www.epo.org(Europian patent office)
http://www.academicleadership.org/emprical_research/The_State_of_Intellectual_Property_Education_Worldwide.shtml (Intellectual property education)

503305 M2(iii) -ELECTIVE-I -Module 2: TECHNICAL COMMUNICATION

Teaching Scheme
Lectures: 1 Hr/Week
Credit: 1

Examination Scheme
In-Semester Examination : 25 Marks

Course Outcome:
At the end of this course student is able to
CO1:Design effective technical presentation and communicate it in verbal and written form.
CO2: Write technical report and paper in typesetting software LATEX.

Unit 1
Effective Presentation Strategies
Define the purpose of presentation, Analyzing audience and locale, organizing contents, Preparing an Outline, Visual Aids, Understanding the nuance of delivery, sample speech and practice the presentation. [3Hrs]
Listening techniques
Types of listening, listening with a purpose, barriers to listening, listening comprehension, effective listening strategies, listening in conversational interaction, team listening. [2Hrs]
Speech techniques
Conversation and oral skills, strategies for good conversation, techniques to develop effective word accent, word stress, primary and secondary stress, use of correct stress pattern, developing voice quality, developing correct tone. [2Hrs]

Unit 2:
Writing technical reports, research papers, dissertation, thesis and research proposals. Important parts of reports like abstract, results, conclusion. Supplementary parts like list of symbols, list of tables, annexure, references etc. Making title page, writing mathematical equations, including graphics, making tables and writing references using LaTex/ MiKTeX.
Assignment for one technical proposal, one research paper and one technical report should be submitted using LaTex/MikTeX for in semester assessment. [7 Hrs]

Reference books:
1) Technical Communication-Principals and Practice, Meenakshi Raman, Sangeeta Sharma, OXFORD university Press.
2) Effective Technical Communication, M Ashraf Rizvi, TATA McGRAW HILL
3) Leslie Lamport, ' Latex: A document preparation system' Addison Wesley, Reading, Massachusetts, second edition, 1994, ISBN 0-201-52983-1.

503305 M2(iv) -ELECTIVE-I -Module 2:SMART GRID TECHNOLOGIES

Teaching Scheme
Lectures: 1 Hr/Week
Credit: 1

Examination Scheme
In-Semester Examination : 25 Marks

Course Outcome:
At the end of this course student is able to
CO1:Draw and describe detail block diagram of phasor measurement unit and its applications
CO2: Apply wide area measurement system with the help of different standard in power system.

Unit 1
Need of Synchrophasor Measurements, Phasor Measurement Unit : Architecture, Functions, Optimal Placement of PMUs, phasor data concentrators and associated communication system. Visualization tools to enhance visibility and control within transmission system, PMU measurements and sampling rates State Estimation & observability by using PMU, phasor data use for real time operation, frequency stability monitoring and trending, power oscillation, voltage monitoring and trending. Alarming and setting system operating limits. Dynamic line rating and congestion management, outage restoration. Application of PMU for wide area monitoring and control. [9Hrs]

Unit 2
WAMS (Wide Area Measurement system): Architecture, Components of WAMS, GUI (Graphical User Interface), Applications: Voltage Stability Assessment, Frequency stability Assessment, Power Oscillation Assessment, Communication needs of WAMS, WAMPAC (Wide Area Monitoring Protection & Control), RAS (Remedial Action Scheme). Standards: IEEE 1344, IEEE C37.118 (2005), IEEE Standard C37.111-1999 (COMTRADE), IEC61850 GOOSE.
[5Hrs]

Text Books:
1. “Synchronized Phasor Measurements and Their Applications”, Arun G. Phadke, J.S. Thorp, Springer Publication.
2. “Event detection and visualization based on phasor measurement units for improved situational awareness”, Joseph Euzebe Tate, UMI Dissertation Publishing.
3. “Wide Area Monitoring, Protection and Control: The Gateway to Smart Grids”, Fahd Hashiesh, M. M. Mansour ,Hossam E. Mostafa Fahd Hashiesh , M. M. Mansour, Hossam E. Mostafa.

Reference Books:
1. “Power System State Estimation”, Mukhtar Ahmad
2. “Computer Relaying for Power Systems”, Dr. Arun G. Phadke, Dr. James S. Thorp, Wiley Publication, Second Edition.
3. “SMART GRID Infrastructure & Networking”, KRZYSZTOF INIEWSKI, TATA McGRAW HILL EDITION.

503306: LAB PRACTICE - I

Teaching Scheme
4 Hrs / Week
Credits : 4

Examination Scheme
TW : 50 Marks
Oral.: 50 Marks

A minimum of Ten experiments should be performed under Lab Practice – I. Out of which minimum six experiments should be from the list below. Minimum six experiments should be based on compulsory subjects. A list of experiments that may be performed under various subjects of semester - I is given below as a guideline:

List of Experiments

1. Modelling and simulation of three phase Induction machine and to study the dynamic behavior of the machine for change in load torque.
2. Modelling and simulation of separately excited DC motor and to study the dynamic behaviour of the machine for change in load torque.
3. Analysis of harmonics of three phase Induction motor.
4. Analyse THD in inverter output using Harmonic analyser.
5. To study the harmonic analysis of CFL, electronic fan regulator, electronic choke of tube, computer and remedy for the same.
6. Simulation & analysis of three phase converters with RLE load.
7. Simulation & analysis of Buck/Boost converters with RLE load.
8. Simulation & analysis of three phase PWM inverter with RLE load.
9. FFT analysis of three phase converter.
10. Design, Simulation and Performance analysis of IIR Butterworth filter.
11. Design, Simulation and Performance analysis of FIR filter by Rectangular window method.
12. Signature analysis of induction motor current.
13. Modelling and performance analysis of solar photovoltaic system.
14. Modelling and performance analysis of wind turbine.

Semester II

503307: AC AND DC DRIVES

Teaching Scheme:
4 Hours / Week
Credits: 4

Examination Scheme
In Semester Assessment: 50Marks
End Semester Assessment: 50Marks

Course Objectives

1. To learn the fundamentals of the drives, it's four quadrant operation and motor load characteristics.-
2. To evaluate performance parameters of single phase and three phase converter fed DC drives.-
3. To evaluate performance parameters of chopper fed DC drives operating in different quadrants.-
4. To describe VSI and CSI fed Induction motor drives, it's steady state performance and speed control techniques.-
5. To understand the direct and indirect vector control methods of Induction motor drives.-
6. To gain the knowledge of various special drives.

Course Outcomes

At the end of this course students should be able to,

CO1. Specify the fundamentals of drives it's four quadrant operation and motor load characteristics.

CO2. Analyze performance parameters of single phase and three phase converter fed DC drives.

CO3. Analyze performance parameters of chopper fed DC drives operating in different quadrants

CO4. Describe VSI and CSI fed Induction motor drives, it's steady state performance and speed control techniques.

CO5. Explain the direct and indirect vector control methods of Induction motor drives and illustrate knowledge of various special drives.

Unit I:Review of Electric drive:

Fundamentals, Four quadrants operation of electric drives, types of industrial loads and matching of drive characteristics, motor duty, heating and cooling, review of converters topologies of motor drives. (08 Hrs)

Unit II: Converter fed DC Drives:

Analysis of series and separately excited DC motor with single phase and three phase converters operating in different modes and configurations - Evaluation of performance parameters, calculation of harmonic torque pulsation. (08 Hrs)

Unit III.Chopperfed DC Drives:

Steady state analysis of series and separately excited DC motor with choppers operating in different quadrants - Evaluation of performance parameters, calculation of pulsating torque. (08 Hrs)

Unit IV:Inverter fed AC Drives:

Static frequency changes. VSI driven Induction motor, Torque Pulsations and drive performance. Steady state evaluation of six steps CSI fed drive system.

Static Kramer's drive- phasor diagram, AC equivalent circuit, torque expression, harmonics and speed control of Kramer drive. (08 Hrs)

Unit V:Vector Controlled Induction Motor Drives:

Principle of field oriented control and DC motor analogy, Direct vector control: flux vector estimation. Indirect vector control.
Sensor less vector control: speed vector estimation (08 Hrs)

Unit VI:.Special Drives

Brushless DC motor, stepper motor and PMDC motor drives, control strategies, torque generation and performance characteristics. (08 Hrs)

Text Books

1. Bimal K Bosei, "Modern Power Electronics and AC Drives" IEEE Press, Low price edition, Pearson Education asia, Inc.
2. GopalK.Dubey, "Fundamentals of Electric Drives", Narosa Publications.

Reference Books

1.R. Krishnan, "Electric Motor Drives Modeling, Analysis and control" PHI Learning Pvt. Ltd.

2.Sen, P.C. "Thyristor DC Drives", John Wiley & sons, New York.

3.Pillai, S.K. "Analysis of Thyristor Power Conditioned Motors", University Press.

4.Peter Vas, "Vector control of Ac machines", Oxford University Press.

5.Leonard, W, "Control of Electric Drives", Springer Verlag.

503308: POWER CONVERTERS - II

Teaching Scheme
4 Hours / Week
Credits : 4

Examination Scheme
In Semester Assessment: 50
End Semester Assessment: 50

Course Objective:
The student will be able to understand

1. Different Inverter control techniques
2. Advance converters like Resonant Converters, multilevel inverters
3. Concept of SMPS and its detailed analysis
4. Different Protections required in power converters

Course Outcome

At the end of course student will be able to

CO1.Use different converters in given application

CO2. Use different control techniques for power converters

CO3. Develop a good insight about the practical issues in power electronics circuit design.

CO4. Gain skills to understand operational issues and limitations of practical converters.

Unit I: PWM Inverters:

Voltage Control of single phase and three phase Inverter: Sinusoidal Pulse Width Modulation, Modified SPWM, Phase displacement control, Space Vector PWM, Comparison of PWM Techniques (08 Hrs)

Unit II: Multilevel Inverters:

Introduction, Concept of Multilevel, Types of Multilevel inverter: Diode Clamped, Cascaded, Flying Capacitor. Application of Multilevel inverter (08 Hrs)

Unit III: Resonant Converters:

Concept of basic resonant circuit, Classification and Analysis of ZVS and ZCS , Advantages , Applications (08 Hrs)

Unit IV: Switch Mode Power Supply

Introduction, Linear power supplies, Overview of Switching power supplies, DC-DC (08

Converters with electrical isolation, Control of Switch mode power supplies, Power supply protection. Design of SMPS (Hrs)

Unit V: Thermal Design

Thermal modelling of power switching devices, Electrical equivalent thermal model, Heat sink design, Selection of Heat Sink. (08 Hrs)

Unit VI:

A) **Magnetic design:**Specific inductor design and procedure
B) **Snubber circuit:** Need of Snubber circuit , Types of Snubber circuits: Turn-ON snubber Turn-OFFsnubber and over voltage Snubber (08 Hrs)

Text Books:

1. Ned Mohan, Undeland, Robbins, “Power Electronics: Converters, Design and Applications”, WILEY India Edition
2. Rashid M.H ,"Power Electronics Circuits, Devices and Applications ", Prentice Hall India,

Reference Books:

1. B.W.Williams, “Power Electronics: Devices, Drivers, Applications and Passive components”, McGraw-Hill.
2. Robert W.Erickson, Dragan Maksimovic, “Fundamentals of Power Electronics”, Springer,2nd Edition, ,
3. Keith Billings, “Switch mode Power Supply Handbook” , Taylor Morey McGraw-Hill.

503309: ADVANCED CONTROL SYSTEMS

Teaching Scheme	**Examination Scheme**
4 Hours / Week	In Semester Assessment: 50
Credits : 4	End Semester Assessment: 50

Course Objectives:

The students will be able to understand

1. the design of different controllers
2. nonlinear control method: Sliding Mode Control and design a controller
3. Widely used observers like Sliding Mode observer and Nonlinear Extended state observer
4. application of SMC to converters
5. different stability concepts in the context of linear and nonlinear systems
6. nonlinear controller design

Course Outcomes:

The students will be able to

CO1. Design and implement controllers like PID, Pole placement, LQR, Feedback Linearization, Sliding
mode control.

CO2. Design and implement observer based control laws.

CO3.Apply sliding mode control to power converters.

Unit I: Classical and Modern Control

PID Control, Tuning methods (Ziegler Nichols, Cohen Coon), State space method, analysis and design of control systems in state space , pole placement (3 methods) Luenberger observer, Design of control system with Luenberger observer Introduction to optimal control problems, design of control system with LQR controller . (08Hrs)

Unit II:Sliding Mode Control

Concept of Sliding mode Control, chattering, chattering attenuation, concept of equivalent control, sliding mode equation, sliding surface design, regular form. (08Hrs)

Unit III: State and Disturbance Observers

Evolution of state and disturbance observers a brief history

A) Sliding Mode Observers: mathematical model of observer, procedure for gain selection, error analysis, application to real life system and stability, advantages and limitations

B) Nonlinear Extended State Observer: mathematical model of observer, nonlinear gain selection, Linear ESO, error analysis, application to real life system and stability, advantages and limitations.

(08 Hrs)

Unit IV- Application of Sliding Mode Control to Power Converters

DC/DC Converters, Direct sliding mode control, Buck-type DC/DC converter, Boost type DC/DC converter,Observer-based control: Observer based control of Buck converters, Observer-based control of boost converters. (08 Hrs)

Unit V: Non-linear Control

Nonlinear systems and equilibrium points, Linearization and local stability, Lyapunov stability criterion, Methods of constructing Lyapunov's functions for Nonlinear systems: Krasovskii, Variable gradient Method. (08Hrs)

Unit VI: Nonlinear Control System Design

Feedback linearization, Input-Output Linearization: Generating a linear Input-Output relation, Normal Form, Zero dynamics, Input-State Linearization. (08 Hrs)

Text Books:

1**.** Katsuhiko Ogata, "Modern Control Engineering'',Prentice Hall India, 5th edition 2010.

2. I.J.Nagrath and M.Gopal ,"Control Systems Engineering".New Age International Publishers Sixth edition ,

3. Jean-Jacques E. Slotine, "Applied Non Linear Control", Prentice Hall Englewood Cliffs, New Jersey.

4. Shtessel, Edwards, L. Fridman, A. Levant ,"Sliding Mode Control and Observation" , Publisher-Springer.

5. VadimUtkin, J. Guldner, J. Shi, , "Sliding Mode Control for Electromechanical systems", Taylor and Francis 1999.

Reference Books:

1.Sarah K. Spurgeon , "Sliding-mode Control: Theory and applications" , Taylor & Francis, 1998

2. IEEE Papers for observers

503310: (ELECTIVE- II)

CODE	TEACHING SCHEME	EXAMINATION SCHEME					CREDITS
		Paper		TW	Oral / Presentation	Total	
503310	Lect/week	In semester Assessment	End Semester Assessment				
	5	50	50	-	-	100	5

Code No.	Modules of 4 credit (Select any one)	Code No.	Modules of 1 credit (Select any one)
503310 M1(i)	Industrial drives And Automation	503310 M2(i)	Electric Vehicles
503310 M1(ii)	Embedded systems	503310 M2(ii)	Fundamentals of Cyber Security
503310 M1(iii)	FACTS	503310 M2(iii)	Disaster Management
-	-	503310 M2(iv)	Communication protocols in SCADA System

503310 M1 (I) :ELECTIVE-II-MODULE1: INDUSTRIAL DRIVES AND AUTOMATION

Teaching Scheme
Lectures: 4 Hrs./Week
Credits : 4

Examination Scheme
In-Semester Examination : 25 Marks
End Semester Examination:50 Marks

Course Objective: The students will be able to understand

1. To learn the fundamentals of the drives and analyzeit's stability.

2. To enable the students to understand the multi quadrant operation of drives and modern control techniques used in it

3. To understand the mathematical knowledge of induction motor drive, speed control techniques and analyze it's stability.

4. To gain the knowledge of various automation tools and sensors, PLC and communication protocols.

5. To describe various industrial applications of drives and recent trends in it.

Course Outcome:
At the end of this course students will be able to

CO1. Specify the fundamentals of drives and describe multiquadrant operation the the drive.

CO2. Analyze steady state and transient stability of DC motor and induction motor drives.

CO3. Describe braking and speed control techniques used in DC motor and Induction motor drives.

CO4. Explain ion tools, sensors, PLC and communication protocols.

CO5. Illustrate industrial applications of drives and recent trends in it.

Unit I: Introduction
Definition, Types of loads, steady state & transient stability of Drive, state of art of power electronics and drives, selection of motor rating. (06Hrs)

Unit II D.C. Drives
Review of braking and speed control of D.C. motors, multi-quadrant operation,
Mathematical modeling of dc drives, stability analysis, modern control techniques:
variable structure, adaptive control. (08Hrs)

Unit III: Induction Motor Drives

Review of braking and speed control of induction motor drives: constant V/F, controlled voltage, controlled current, Mathematical modeling of induction motor drives, transient response and stability analysis (08Hrs)

Unit IV:

Introduction, various components of automation, different sensors used in automation Introduction to automation tools:PLC, DCS, HMI, SCADA, Hybrid DCS/PLC. Benefits of automation (08Hrs)

Unit V:

Programmable Logic Controllers: Introduction of Advanced PLC programming, Selection of PLC Input/output modules, Interfacing of Input/output devices, Types of communication interface, Communication Protocols, Control, study of SCADA, PLC SCADA Interfacing. (10Hrs)

Unit VI:

Industrial application of automation, sensor less vector control and DTC drive, Recent trends in automation and case studies. (08Hrs)

Text Books:

1. Dubey G.K. “Power Semiconductor Controlled Drive”, Prentice Hall, New Jersey
2. Sen P.C., “Thyristor Controlled DC Drives”, Wiley, New York
3. Gary Dunning, “Introduction to Programmable logic Controllers”, Delmar Publisher
4. Webb & Reis, “Programmable logic Controllers”, Prentice Hall of India

References:

1. Bose B.K., “Power Electronics and AC Drives”, Prentice Hall, New Jersey
2. Bose B.K., “Power Electronics and Variable Frequency Drives-Technology and applications”, IEEE Press
3. Murphy J.M.D. and Turnbull F.G., “Power Electronics Control of AC Motors”, Franklin Book
4.”Microcontroller control of drives”, IEEE Press.
5. Installation and user manuals of different DCS, PLC Vendors.

503310 M1 (ii) :ELECTIVE-II-Module1:EMBEDDED SYSTEMS

Teaching Scheme
Lectures: 4 Hrs./Week
Credits : 4

Examination Scheme
In-Semester Examination : 25 Marks
End Semester Examination:50 Marks

Course Objectives The students will be able
1. To have knowledge about the basic working of a AVR microcontroller system and its programming in assembly language.
2. To provide experience to integrate hardware and software for AVR microcontroller applications systems.

Course Outcomes The students will be able to understand
CO1.To acquire knowledge about AVR microcontrollers and their applications.
CO2. Foster ability to understand the internal architecture and interfacing of different peripheral devices with AVR Microcontrollers.
CO3. Foster ability to write the programs for AVR microcontroller.
CO4. Foster ability to understand the role of embedded systems in industry.
CO5. Foster ability to understand the design concept of embedded systems.

Unit I: Introduction to Embedded System
An embedded system, processor, hardware unit, soft ware embedded into a system, Example of an embedded system, Real time and embedded OS. Structural unit in a processor selection for embedded systems. (08Hrs)

Unit II
AVR system - AVR family processors, Architecture, Addressing modes, Instruction overview, Branch, Call, and Time Delay Loop, AVR I/O Port Programming. (08Hrs)

Unit III
AVR Programming in C,Timer Programming, Interrupt Programming. (08Hrs)

Unit IV
AVR LCD and Keyboard Interfacing, ADC, DAC, and different Sensor Interfacing, Relay, Opt isolator interface. (08Hrs)

Unit V
Stepper Motor Interfacing, Servo motor interfacing, PWM Programming, RTC, PC interface, data acquisition system. (08Hrs)

Unit VI

Case studies

DC motor control, Induction Motor control (VSI and CSI fed) , UPS Applications , Special Machine control (PMBLDC). (08Hrs)

Text Books:

1. M A Mazidi, S Naimi “AVR Microcontroller and Embedded Systems: Using Assembly and C“
2. Rajkamal “Embedded System Architecture: Programming & Design”, TMH Edition, 2007.
3. J. W. Valvano “ Embedded Microcomputer System: Real time interfacing”, Cengage-Engineering, 1st Edition, 2000.

Reference Books:

1. Jane W.S. Liu, “Real Time Systems”, Prentice Hall, 2000.
2. David E. Simon, “An Embedded Software Primer”, Pearson Education, 1999.

503310 M1 (iii) :ELECTIVE-II-Module1: FACTS

Teaching Scheme	**Examination Scheme**
4 Hours / Week	In Semester Assessment: 25 Marks
Credits: 4	End Semester Assessment: 50 Marks

Course Objectives

1. To understand the steady state and dynamic problems in AC systems-
2. To learn static shunt, series, combined and special purpose compensator for power system performance improvement-

Course Outcomes: After successful completion of this course students will

CO1. Apply the knowledge of FACTS for power system performance improvement.

CO2. Apply the knowledge of Compensators and controllers for power system performance improvement.

UnitI-FACTS Concept

Steady state and dynamic problems in AC systems, Transmission interconnections, Flow of power in an AC system, Loading capability, Power flow and dynamic stability considerations of a transmission interconnection, Relative importance of controllable parameters, Basic types of FACTS controllers-brief description and definitions, Fundamentals of Voltage-Sourced Converters and Current-Sourced Converters, Benefits from FACTS technology. (08 Hrs)

Unit II -Static Shunt Compensator

Objectives of shunt compensation, Methods of controllable Var generation- Variable impedance type static Var generators - TCR, TSR, TSC, FC-TCR, Switching converter type Shunt Var generators - STATCOM. (08 Hrs)

Unit III-Static Series compensators

Objectives of series compensation- Variable impedance type seriesCompensation-TSSC and TCSC, Basic operating control schemes for TSSC and TCSC, Switching converter type series compensators - SSSC, Transmitted power versus transmission angle characteristic- (08 Hrs)

Unit IV-Static Voltage and Phase angle regulator

Objectives of voltage and phase angle regulators, Approaches to TCVR and TCPAR, Switching converter based voltage and phase angle regulators (08 Hrs)

Unit V- UPFC and IPFC

UPFC – Basic operating principles, Conventional transmission control capabilities, Independent real and reactive power flow control

IPFC –Basic operating principles and characteristic, Control structure (08 Hrs)

Unit VI Special purpose FACTS Controller

Compensating single phase loads using DSTATCOM, Series compensation of power distribution system using DVR, Rectifier supported DVR, DC Capacitor supported DVR(Fundamental Frequency series compensator characteristic), Thyristor-Controlled Braking Resistor (08 Hrs)

Text Books

1-NarainHingorani, “Understanding FACTS- Concepts and Technology of Flexible AC Transmission Systems” IEEE Press, A John Wiley and Sons, Inc., Publication

Reference Books

1-R. Mohan Mathur, Rajiv K. Varma, “Thyristor based FACTs controller for Electrical transmission system”, John Wiley & Sons Inc

2-J. Arrilaga, Y.H.Liu and N.R.Watson, “Flexible Power Transmission The HVDC Options”, John Wiley and sons Ltd., New York

3-Yong Hua Song & Allan T Johns, “Flexible ac transmission systems(FACTS), Published by The Institution of Electrical Engineers, London

4-K.R.Padiyar, “FACTS controllers in transmission and Distribution” New Age Publications, New Delhi

503310 M2 (i):ELECTIVE-II-Module2 : ELECTRIC VEHICLES

Teaching Scheme **Examination Scheme**

Lectures: 1 Hr/Week In-Semester Examination : 25 Marks

Credit: 1

Course Outcome:

At the end of this course student will be able to

CO1:Distinguish between different configuration of electric vehicles with merits and demerits.
CO2: Recommend drive for EV applications with suitable energy storage technology.

Unit 1

History and development of on-road Electric Vehicles (EV). Different configurations of hybrid EVs with block diagram representation, merits & demerits of different configurations in view of vehicle efficiency and energy storage system. [7 Hrs]

Unit 2

Energy storage systems – Basics of EV batteries, specifications, power density, Energy density, Charging &Discharging cycle and recommended methodologies for charging. Recommended drives for EV and converter topology used in EVs. [7 Hrs]

Reference books:

1. Ron Hodkinson & John Fenton, Light Weight Electric/ Hybrid Vehicle design, Butterworth Publications, Heinemann
2. H. A. Kiehne, Battery Technology Handbook, MARCEDLE KKEIRN,C
3. Sandeep Dhameja , Electric vehicle battery systems , Butterworth–Heinemann

503310 M2 (ii):ELECTIVE-II-Module2: FUNDAMENTALS OF CYBER SECURITY

Teaching Scheme
Lectures: 1 Hr/Week
Credit : 1

Examination Scheme
Semester Examination : 25 Marks

Course Outcome:
At the end of this course student is able to

CO1: Be familiar with information security awareness, a clear understanding of its importance, network security threats and countermeasures
CO2: Master fundamentals of secret and public cryptography using different security models.

Unit 1:
Introduction cyber security
Ethics and Law, What is a Cyber Crime / Social Theories, Computer Security: Then and Now, Computer System Security / Access Controls, Intrusion Detection: An Overview, Malicious Software Use and Detection [4 Hrs]
Security principles, threats and attack techniques: Introduction to security, Information security, Security triad: Confidential, Integrity, Availability, Focus of control, Security threats and attacks, Security management **[**2 Hrs**]**
Authentication and access control: Identification, Authentication, Authentication by passwords, Protecting passwords, Access control structures, Types of access control **[**2 Hrs**]**

Unit 2:
Lattice and reference monitors: Security levels and categories, Lattice diagram, Reference monitors, Security kernel, Hardware security features, protecting memory **[**2 Hrs**]**
Security models: Bell-LaPadula, Biba, Non-deducibility, Non-interference, Other models **[**2 Hrs**]**
Cryptography: Cryptographic mechanisms, Digital signatures, Encryption, Certificates **[**2 Hrs**]**

Reference Books:
1. Dieter Gollmann, “Computer Security”, 2nd ed., John Wiley & Sons, 2006 ISBN: 0-470-86293-9
2. Rick Lehtinen and G.T. Gangemi, “Computer Security Basics”, O'Reilly Media, Inc., 2nd 2006 ISBN: 10: 0596006691

WEBSITES:
1) www.cert.org
2) www.microsoft.com/security/
3) www.sans.org
4) www.us.cert.gov

503310 M2 (iii) :-ELECTIVE-II-Module2 : DISASTER MANAGEMENT

Teaching Scheme
Lectures: 1 Hr/Week
Credit: 1

Examination Scheme
In-Semester Examination : 25 Marks

At the end of this course student will be able to

CO1:Get knowledge about various disasters
CO2: Make plan for relief and strategies of disaster management

Unit 1 Disaster, Hazards and Vulnerability
Concept of disaster, different approaches, concept of risk, levels of disasters Disaster phenomena and events, Natural and man-made hazards; response time, frequency and forewarning levels of different hazards, Characteristics and damage potential of natural hazards; hazard assessment , dimensions of vulnerability factors; vulnerability assessment, Vulnerability and disaster risk, Vulnerabilities to flood and earthquake hazards. [7 Hrs]

Unit 2 Disaster management mechanism and Planning
Concepts of risk management and crisis management, Disaster management cycle Response and Recovery, Development, Prevention, Mitigation and Preparedness Planning for relief, Strategies for disaster management planning , Steps for formulating a disaster risk reduction plan, Disaster management Act and Policy in India, Organizational structure for disaster management in India, Preparation of state and district disaster management plans. [7Hrs]

Students shall submit a detailed case study report on any disaster, prevention and preparedness.

Text books:
1. Alexander, D. Natural Disasters, ULC press Ltd, London, 1993.
2. Carter. W. N., Disaster Management: A Disaster Management Handbook, Asian Development Bank, Bangkok, 1991.
3. Chakrabarty U. K., Industrial Disaster Management and Emergency Response, Asian Books Pvt. Ltd., New Delhi 2007.
4. Disaster Management, Lotus Publications Pvt. Ltd.

Reference Books:
1. Manual on Natural Disaster Management in India, NCDM, New Delhi, 2001.
2. Disaster Management in India, Ministry of Home Affairs, Government of India, New Delhi, 2011.
3. National Policy on Disaster Management, NDMA, New Delhi, 2009.
4. Disaster Management Act. (2005), Ministry of Home Affairs, Government of India, New Delhi, 2005.
5. http://nidm.gov.in/ - National Institute of Disaster Management (NIDM) (Ministry of Home Affairs, Govt. of India) website

503310 M2 (iv) -ELECTIVE-II-Module2: COMMUNICATION PROTOCOLS IN SCADA SYSTEM

Teaching Scheme
Lectures: 1 Hr/
Credit: 1

Examination Scheme
In-Semester Examination : 25 Marks

Course outcome
At the end of this course student will be able to

CO1:Familiar basic structure of SCADA system architecture.
CO2: Describe communication and protocols in SCADA system.

Unit 1
SCADA Systems: Introduction and definitions of SCADA
Basic SCADA system Architecture: Human Machine Interface, Master Terminal Unit, Remote Terminal Unit Communications for SCADA systems, Configuration of SCADA systems, SCADA system applications, SCADA systems in operation and control of interconnected power systems, Functions of SCADA systems, Common features of SCADA systems Automatic substation control, SCADA configuration, Energy management system, system operating states, system security, State estimation. [7 Hrs]

Unit 2
Communication in power systems: Inductive coordination, Voice communication, carrier systems, Power line carrier systems, Microwave systems, co axial cable and optical fiber system, two way mobile radio systems.
The Evolution of SCADA Protocols: Overview of Open systems interconnection (OSI) Model, Functions of OSI Model Layers, OSI Protocols, Functions of Transmission control protocol / Internet protocol (TCP/IP) Layers, TCP/IP protocol, MODBUS model, DNP3 protocol, IEC61850 layered architecture, Control area network, Control and Information Protocol (CIP), DeviceNet, Control Net, EtherNet/IP, Flexible Function Block process (FFB), Process Field bus (Profibus), The Security Implications of the SCADA protocols. [7 Hrs]

Text Books:
1. Ronald L. Krutz, “Securing SCADA System”, Wiley Publication.
2. Sunil S. Rao, “Switchgear and Protections”, Khanna Publication.
3. Robert Miller, James Malinowski “Power System Operation”, McGraw-Hill, Inc.

Reference Books:
1. Gordan Clark, Deem Reynders, “Practical Modem SCADA Protocols”
2. Stuart A Boyer, “SCADA supervisory control and data acquisition” International Society of Automation, North Carolina, 4th Edition.

503311: LAB PRACTICE II

Teaching Scheme
4 Hrs / Week
Credits : 4

Examination Scheme
Term Work : 50 Marks
Oral.: 50 Marks

A minimum of Ten experiments should be performed under Lab Practice – II. Out of which minimum six experiments should be from the list below. Minimum six experiments should be based on compulsory subjects. A list of experiments that may be performed under various subjects of semester -II is given below as a guideline:

List of Experiments

1. Modeling and simulation of Chopper fed DC drive.
2. Study of the performance characteristics of vector controlled three phase Induction motor.
3. Study of performance characteristics of BLDC motor drive.
4. To study the performance characteristics of Switched Reluctance motor.
5. Simulation of three phase voltage regulator.
6. Design and analysis of snubber circuit.
7. Design of heat sink.
8. To develop AVR based data acquisition system.
9. To develop AVR based speed and direction control of any two types of motors (AC or DC)
10. To develop AVR based variable DC supply.
11. Design of Luenberger observer for DC motor drive.
12. State feedback control using Input-Output linearization.
13. Design and simulation of finite time Linear Quadratic Regulator (LQR).
14. Design and simulation of sliding mode control for double integrating system.
15. Analysis of closed loop control of converter based system.

503312 : SEMINAR – I

Teaching Scheme	Examination Scheme
4 Hrs/Week	Term Work: 50 Marks
Credits: 4	Oral/Presentation : 50Marks

Seminar I **s**hall be on the state of the art topic of student's own choice based on relevant specialization approved by an authority. Topic should cover the advancement on the technology under specialization. The content of seminar report may include basic theory, concept, schematics, models, methods, economics, merits, demerits etc. relevant to the selected topic of seminar. A student should study sufficient number of papers from referred journals related to the topic in consultation with the guide. A guide should maintain weekly record of discussion related to the topic. The student shall submit the seminar report in standard format, duly certified by the concerned Guide and Head of the department/institute for satisfactory completion of the work.

Semester III

603301 SPECIAL APPLICATIONS OF POWER ELECTRONICS

Teaching Scheme
4 Hours / Week
Credits: 4

Examination Scheme
In Semester Assessment: 50
End Semester Assessment: 50

Course Objective:

1. To enable the students to understand the use of power electronics in utility applications.
2. To learn the fundamentals of the smart grid, its purpose and objectives, architectures
3. To gain the knowledge of, issues and challenges that remain to be solved and understand the various aspects of the smart grid, including communication and measurement technologies.
4. To understand role of Internet of Things in smart grid..
5. To introduce objectives, communication technologies and automotive applications of smart cities.
6.To understand the different compensation techniques using FACTS.

Course Outcome: After completion of course students will be able to-

CO1. Specify the need and describe the components of smart grid and smart communication
CO2. Comprehend the implementation of power electronics in utility applications
CO3. Describe concept, definitions, functions and architectures of smart grid, micro grid and distributed energy
generation.
CO4. Explain issues and challenges of interconnection along with various measurement and communication technology
CO5. Explain Internet of Things and devices, its applications for smart grid and smart power transmission.
CO6. Describe concept, objectives of smart cities and communication networks.

Unit I: MTDC system and HVDC light
Multi terminal HVDC system and HVDC light, configuration and types. Introduction to VSC transmission, power transfer characteristics, structure of VSC link. HVDC light technology(08 Hrs)

Unit II: Compensation: Modelling and control of Thyristorised controlled series compensators. Static VAR Compensation – Basic concepts, Thyristor controlled reactor (TCR), Thyristor switched reactor(TSR), Thyristor switched capacitor (08 Hrs)

Unit III: Internet of things
Introduction to Internet of Things (Why? How? and Where?), Role of IoT in smart grid and its application for smart grid power transmission. Sensors and actuators used for signal acquisition and control eg. Smart Metering, power electronics in signal conditioning required for Inter facing sensors to open source hardware. (08 Hrs)

Unit IV:Communication infrastructures for Smart City

Concept and Objectives of smart city, Two-way Digital Communications Paradigm, infrastructures Modern communication networks like Zigbee, Bluetooth, HAN, WLAN , WIMaxetc, Automotive Applications, smart home, smart building, Concept of Cyber security and cloud computing.(08 Hrs)

Unit V: Smart grid applications

Concept of Smart Grid, Definitions, Need of Smart Grid, Functions of Smart Grid,
Micro Grids, Distributed Energy Resources and their interconnection with a hosting grid, integration and interconnection issues and challenges. Wide Area Measurement System (WAMS), Phase Measurement Unit (PMU), (PMU), Application of PMU for wide area monitoring Protection and control(WAMPAC). (08 Hrs)

Unit VI: Utility Applications
Switched Mode Power Supplies, UPS and Battery charging system, applications of Power Electronics in Heating & Welding, Illumination application, Electronic Ballast, AC-DC electric locomotives systems, Hybrid vehicle system (08 Hrs)

Text Book:

1. Synchronized Phasor Measurements and Their Applications, Arun G. Phadke, J.S. Thorp, Springer Publication.

2. The Smart Grid: Enabling energy efficiency and demand response, Clark Gellings: CRC Pres

3. Daniel Minoli, “Building the Internet of Things with IPv6 and MIPv6: The Evolving World of M2M Communications”, ISBN: 978-1-118-47347-4, Willy Publications

Reference Books:.

1. Padiyar K.R; HVDC Transmission Systems, Wiley Eastern Limited, New Delhi, 1990 .
2. Kimbark E.X., “Direct Current Transmission”, Vol. I, Wiley Interscience, NewYork 1971
3. Narain G. Hingorani and L.Gyugi, , Understanding FACTS, IEEE Press, New York.
4. Rashid M.H., "Power Electronics Circuits, Devices and Applications ", Prentice Hall India, Second Edition, New Delhi
5. Ned Mohan,“Power Electronics Converters Applications & Design”, Wiley India.
6. Smart Grid Infrastructure & Networking, Krzysztof Iniewski, Tata Mcgraw hill edition.
7. Smart Cities Technologies, Edited By Ivan Nunes Da Silva &Rogerio Andrade Flauzino, Publisher- InTech.
8. Control and Automation of Electric Power Distribution System (Power Engineering), James Northcote, Green – CRC Press.

603302: ENERGY MANAGEMENT AND POWER QUALITY

Teaching Scheme	**Examination Scheme**
4 Hours / Week	In Semester Assessment: 50
Credits : 4	End Semester Assessment: 50

Course Objectives:
The students will be able to understand:

1. Concept and implementation of energy management in electrical field.
2. Design and analysis of good grounding system.
3. Power quality problems and steps to eliminate / minimise them.

Course Outcomes:
The students will be able to:

CO1. Analyse and represent Power Quality problem data in various form.
CO2. Perform assessment of electrical system and give power quality improvement solutions
CO3. Assess the requirements of good grounding system on site.

Unit I: Electric motors
Energy efficient controls and starting efficiency-Motor Efficiency and Load Analysis- Energy efficient /high efficient Motors-Case study; Load Matching and selection of motors. Variable speed drives; Pumps and Fans-Efficient Control strategies- Optimal selection and sizing -Optimal operation and Storage; Case study. (08Hrs)

Unit II: Grounding
Grounding definitions as per IEEE. Typical Earthing System , Reasons for Grounding. Grounding Problems. Solutions to Wiring and Grounding Problems. Grounding aspects in power electronics circuits. (08 Hrs)

Unit III: Power Quality

Introduction to Power Quality, types of power quality disturbances, Causes and effects of power quality disturbances, Voltage sags and interruptions. (08 Hrs)

Unit IV: Transient over voltages
Sources of transient over voltages, overvoltage protection systems, Ferro resonance management, tools for transient analysis. Causes of harmonics generation, harmonic indices, harmonic sources, effect of harmonic distortion, inter harmonics. (08 Hrs)

Unit V: Harmonics
Harmonic distortion evaluation, controlling harmonic distortion, harmonic filter design case study, voltage regulation devices, voltage flicker, Power quality benchmarking, voltage variation indices, power quality state estimations. (08 Hrs)

Unit VI: Power Quality Monitoring

Monitoring considerations, Power quality measuring equipment, application of intelligent systems, power quality monitoring standards. (08 Hrs)

Text Books:

1. M. H. J. Bollen, "Understanding Power Quality Problems, Voltage Sag & Interruptions", New York: IEEE Press, 2000, Series On Power Engineering
2. R. C. Dugan, Mark F. McGranghan, Surya Santoso, H. Wayne Beaty, "Electrical Power System Quality", 2nd Edition, McGraw Hill Pub.
3. J. Arrillaga, M. R. Watson, S. Chan, "Power System Quality Assessment", John Wiley and Sons

References Books:

1. G. J. Heydt, "Electric Power Quality", Stars in a Circule Publications.
2. EnriquesAcha, Manuel Madrigal, "Power System Harmonics: Computer Modeling & Analysis", John Wiley and Sons Ltd.
3. IEEE Std. 519-1992, IEEE recommended practices and requirements for harmonics control in electrical power system.
4. Donald R. W., Energy Efficiency Manual., Energy Institute Press.
5. Partab H., 'Art and Science of Utilisation of Electrical Energy', DhanpatRai and Sons, New Delhi.
6. TripathyS.C.,'Electric Energy Utilization And Conservation', Tata McGraw Hill.
7. Turner, Wayne C., .Energy Management Handbook., 2nd ed.
8. Lilburn, GA: The Fairmont Press Inc., 1993.
9. UNESCAP-Guide Book on Promotion of Sustainable Energy Consumption.
10. (www.unescap.org/enrd/energy)
11. E.F.Fuchs, M.A.S Masoum" Power quality in Power systems and Electrical Machines", Elsevier, Academic Press.

603303: (ELECTIVE - III)

CODE	TEACHING SCHEME	EXAMINATION SCHEME					CREDITS
		Paper		TW	Oral / Presentation	Total	
603303	Lect/week	In semester Assessment	End Semester Assessment				
	5	50	50	-	-	100	5

Code No.	Modules of 4 credit (Select any one)	Code No.	Modules of 1 credit (Select any one)
603303 M1(i)	Artificial Intelligence Based Electrical drives	603303 M2(i)	Artificial Intelligent tools
603303 M1(ii)	Industrial Automation And Control	603303 M2(ii)	Intelligent Sensors and instrumentation
603303 M1(iii)	Energy Storage Systems	603303 M2(iii)	Human Rights
603303 M1(iv)	High Voltage DC Transmission (HVDC)	603303 M2(iv)	Green building design

603303 M1 (i) : ELECTIVE-III Module 1: ARTIFICIAL INTELLIGENCE BASED ELECTRICAL DRIVES

Teaching Scheme
4 Hours / Week
Credits : 4

Examination Scheme
In Semester Assessment: 25
End Semester Assessment: 50

Course Objectives:
Students will be able to

1. Get knowhow of Artificial Intelligence and expert system matching techniques, memory organization and communication
2. Understand the concepts of Fuzzy logic, AI Programming languages and application of Object Oriented Programming for electric vehicles
3. Understand AI the based DC motor drives,Induction motor drive scope of AI for based DC motor drives

Course Outcomes:
At the end of this course students will be able to

CO1. Develop generic algorithm
CO2. Develop fuzzy logic system for electric vehicles
CO3. Develop AI concept to control different motor drives

Unit I. Electrical drive
Basics of drive and system and control strategies. Closed loop control of dc drives. AC drives: vector drives, direct torque-controlled drives, reluctance motor drives.
Past, present, and future of electrical machines and variable-speed drives. (06 Hrs)

Unit II. Artificial neural networks
ANN fundamentals: Biological neuron model, artificial neuron model, Static and dynamic artificial neuron models.
ANN networks: Adaptive function estimators, weights, Inputs and bias. Activation functions.
Single-layer ANN, Multi-layer ANN, Radial basis function neural network. Various ANNs and training strategies for different applications, Application of the error back propagation algorithm, Nodes, layers. Back propagation training and learning. (08 Hrs)

Unit III. Fuzzy logic systems
Basics of fuzzy logic system: Classical (crisp) set, characteristic function, Fuzzy set, membership function. Fuzzy set operations: Membership function, various membership functions, parameter sets, fuzzy rules and conventional fuzzy set operations. Fuzzy inference systems (fuzzy logic controllers). (08 Hrs)

Unit IV. Genetic algorithms

Potential applications of Genetic algorithms. Genetic algorithm steps, tuning of membership functions using genetic algorithms. Application of genetic algorithms to neural networks, Tuning of controllers using genetic algorithms. (08 Hrs)

Unit V. Artificial-intelligence-based DC motor drives

ANN based speed and torque estimation, Fuzzy-neural based speed estimator for a DC motor. DC drives with ANN speed estimator. DC drive with fuzzy based controllers: Fuzzy based speed controller, armature current controller and flux controller. Design and simulation of fuzzy-neural based DC drive. (08 Hrs)

Unit VI. Artificial-intelligence-based Induction motor drive

ANNs for a slip-ring induction machine: Speed estimation, Stator flux linkage estimation and torque estimation. ANNs for a squirrel-cage induction machine: Speed and position estimation, Simultaneous speed, torque and flux estimation.Fuzzy-neural-network-based steady-state and transient analysis of induction machines. Design and simulation of fuzzy-neural based induction motor drive. (08 Hrs)

Text Books:

1. Peter Vas, "Artificial-Intelligence-based Electrical Machines and Drives" ,Oxford University press, 2010
2. Rajasekaran S. and Pai G.A.V., "Neural Networks, Fuzzy Logic and Genetic Algorithm Synthesis and applications, PHI New Delhi.
3. Kosko B., "Neural Networks & Fuzzy Systems A dynamical systems approach to machine intelligence, Prentice Hall of India.

Reference Books:

1. Goldberg D.E. "Genetic Algorithms in Search Optimization & Machine Learning", Wesley Co., New York.
2. Lin C. and Lee G., "Neural Fuzzy Systems", Prentice Hall International Inc.

603303 M1, (ii) : ELECTIVE-III Module 1: INDUSTRIAL AUTOMATION AND CONTROL

Teaching Scheme
Lectures: 4 Hrs./Week
Credits : 4

Examination Scheme
In-Semester Examination : 25 Marks
End Semester Examination:50 Marks

Course Objectives:
The students will be able to:

1. Explain the function of Industrial Automation in general.
2. Identify types of Industrial Sensors and actuators for different measurements.
3. Know the history of the PLC. Identify Practical Programmable Logic Controller Applications.
4. Recognize fundamentals of Programming including coils, contacts, timers and counters. Logical Program Development, Indentify and categorize Input/Output Modules.
5. Understand and utilize PLC, SCADA and DCS for process control.
6. Identify Safety in Industrial Automation.

Course Outcomes:
Upon completion of this course, the students willbe able to:

CO1. Describe working of various blocks of basic industrial automation system.
CO2.Use of PLC for various applications.
CO3. Learn typical Distributed control system and SCADA system.
CO4. Use various industrial motor drives for the Industrial Automation.

Unit I:Introduction to Industrial Automation and Control
Architecture of Industrial Automation Systems. Introduction to automation tools PLC, DCS, HMI, SCADA. Benefits and inconveniences of automation. (08 Hrs)

Unit II Sensors and Actuators
Introduction to sensors and measurement system.
Sensors: Temperature, pressure, force,displacement, speed, flow, level, humidity and pH measurement.
Actuators: Electrical, Hydraulic and Pneumatic, Process control valves, Introduction of DC and AC servo drives for motion control. (08 Hrs)

Unit III Programmable Logic Controllers
Architecture of PLC,Selection of PLC Input/output modules, Interfacing of Input/output devices, Introduction of PLC programming, Advantage of using PLC for Industrial automation, Application of PLC to process control industries. (08 Hrs)

Unit IV SCADA and Communication Protocols

Architecture of SCADA, PLC SCADA Interfacing. Types of communication interface, Communication Protocols Introduction to Open System Interconnection (OSI) model, Modbus (ASCII/RTU), Functions of Transmission control protocol TCP/IP protocol, DNP3 protocol, IEC61850, Control and Information Protocol (CIP), Device Net, Control Net, Ether Net/IP, Process Field bus (Profibus). (08 Hrs)

Unit V: Distributed Control System

Overview of DCS, Architecture, Specifications, configuration of DCS blocks for different applications, DCS software configuration, DCS communication, DCS Supervisory Computer Tasks, DCS integration with PLC and Computers, Features of DCS (For any one popular DCS), Advantages of DCS. (08 Hrs)

Unit VI: Industrial Safety

Need for safety instrumentation system (SIS), hazards analysis. Process control systems and SIS. Safety Integrity Levels (SIL) and availability. Introduction to the international functional safety standard IEC61508. (08 Hrs)

Text Book:

1. Gary Dunning, 'Introduction to Programmable logic Controllers', (Delmar Publisher)
2. Webb & Reis, 'Programmable logic Controllers',(Prentice Hall of India)
3. Jose A. Romagnoli, Ahmet Palazoglu, 'Introduction to process Control' (CRC Taylor and Francis group)
4. John R. Hackworth, Frederick D., Hackworth Jr., "Programmable Logic Controllers Programming Methods and Applications"
5. Ronald L. Krutz, "Securing SCADA System", Wiley Publishing

Reference Books:

1. Gordan Clark, Deem Reynders, "Practical Modem SCADA Protocols"
2. Statistical Process Control –ISA Handbook.
3. B.G. Liptak 'Handbook of Instrumentation- Process Control'
4. Installation and user manuals of different DCS, PLC Vendors.

603303 M1 (iii): ELECTIVE-III Module 1: ENERGY STORAGE SYSTEMS

Teaching Scheme	**Examination Scheme**
4 Hours / Week	In Semester Assessment: 25
Credits: 4	End Semester Assessment: 50

Course Objectives Student will get

1. Knowledge of different principles of energy storage and conversion.
2. Learn about feasibility of different energy storage devices and their integration for complete control system.
3. Knowledge of Electrical energy storage systems namely battery and Ultra-capacitor.
4. Design different converter topologies for Energy storage system and tie integration with power system.

Course Outcomes, Students will be

CO1.Able to explain the fundamental principles of energy storage and conversion
CO2.Analyze, model and simulate a Energy system to know its performance characteristics.
CO3. Select a battery storage system based on load requirement in a electric vehicle.
CO4. Design a converter topology for hybrid energy storage system and realize the same as a hardware system.
CO5. Select, design and implement a energy storage device based on load delivery pattern.

Unit I. Conventional energy storage systems

Compressed gas storage system: bulk energy storage. System cost, capacity, conversion efficiency, Flywheel: Models for flywheel capacity, availability, efficiency, and self-discharge, applications in transportation, uninterruptible power supply (UPS). (06 Hrs)

Unit II. Battery energy storage system

Battery specifications and performance characteristics, emerging battery technologies. Comprehensive analysis of design considerations and application specific needs. Impacts on system cost in terms of life cycle, environmental, and reliability of the end solutions.

Batteries for Automobiles and Electric Vehicles: Specifications and performance characteristics of Lead-Acid , Nickel-Cadmium, Nickel-Metal, Hydride and, Lithium-Ion Batteries. (10 Hrs)

Unit III. Fuel Cells

Introduction to fuel cells. Proton exchange membrane (PEM) including direct methanol, phosphoric acid, alkali, solid oxide, and molten carbonate. Topics include understanding of operation, benefits, economics, lifetimes and failure mechanisms. Application of fuel cells in the bulk power and energy system. (08 Hrs)

Unit IV. Capacitors

Introduction to ultra-capacitors including operation, applications, and emerging technologies. Topics include the usage in mobile applications and close proximity to renewable energy sources. Discussion of primary target market usage in today's energy and power sectors.

(10 Hrs)

Unit V. Hybrid energy storage systems

Battery-Ultra capacitor hybrid storage systems: Matching characteristics both energy devices supplying a common load.

Energy and power management of Hybrid energy storage system, control strategies for applications like Electric vehicle and grid connected renewable. (08Hrs)

Unit VI. Converter topology for Electric energy storage and utility

Design of converters for battery storage, standalone PV system and grid integration with renewables. (06 Hrs)

Text Books:

1. Sukhatme,S.P., "Solar Energy", TataMcGrawHill,1984
2. Kishore V V "Renewable Energy Engineering and Technology" ,Teri Press,NewDelhi,2012

Reference Books:

1. Thaler, Alexander, Watzenig, Daniel, "Automotive Battery Technology" Springer
2. A.TerGazarian, "Energy storage for Power Systems", Peter Peregrinus Ltd on behalf of Institution of Electrical Engineers
3. Ibrahim Dincer and Mark A. Rosen, Thermal Energy Storage Systems and Applications, John Wiley & Sons 2002
4. Fuel cell systems Explained, James Larminie and Andrew Dicks, Wiley publications, 2003.
5. Electrochemical technologies for energy storage and conversion, Ru-shiliu, Leizhang, Xueliang sun, Wiley publications, 2012
6. Robert Huggins, "Energy storage –Fundamentals, Materials And Applications ",Springer

7 National Academy Press ,Washington, "A comparison of Alternative Storage Systems for automobiles"

8 Patrick T. Moseley, Jürgen Garche , "Electrochemical Energy Storage for Renewable Sources and Grid balancing" ,Elsevier Publication

603303 M1 (iv) : ELECTIVE-III Module 1:HIGH VOLTAGE DC TRANSMISSION (HVDC)

Teaching Scheme
4 Hours / Week
Credits: 4

Examination Scheme
In Semester Assessment: 25
End Semester Assessments: 50

Course Objectives:

Students will be able to understand

1. The Fundamentals of about HVDC Transmission systems;
2. Basic understanding of operation of HVDC system;
3. Overview of reactive power requirements and protection issues in HVDC Transmission systems

Course Outcome:

Upon completion of this course, the students will be able to:

CO1. Demonstrated an ability to understand the High voltage DC Transmission control
CO2. Demonstration of ability to understand protection related issues

Unit I:
Historical development of HVAC and DC links – kinds of DC links-HVDC projects in India and abroad – advantages and disadvantages of HVDC transmission; Applications of DC transmission – economic factors –development of power devices for HVDC transmission – thyristors – light activated thyristors (08 Hrs)

Unit II:
Three phase fully controlled thyristor bridge converters – operation as rectifiers and line commutated inverters; Converter equivalent circuits – parameters and characteristics of rectifiers and inverters; Series and parallel arrangement of thyristors – multi-bridge converters.
(08 Hrs)

Unit III:
Gate control – basic means of control and modes of operation – power reversal – desired features of control; Control characteristics – constant current control – constant extinction angle control; Stability of control – tap changer control – power control and current limits. (08 Hrs)

Unit IV: Reactive Power Requirements, Reactive Power Control during Steady State and Transients
(08 Hrs)

Unit V:
Basics of protection of HVDC systems – DC reactors – voltage and current oscillations – DC line oscillations; clearing line faults and re-energizing the line – circuit breakers – over voltage protection
(08 Hrs)

Unit VI:
Characteristics and uncharacteristic harmonics – troubles caused by harmonics – means of reducing harmonics — harmonic filters; Corona and Radio interference; Ground return and ground Electrodes
(08 Hrs)

Text Books:
1. Padiyar K.R; HVDC Transmission Systems, Wiley Eastern

References:
1. Kimbark E.X., "Direct Current Transmission", Vol. I, Wiley Interscience, NewYork 1971
2. Allan Greenwood, 'Electrical Transients in Power Systems', John Wiley and Sons New York, 1992
3. Adamson and Hingorani N.G., "High Voltage Direct Current Power Transmission", Garraway ltd., England, 1960.
4. Arrillaga. J, "High Voltage Direct Current Transmission", Peter Peregrines, London, 1983

603303 M2, (i) : ELECTIVE-III Module 2: ARTIFICIAL INTELLIGENT TOOLS

Teaching Scheme
Lectures: 1 Hr/Week
Credit : 1

Examination Scheme
In-Semester Examination : 25 Marks

Course outcome
At the end of this course student is able to
CO1: Model and design control scheme using fuzzy logic.
CO2: Apply genetic algorithm in power system optimization problem.

Unit 1: Fuzzy Logic System
Introduction to crisp sets and fuzzy sets, basic fuzzy set operation and approximate reasoning. Introduction to fuzzy logic modeling and control. Fuzzification, inferencing and defuzzification. Fuzzy knowledge and rule bases. Fuzzy modeling and control schemes for nonlinear systems. Selforganizing fuzzy logic control. Case studies and assignment based on applications of fuzzy logic. [7Hrs]

Unit 2 : Genetic Algorithm
Basic concept of Genetic algorithm and detail algorithmic steps, adjustment of free parameters. Concept on some other search techniques like tabu search and and-colony search techniques for solving optimization problems. GA application to power system optimization problem, Case studies: based on use of GA for optimization. [7Hrs]

Text Books:
1) M. Ganesh “Introduction to Fuzzy Sets and Fuzzy Logic”, Prentice Hall, India.
2) Zimmerman H.J. "Fuzzy set theory-and its Applications"-Kluwer Academic Publishers, 1994.

Reference Books:
1) KOSKO B. "Neural Networks And Fuzzy Systems", Prentice-Hall of India Pvt. Ltd., 1994.
2) KLIR G.J. & FOLGER T.A. "Fuzzy sets, uncertainty and Information", Prentice-Hall of India Pvt. Ltd., 1993.
3) Driankov, Hellendroon, "Introduction to Fuzzy Control", Narosa Publishers.

603303 M2, (ii) : ELECTIVE-III Module 2 : INTELLIGENT SENSORS AND INSTRUMENTATION

Teaching Scheme
Lectures: 1 Hr/Week
Credit: 1

Examination Scheme
In-Semester Examination : 25 Marks

Course outcome
At the end of this course student will be able to
CO1: Design sensors and transducer for measurement of electrical and non electrical quantities and convert signals into analog or digital form.
CO2: Distinguish between primary sensors, IC technologies, micro and nano sensors.

Unit 1 : Introduction
Sensors: primary sensing principles and measurement variables, sensor performance characteristics and terminology. Instrumentation: transducer measurement circuit, signal conditioning circuit, Data conversion: DAC, ADC, virtual instrumentation with Lab View. [7 Hrs]

Unit 2 Smart Sensors
Primary sensors; excitation; compensation; information coding/ processing; data communication; standards for smart sensor interface. Recent trends in sensor technologies: Introduction; film sensors (thick film sensors, thin film sensors); semiconductor IC technology standard methods; Micro Electro-Mechanical Systems (micro-machining, some application examples); nanosensors. [7 Hrs]

Text books:
1) Barney, G. C., “Intelligent Instrumentation”, Prentice Hall, 1995.
2) D. Patranabis, “Sensors and Transducers”, PHI, 2003.

Reference Book:
1. Alan S. Morris, “Principles of Measurement & Instrumentation”, PHI Pvt. Ltd., 1999.

603303 M2, (iii) : ELECTIVE-III ,Module 2:HUMAN RIGHTS

Teaching Scheme | **Examination Scheme**

Lectures: 1 Hr/Week | In-Semester Examination : 25 Marks

Credit : 1

Course outcome

At the end of this course student be able to

CO1:Learn about policies, schemes and Constitution about Human rights

CO2: Learn roles of various entities about human rights

Unit 1:

Human Rights – Concept, Development, Evolution

- Philosophical, Sociological and Political debates
- Benchmarks of Human Rights Movement.

Human Rights and the Indian Constitution

- Constitutional framework
- Fundamental Rights & Duties
- Directive Principles of State Policy
- Welfare State & Welfare Schemes

Human Rights & State Mechanisms

- Police & Human Rights
- Judiciary & Human Rights
- Prisons & Human Rights
- National and State Human Rights Commissions [7 Hrs]

Unit 2 :

Human Rights of the Different Sections and contemporary issues

- Unorganized Sector
- Right to Environment,

-Globalization and Human Rights

- Right to Development,

Citizens' Role and Civil Society

- Social Movements and Non-Governmental Organizations
- Public Interest Litigation

-Role of Non Government organizations in implementation of Human rights.

- Right to Information

Human Rights and the international scene –Primary Information with reference to Engineering Industry

- UN Documents
- International Mechanisms (UN & Regional)
- International Criminal Court [7Hrs]

References:

1) Study material on UNESCO,UNICEF web site

2) HUMAN RIGHTS IN INDIA A MAPPING, UshaRamanathan

Available at: http://www.ielrc.org/content/w0103.pdf

3) Introduction to International Humanitarian Law by Curtis F. J. Doebbler - CD Publishing , 2005.

4) Freedom of Information by Toby Mendel - UNESCO, 2008

603303 M2 (iv) : ELECTIVE-III Module 2: GREEN BUILDING DESIGN

Teaching Scheme
Lectures: 1 Hr/Week
Credit : 1

Examination Scheme
In-Semester Examination : 25 Marks

Course outcome
At the end of this course student will be able to
CO1: Learn green and sustainable design techniques for both commercial and residential buildings.
CO2: Design water, lighting, energy efficiency plan using renewable energy source.

Unit1 : Sustainability and Building design
Sustainability, objectives of sustainable development, Sustainable aspects of habitat design, sustainable buildings, principles, approaches and characteristics, climate data, climate parameters and zones, comparative analysis of various climatic zones, site planning recommended check list for identifying site characteristics, site development and layout. Efficient water management and waste water treatment, solid waste management. [7 Hrs]

Unit 2 : Energy efficiency
Solar passive techniques in building design to minimize load on conventional system i.e. heating, cooling, ventilation and lighting. Designing Energy efficient lighting and HVAC systems. Use of renewable energy system to meet part of building load. Green building certification. Overview various green building in India. Policy and regulatory mechanism. [7 Hrs]

Text Book :
Seven wonders of Green Building Technology- Karen Sirvaitis, Twenty first century books.

References :
1. Sustainable Building Design Manual, Volume 2, TERI, New Delhi
2. Energy Efficient Buildings in India, TERI, New Delhi
3. Sustainable Building Design Manual, Volume 1 TERI, New Delhi

603304 SEMINAR– II

Teaching Scheme
4 Hrs / week
Credits: 04

Examination Scheme
Term work: 50 Marks
Oral/ Presentation: 50Marks

Seminar II shall be on the topic relevant to latest trends in the field of concerned branch, preferably on the topic of specialization and based on broader area of interest to facilitate to proceed for dissertation work, selected by him/her approved by the guide and authority. He/she should study basic theory related to the topic from standard references. A student is expected to perform the exhaustive literature review of the topic. The student should focus on understanding the state of art – concept, literature published at standard platforms to enable the finalization of objective of his/her ME dissertation. A guide should maintain weekly record of discussion related to the topic. The student shall submit the duly certified seminar report in standard format, for satisfactory completion of the work by the concerned Guide and head of the department/institute.

603305: PROJECT STAGE - I

Teaching Scheme
8 Hrs / week
Credits: 08

Examination Scheme
Term work: 50 marks
Oral: 50 Marks

Project work Stage – I is an integral part of the project work. In this, the student shall complete the partial work of the project which will consist of problem statement, literature review, project overview, scheme of implementation (Mathematical Model/block diagram/ PERT chart, etc.) simulation model, Layout & Design of the Set-up and results if obtained. As a part of the progress report of Project Stage-I, the student shall deliver a presentation on the advancement in Technology pertaining to the selected dissertation topic. The project stage I is the progress presentation of dissertation work. The student should clearly present different stages in which dissertation work is to be completed, giving planning of the remaining part to be completed in Project Stage-II. Publication based on the work is desirable in the reputed national or international journal or in the proceedings of reputed and reviewed conferences. A guide should maintain record of discussion related to the topic, work carried out by the student. The student shall submit the duly certified progress report of Project work Stage-I in standard format for satisfactory completion of the work by the concerned guide and head of the Department / Institute.

Semester IV

603306: SEMINAR- III

Teaching Scheme
5 Hrs / week
Credits: 05

Examination Scheme
Term work: 50 Marks
Oral/ Presentation: 50Marks

Seminar III shall preferably be an extension of seminar II. The content of report of seminar III will include development of the work till date along with relevant theory. A guide should maintain record of discussion related to the topic, work carried out by the student, action taken etc. The student shall submit the duly certified seminar report in standard format, for satisfactory completion of the work by the concerned guide and head of the Department/Institute.

603307 : PROJECT WORK STAGE - II

Teaching Scheme
20Hrs / week
Credits: 20

Examination Scheme
Term work: 150 marks
Oral: 50 Marks

In Project Work Stage – II, the student shall complete the remaining part of the project which will consist of simulation, fabrication of set up required for the project, work station, conducting experiments and taking results, analysis & validation of results and conclusions. A student must publish minimum one paper based on the dissertation work in the reputed national or international journal or in the proceedings of reputed and reviewed conferences. Details of this publication should be mentioned in the final report. The dissertation work of candidate would be evaluated by the guide as well as panel of internal/external experts, before submitting it to the university so as to ensure basic minimum quality standard. A proper record of this evaluation is needed to be maintained. A guide should maintain record of discussion related to the topic, work carried out by the student, action taken etc. The student shall prepare the duly certified final report of project work in standard format for satisfactory completion of the work by the concerned guide, head of the Department and head of the Institute.