Scheme & Syllabi
ME
(Power Electronics & Drives)

w.e.f. 2017

(Revision of Scheme for one year course work and one year dissertation)

Department of Electrical and Instrumentation Engineering
Thapar University, Patiala

Electrical & Instrumentation Engg. Dept.
ME (Power Electronics & Drives) *w.e.f. 2017*

First Semester

S. No.	Course No.	Course Name	L	T	P	Cr
1.	PPE101	Power Semiconductor Devices	3	1	0	3.5
2.	PPE102	Power Converters	3	1	2	4.5
3,	PPE103	Analysis of Machine Drives	3	1	0	3.5
4.	PPE104	FACTS Controllers	3	1	0	3.5
5.	PEE205	Intelligent Algorithms in Power Systems	3	1	2	4.5
6.	PEE301	Digital Signal Processing and Applications	3	1	2	4.5
		Total	**18**	**6**	**6**	**24.0**

Contact Hrs./week: 30
Credits first sem.: 24.0

Second Semester

S. No.	Course No.	Course Name	L	T	P	Cr
1.	PPE201	High Power Converters	3	1	0	3.5
2.	PPE202	Advanced Electric Drives and Control	3	0	2	4.0
3.	PPE203	Digital Drives	3	1	2	4.5
4.	PEE216	Digital Control Systems	3	1	0	3.5
5.		Elective-I	3	1	2	4.5
6.		Elective-II	3	1	0	3.5
7.	PPE204	System Simulation Laboratory	0	0	3	1.5
		Total	**18**	**4**	**9**	**24.5**

Contact Hrs./week: 31
Credits first sem.: 25.0

Third Semester

S. No.	Course No.	Course Name	L	T	P	Cr
1	PPE391	Seminar (Internship based)				4.0
2.	PPE392	Project	0	0	0	6.0
3.	PPE393	Seminar (Dissertation based)				4.0
4.	PPE491	Dissertation (starts)				--
		Total				**14.0**

Fourth Semester

S. No.	Course No.	Course Name	L	T	P	Cr
1.	PPE491	Dissertation				**16.0**
		Total				**16.0**

List of Electives						
Elective–I						
S. No.	**Course No.**	**Course Name**	**L**	**T**	**P**	**Cr**
1	PMC 302	Probability and Statitics	3	1	2	4.5
2	PPE212	Data Structures using Object oriented Programming	3	1	2	4.5
3	PVL	FPGA based Digital System Design	3	1	2	4.5
4.	PPE221	Sensors and Signal Conditioning	3	1	2	4.5
	PPE341	Digital Instrumentation and applications	3	1	2	4.5
Elective–II						
1.	PPE331	Power System Harmonics and Filters	3	1	0	3.5
2.	PPE342	Distributed Generation and Microgrid	3	1	0	3.5
3.	PPE333	Switched Mode Power Supplies and UPS	3	1	0	3.5
4.	PEE309	Power Quality and Custom Power	3	1	0	3.5
5.	PEE305	Load and Energy Management	3	1	0	3.5
6.	PEE322	HVAC & HVDC Transmission Systems	3	1	0	3.5

Total Number of Credits: 79.0

PPE101POWER SEMICONDUCTOR DEVICES

	L	T	P	Cr
	3	**1**	**0**	**3.5**

Course Objectives: To understand structure of power devices, to understand design of snubber and firing circuits, to impart knowledge about converters and their analysis.

OVERVIEW OF POWER SEMICONDUCTOR SWITCHES : Introduction - Diodes, Thyristors, BJTs, JFETs, MOSFETs, GTOs IGBTs, Comparison of these as switching devices, Drive and Protection circuit for these devices – New Semiconductor materials for Power devices.
POWER DIODE AND POWER BJT : Basic structure and I-V & Switching characteristics of Power diode, Structure and Switching characteristics of Power BJT, Breakdown voltage considerations , operating limits and Safe operating area, Drive circuits for BJT, Snubber design for Power diode.
THYRISTORS AND GTOs : Basic structures - I-V characteristics, Physics of device operation, Switching characteristics of Thyristors and GTOs, Drive circuits, Snubber circuits for Thyristors and GTOs - Over current protection of GTO.
IGBT, POWER JFET & MOSFETS: :Basic structures, I-V characteristics, physics of device operation, Switching characteristics , Safe operating area of IGBT and Power JFET & MOSFET - Derive circuits and Protection. Loss in switching devices
GATE AND DRIVE CIRCUITS: Design Consideration, De-coupled drive circuits, electrically isolated driver circuits, Cascade connected drive circuits, Power device protections scheme in drive circuits, Circuit layout considerations.
Filters and Heat sink Design. Line frequency inductor (AC choke & DC choke) design, High frequency inductor and transformer design for power converters.
RECENT TRENDS IN SEMICONDUCTOR DEVICES: Basic structures and I-V characteristics of recent thyrister (IGCT, SGCT) and transistor (MV IGBT, IEGT) family switching devices. SiC devices - IGBT & MOSFET. Drive circuits and protections. Comparative analysis of recent switching devices and applications.
APPLICATIONS : Single phase rectifiers and Three phase rectifiers using Diodes and Thyristors, Choppers, Inverters using GTOs-IGBTs and power JFETs & MOSFETs.
Course Outcomes: After the completion of the course the student may be able

- To analyse the device structure
- To design and develop firing circuit and snubber circuit
- To design high frequency inductor and transformers

Recommended Books :

1. *Mohan. N et al.,"Power Electronics: Converters, Applications and Design", John Wiley and Sons, Newyork, Third Edition,2002.*
2. *Kassakian, J.G .et.al.,"Principles of Power Electronics", Pearson Education India., 2010.*
3. *Rashid M.H., "Power Electronics Circuits, Devices and Applications", Prentice Hall India, Third edition, New Delhi 2004.*
4. *M.D. Singh and K.B. Khanchandani , "Power Electronics", Tata McGraw Hill, New Delhi, Second Edition,2008.*
5. *Donald A. Neamen, "Semiconductor Physics and Devices", Tata McGraw Hill, New Delhi, Fourth Edition, 2011*

Evaluation Scheme:

S.No.	Evaluation Elements	Weightage (%)
1.	MST	30
2.	EST	45
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes etc.)	25

PPE102POWER CONVERTERS

	L	T	P	Cr
	3	1	2	4.5

Course Objectives: To impart knowledge about the physics of device operation, static and dynamic characteristics, ratings, protection, operating limitations and safe operating area , to discuss the design issues of drive circuits and their usage. PWM schemes, understanding of inverters and cyclo-converters, DC-DC converters and resonant inverters and their analysis with R, RL, RLE type of loads

POWER CONVERTERS : H-bridge configuration of converter, Brief overview of power converters, Dual converter - Sequence control of converters, performance parameters: harmonics, ripple, distortion, power factor, effect of source impedance and overlap-reactive power and power balance in converter circuits. Six pulse, twelve pulse and Active Front End (AFE) conversion.

AC VOLTAGE CONTROLLERS : Introduction-Static Characteristics of TRIAC- Principle of phase control -Single phase AC voltage regulators with R, & R-L loads, Sequence control of AC regulator, Three phase AC regulator ,various configurations , analysis with R and R-L loads.

CYCLOCONVERTERS: Single phase to single phase, three phase to single phase, three phase to three phase, Forced commutated cycloconverters, Output voltage of a three phase cycloconverter, Harmonics, Power factor Control

INVERTERS: 120^0 and 180^0 mode of operation of three phase inverters, Three phase Step wave inverter circuits, Three phase PWM controlled inverter circuits

DC-DC CONVERTER: Buck/ Boost Converter, Buck-Boost Converter; High-Frequency Switching, High-Frequency Isolation transformer, Push-Pull Converter, Full-Bridge Converter, Forward Converter, Fly-back Converter; Resonant DC-DC converters: Analysis and design of Resonant Converter (SRC) Circuits namely Series, Parallel, and Series-Parallel, Zero-Voltage, Zero-Current Resonant Converter, Industrial applications of DC–DC resonant converters and reduction in THD and power factor improvement

PWM INVERTER MODULATION STRATEGIES: Single and multiple PWM, Sinusoidal PWM (SPWM), Modified SPWM, Space vector modulation and hysteresis band current control PWM techniques. PWM based inverters and resonant converters

CONTROL CIRCUITS: Introduction-Gating circuits for single phase and three phase fully controlled thyristor converters: Gating pulse requirements – Schemes for generating gating pulses. Gating requirements for choppers, A gating circuit for PWM type A chopper., Control circuit for cycloconverter: Synchronizing circuit – Reference voltage signals , Logic and Triggering circuit , Converter group selection - Firing circuits for three phase AC regulators.

LABORATORY: Device characteristics of IGBT, GTO, MOSFET, Gate Drive Circuits, PWM signal Generation, DC-DC Converter, Three phase full converter, Three phase Voltage Source Inverter, Half and Full wave Cyclo-converter, Simulation of Power Converters and harmonic analysis.

Course Outcome:

- To realize drive and control circuits for power converters,
- To develop power converters used for the control of DC and AC
- To conceptualise and anlyse the issues related to recent converter operation

Recommended Books

1. *Mohan, N., Undeland, T.M. and Robbins, W. P., Power Electronics: Converter Applications and Design, John Wiley and Sons (2007).*

2. *Rashid, M.H., Power Electronics Circuits, Devices and Applications, Prentice-Hall of India Private Limited (2006).*
3. *Sen, P.C., Power Electronics, Tata McGraw-Hill Publishing Company (1996).*
4. *Philip T. Krein, Elements of Power Electronics, Oxford university Press (2008)*
5. *Bose B.K., Power Electronics & AC Drives, Prentice Hall Englewood cliffs, NJ, (1986)*

Evaluation Scheme:

S. No.	Evaluation Elements	Weightage (%)
1.	MST	25
2.	EST	35
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes etc.)	40

PPE103 ANALYSIS OF MACHINE DRIVES

L	T	P	Cr
3	1	0	3.5

Course Objectives: To impart knowledge about fundamentals of Electric drives and control operational strategies of dc and ac motor drives as per different quadrant operations and to discuss the modeling and control of dc motor drive, ac motor drives and permanent magnet machines.

BASICS OF ENERGY CONVERSION IN DRIVES: General expression of stored magnetic energy, Concepts co–energy and development of force/torque in single and doubly excited electro–mechanical system, Determination of air gap mmf and per phase machine inductance using physical machine data, Voltage and torque equation of DC machine, Three phase symmetrical induction machine and salient pole synchronous machines in phase variable form, Switching and surge voltage transients in transformers.

INTRODUCTION TO REFERENCE FRAME THEORY: Static and rotating reference frames, Transformation model relationships with static symmetrical three phase circuits, Application of reference frame theory to three phase symmetrical alternating current machines. State Space Modelling.

DYNAMIC MODELS: Dynamic direct–axis and quadrature–axis model in arbitrarily rotating reference frames, Voltage and torque equations, Derivation of steady state phasor relationship from dynamic model, Comparison of generalized theory of rotating electrical machine and Kron's primitive machine.

DETERMINATION OF DYNAMIC EQUIVALENT CIRCUIT PARAMETERS: Standard and derived machine time constants, Analysis and dynamic modelling of two phase asymmetrical induction machine and single phase induction machine, Linearized and non-linearized analysis; Operation on harmonic supplies, Unbalanced operation of three-phase machine.

PERMANENT MAGNET SYNCHRONOUS MACHINE: Trapezoidal and sinusoidal back emf type, Surface permanent magnet and interior permanent magnet machines, Construction, Operating principle and its characteristics, Dynamic modeling and self controlled operation of BLDC & PMSM.

SWITCH RELUCTANCE MOTORS: Analysis and design trade–off, Basic operating characteristics. Different control topologies of SRM

Course Learning Outcome: On the completion of the course, the student will be able

- To acquire the knowledge of selection of drives as per practical operational industrial requirement.
- To apply their knowledge to prepare control schemes as per different types of motors used in industries.
- To estimate & solve harmonic and power factor related problems in controlling AC and DC drives

Recommended Books

1. *Bimbhra, P.S., Generalized Theory of Electric Machines, Khanna Publishers (2006).*
2. *Krause, P. C., Wasynczuk, O. and Sudhoff, S. D., Analysis of Electric Machinery and Drive Systems, Wiley IEEE Press (2002).*
3. *Bose B.K., Modern Power Electronics Control and AC Drives,Prentice Hall, 2nd ed., (2001)*

Evaluation Scheme:

S.No.	Evaluation Elements	Weightage (%)
1.	MST	30
2.	EST	45
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes etc.)	25

PPE104 FACTS CONTROLLERS

	L	T	P	Cr
	3	**1**	**0**	**3.5**

Course Objectives: To learn the concept of power flow control through various power electronic controllers including state of art FACTS controllers, operational aspects and their capabilities and their integration in power flow analysis, FACTS controllers and to learn the effectiveness of FACTS controllers in distribution system for harmonic mitigation etc.

OVERVIEW: Concept of reactive power compensation, Review of Power Flow methods and series-shunt compensation, Review of voltage and current sourced converters, Concepts of transient stability and voltage stability, Power system oscillations.Need for FACTS controllers- types of FACTS controllers.

SHUNT COMPENSATORS: Mid point voltage regulation, Method of controlled VAr generation, principle of operation, Control and characteristics of SVC, STATCOM, General applications, Multi-control functional model of STATCOM for power flow analysis, Implementation of STATCOM models in Newton power flow, STATCOM in optimal power flow (OPF), STATCOM in distribution system (DSTATCOM), DSTATCOM performance in various modes including harmonic mitigation.

SERIES COMPENSATORS : Series compensation and voltage stability, Variable impedance type series compensators (TCSC) and switching converter type series converter (SSSC), Configurations, Control and characteristics, General applications, Modelling of multi–control functional model of SSSC in power flow analysis, Implemetation of SSC models in Newton power flow, SSSC in OPF, Dynamic Voltage Restorer (DVR) in Distribution, Subsynchronous Resonance, NGH Scheme.

UNIFIED POWER FLOW CONTROLLERS : Objectives and principle of operation of voltage, phase angle regulations, Static phase shifter, Operating characteristics of SPS**,** Unified Power Flow Controller (UPFC) control and characteristics, UPFC as generalised SSSC, Modelling of UPFC for power flow and optimum power flow studies, Implementing UPFC in Newton power flow, Control of power oscillations using UPFC.

POWER FLOW CONTROLLER: Principle of operation, Control and characteristics, Model of IPFC for power flow and optimum power flow studies. FACTS Controller interactions – SVC–SVG interaction - co-ordination of multiple controllers using linear control techniques – Quantitative treatment of control coordination

RECENT TRENDS: Application of basic active filters, multilevel and multipulse converters and Z-source inverter in various FACTS and FACDS devices for improving the performances of transmission system network and distribution system network, respectively.

Course Outcome:

Understanding with the power system control through various power electronic controllers including state of art FACTS controllers. Understanding about the operational aspects and their effectiveness in transient stability enhancement, damping to power system oscillations, real and reactive power control capability in power system and their effectiveness in distribution system for harmonic mitigation etc.

Recommended Books

1. *Song, Y.H. and Johns, A.T., Flexible AC Transmission Systems, IEEE Press (1999).*
2. *Hingorani, N.G. and Gyragyi, L., Understanding FACTS (Concepts and Technology of Flexible AC Transmission System), Standard Publishers & Distributors (2001).*
3. *Mathur, R.M. and Verma, R.K., Thyristor based FACTS controllers for Electrical Transmission Systems, IEEE Press (2002).*

4. *Zhang, X. P., Rehtanz, C. and Pal, B., Flexible AC Transmission Systems: Modelling and Control, Springer (2006).*
5. *A.T.John, "Flexible AC Transmission System", Institution of Electrical and Electronic Engineers (IEEE), 1999.*
6. *V. K.Sood, "HVDC and FACTS controllers- Applications of Static Converters in Power System", 2004, Kluwer Academic Publishers.*
7. *K.R.Padiyar," FACTS Controllers in Power Transmission and Distribution", New Age International(P) Ltd., Publishers New Delhi, Reprint 2008*

Evaluation Scheme:

S.No.	Evaluation Elements	Weightage (%)
1.	MST	30
2.	EST	45
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes etc.)	25

PEE205 INTELLIEGENT ALGORITHMS IN POWER SYSTEMS

L	T	P	Cr
3	1	2	4.5

Course Objectives: To impart knowledge about basic significance of artificial intelligence in the area of decision making, recognition, similarity matching etc.To explain the concept of artificial neural network and its models, various learning algorithms in supervised and unsupervised mode, concept of fuzzy logic and fuzzy logic system, concept of genetic algorithms and genetic operator, to understand the hybrid structure .

Overview: Concepts of artificial intelligence (AI) and optimization, Introduction of various AI techniques, features and advantages in comparison to conventional methods, applications in electrical systems.

Artificial Neural Network: Review of ANN and learning processes, Learning algorithms, Transforming static neural network into dynamic, Neuronal filters, Supervised learning as an optimization method, Temporal back–propagation algorithm, neurodynamical model, Application of Hopfield neural network for constrained and unconstrained optimization, Stochastic machines, recurrent network architectures,

Fuzzy Logic: Review offuzzy sets and fuzzy systems, Development of membership function, Fuzzy measures, LR Fuzzy numbers, Fuzzy Bayesian decision making, Fuzzy system design and simulation, Fuzzy optimization, Solution of linear system under fuzzy environment, Multi–input, Multi–output system, Multi–objective decision making.

Evolutionary computation: Review of evolutionary computation techniques, algorithms and various operators, Mapping unconstrained and constrained optimization problems, Evolutionary programming

Multi-objective optimization: Comparison with single objective optimization, Concept of dominance, Non–dominated sorting, Multi-objective optimization using genetic algorithm.

Integrated Systems: Introduction to integrating systems like fuzzification of neural network, Neural–fuzzy controller, GA based fuzzy classification, GA based parameter learning of neural network.

AI Applications in Power Systems: Case studies such as Economic load dispatch, Load forecasting, Optimal power flow, transient stability and power system stabilizers, Hydro–thermal scheduling, voltage control, Protection system

Laboratory Work: Understanding the Fuzzy, Neural network and GA concepts through programming, MATLAB Tool boxes, Fuzzy system applications, Power system stabilizer, Neural network models and learning, Constrained optimization using neural network like Economic Dispatch, Implementing binary and real valued GA.

Minor Project: Implementation of Intelligent technique for economic load dispatch, speed control of induction motor, Load forecasting using Fuzzy logic

Course Learning Outcome: On the completion of the course, the student will be able

- To develop the neuron models with analog and discrete inputs, network architectures and training of network through various learning algorithms in supervised and unsupervised mode.
- To implement the concept of fuzzy logic concept and its implementation in controller applications
- To demonstrate the concept of evolutionary computation using Genetic algorithm for decision making problems.

Recommended Books

1. Ross, J. T., Fuzzy Logic with Engineering Applications, McGraw–Hill (1995).

2. S. Haykin, Neural Network : A Comprehensive Foundation, Pearson Education (2003).

3. Lin, C., Lee, G., Neural Fuzzy Systems, Prentice Hall International Inc. (2000)

4. Deb, K., Multiobjective Optimization using Evolutionary Algorithms, John Wiley and Sons (2002).

Evaluation Scheme:

S.No.	Evaluation Elements	Weightage (%)
1.	MST	25
2.	EST	35
3.	Sessionals (May include ssignments/Projects/Tutorials/Quizes etc.)	40

PEE301 DIGITAL SIGNAL PROCESSING AND APPLICATION

L	T	P	Cr
3	1	2	4.5

Course Objectives: To introduce with concept of continuous and discrete signals, Frequency analysis of signals, design of digital filters , to explain z-transform and FFT transform

Overview: Concept of frequency in continuous and discrete time signals, A–D Conversion process, Sampling Theorem, Introduction and classification of discrete time signals and systems, Analysis of discrete linear time-invariant (LTI) systems, Convolution and correlation of discrete time signals, Implementation of discrete time systems.

Z-Transform: Z-Transform and inverse z-transform, rational z-transform, Analysis of Linear Time Invariant (LTI) systems in z-domain.

Frequency Analysis of Signals and System: Frequency analysis of continuous and discrete time signals, Fourier series and Fourier Transform for discrete and continuous periodic and non periodic signals.

Discrete Fourier Transform: Frequency domain sampling, Discrete Fourier Transform (DFT), Linear filtering methods based on DFT, Frequency analysis of signals using DFT, Fast Fourier Transform (FFT), FFT algorithms, Methods and Applications of FFT algorithms.

Digital Filter Design: Digital filter, filter design, Infinite Impulse Filter (IIR), finite Impulse filters (FIR)

Multirate Signal Processing: Decimation and Interpolation, Sample rate conversion by Integer and Non-Integer factors.

Random Signals: Random variables, random process, auto-correlation functions, power spectrum density, filtering random signals, window function, wavelet transform, spectrum analysis of random signals.

Applications to Power Systems : DSP applications to power systems such as measurement of frequency, measurement of harmonic level, harmonic analysis, static and digital relays, digital protection, power metering, magnetic field measurement.

Laboratory Work : Determination of Z, Fourier transform, Design of FIR and IIR Filters, Realization of Prediction, equalizer and compression algorithms, use of wavelet transform,

Course Learning Outcome: On the completion of the course, the student will be able

- To learn to apply z-transform and FFT analysis
- To analyse continuous and discrete signals in frequency domain.
- To implement the concepts for measurement of frequency, harmonic level etc.
- To design digital filters for reduction of noise signals
- To apply concepts of DSP to power system protection for measurement of signals.

Recommended Books

1. *Proakis, J.G., and Manolakis D.G., Digital Signal Processing, Prentice Hall of India Private Limited, (1996).*
2. *Rabiner, C.R., and Gold, B., Theory and Applications of Digital Signal Processing, Prentice Hall of India Private Limited (2000).*
3. *Helmut, U., Wilibald, W. and Andrzej, W., Protection Techniques in Electrical Energy Systems, CRC Press, New York (1995).*
4. *Oppenhein, A.V., and Schafer, R.W., Discrete Time Signal Processing, Prentice Hall of India Private Limited (2001).*

Evaluation Scheme:

S. No.	Evaluation Elements	Weightage (%)
1.	MST	25
2.	EST	35
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes etc.)	40

PMA COMPUTATIONAL TECHNIQUES AND STATISTICAL METHODS

L	T	P	Cr
3	1	2	4.5

Course Objectives: To explain the necessary conditions of convex and concave optimisation problems, To describe various types of conventional solution techniques applied to optimisation problems, To impart knowledge about the probability concepts, To demonstrate the ANOVA process

Introduction: Review of Linear Programming concepts.

Unconstrained Problems: First-Order Necessary Conditions, Second-Order Conditions Convex and Concave Functions, Minimization and Maximization of Convex Functions Zero-Order Conditions, Global Convergence of Descent Algorithms, Speed of Convergence.

Basic Descent Methods: Fibonacci and Golden Section Search, Line Search by Curve fitting, Global Convergence of Curve Fitting, Closedness of Line Search Algorithms, Inaccurate Line Search, The Method of Steepest Descent, Newton's Method, Coordinate Descent Methods, Spacer Steps.

Conjugate Direction Methods: Conjugate Directions, Descent Properties of the Conjugate Direction Method, The Conjugate Gradient Method, The CûG Method as an Optimal Process, The Partial Conjugate Gradient Method, Extension to Nonquadratic Problems,

Quasi-Newton Methods: Modified Newton Method, Construction of the Inverse, DavidonûFletcherûPowell Method, The Broyden Family, Convergence Properties, Scaling, Memoryless Quasi-Newton Methods, Combination of Steepest Descent and Newton's Method.

Constrained optimization: Kuhn-Tucker conditions, Quadratic programming problems, Algorithm for constrained optimization, Gradient projection method, Dual of quadratic programming problems**.**

Review of Probability: Appraisal of axiomatic approach of probability, Conditional probability, Baye’s rule, Conditional distributions, and conditional expectations.

Markov chains: Basics of markov chains, Finite state space, Markov chains, Transition and stationary markov chains. Continuous time markov process: continuous time branching processes, Kolmogorov, Forward and backward equations, Pure birth, Pure death, Birth and death process.

Analysis of variance: One Way Classification: ANOVA for fixed effect model, ANOVA for Random Effect Model, Two-way Classification (one observation per cell): ANOVA for fixed effect model, ANOVA for Random Effect Model.

Design of Experiments: Completely Randomised Design, Randomised Block Design, Latin Square Design, their statistical analysis and variance of estimates, Analysis of Covariance.

.**Course Learning Outcome:** On the completion of the course, the student will be able

- To apply conventional techniques of direct search to solve un constrained optimisation problems
- To solve constrined optimisation problems.
- To apply ANOVA test to assess the degree of variance,
- To analyse design of experiments through variance and covariance estimates
- To apply the concept of proabilibity to understand the frequency of occurrence and adequacy estimate.

Recommended Books

1. *Luenberger D.G., Linear and Nonlinear Programming, Addison Wesley (2003).*
2. *Fletcher R., Practical methods of Optimization, John Wiley (1980).*
3. *Taha H.A., Operation research- An Introduction, PHI (2007).*
4. *Populis,A., Random Variables and Stochastic Processes, Tata McGraw Hill (2002).*
5. *Montgomery, Introduction to Statistical Quality Control, John Wiley and Sons (2005).*

Evaluation Scheme:

S. No.	Evaluation Elements	Weightage (%)
1.	MST	25
2.	EST	40
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes etc.)	35

PPE201HIGH POWER CONVERTERS

	L	T	P	Cr
	3	**1**	**0**	**3.5**

Course Objectives: To impart knowledge about the. PWM schemes, understanding of current and voltage source inverters and multilevel converters, DC-DC converters and resonant inverters and their analysis with R, RL, RLE type of loads

VOLTAGE SOURCE INVERTERS: Three phase Inverters with star and delta connected loads, voltage control of three phase inverters: Performance parameters single, multi pulse, sinusoidal, space vector modulation techniques, Voltage control of single phase inverters using various PWM techniques , various harmonic elimination techniques. Multiple commutation & transformer connection , Harmonic filters, Application to drive system

CURRENT SOURCE INVERTERS: Operation of six-step thyristor inverter , inverter operation modes, load commutated inverters, Auto sequential current source inverter (ASCI) , current pulsations, comparison of current source inverter and voltage source inverters, PWM techniques for current source inverters.

MULTILEVEL & BOOST INVERTERS: Multilevel concept , diode clamped MLI, Flying capacitor MLI, Cascade/Series Hybrid Bridge type multilevel inverters, Modular Multilevel Conversion, Comparison of multilevel inverters, application of multilevel inverters , PWM techniques for MLI , Single phase & Three phase Impedance source inverters . Time sharing high frequency inverter , multipulse converters, their need analysis, various multipulse converter topologies, modulation techniques for multipulse inverters.

RESONANT INVERTERS: Series and parallel resonant inverters, voltage control of resonant inverters, Class E resonant inverter, resonant DC link inverters.

Z-SOURCE INVERTER: VSI versus CSI, Limitations of conventional converters, Z-source inverter topology, control techniques of Z-source inverters, Comparative performance analysis of control techniques of Z-source inverters

Course Learning Outcome: On the completion of the course, the student will be able

- To design the Gate and base drive circuits
- To develop skills to utilize the different PWM schemes
- To validate the performance of different types of inverters.
- To select the power converter for variety of applications

Recommended Books

1. *Bimal K.Bose "Modern Power Electronics and AC Drives", Pearson Education,Second Edition, 2003.*
2. *Ned Mohan,T.M Undeland and W.P Robbin, "Power Electronics: converters, Application and design" John Wiley and sons.Wiley India edition, 2006.*
3. *Philip T. krein, "Elements of Power Electronics" Oxford University Press -1998.*
4. *P.C. Sen, "Modern Power Electronics", Wheeler Publishing Co, First Edition, New Delhi, 1998.*

PPE202 ADVANCED ELECTRIC DRIVES AND CONTROL

L	T	P	Cr
3	0	2	4.0

Course Objectives: To impart knowledge about fundamentals of Electric drives and control, operational strategies of dc and ac motor drives as per different quadrant operations and to discuss

Review of Drive Concept: Review of introductory concepts of drives.

DC Motor Drive and its Operational Strategies: Dynamic model of machine with armature voltage control only and converters with continuous conduction only; Closed loop control using single (speed) and two loops (speed, current), Implementation using circulating current type three phase dual converter and four quadrant transistorized chopper.

Modelling and Control of DC Drives: State feedback control and sliding mode control of separately−excited DC machine, Modelling and control of separately−excited DC machine in field weakening region and discontinuous converter conduction mode, Control of DC series machine.

Open-loop Dynamic Performance of AC & DC Drives: Starting & reversal time, Energy consumption & energy savings principle. Drives Application Engineering for Fan, Pump, Compressor, Lift-Elevator, Kiln, Winder-Un-Winder, Traction application. Synchronization and master-slave configuration.

AC Drives and its Operational Strategies: Variable frequency operation of three−phase symmetrical induction machine, Scalar control methods for constant power an constant torque modes, Vector control of induction machine, Methods of field sensing and estimation, Field orientation methods: Implementation of IRFO scheme using current controlled PWM, VSI and implementation of DSFO scheme using CSI, Performance of vector controlled permanent magnet machine.

CONTROL AND ESTIMATION OF AC DRIVES: Introduction to speed control of Switched Reluctance Machine, Induction motor drive, basic of Scalar & Vector control V/f Control, Sensorless vector control, Field Oriented Control, Direct torque control and flux observation, Speed control of wound rotor induction motors: Converter based static rotor resistance control, Static scherbius drive using line commutated converter cascade, Analysis and estimation of harmonics and power factor, Vector control of wound rotor induction machine using self-commutated converter cascade and improvement in power factor, Variable speed constant frequency (VSCF) generation.

CONTROL OF PERMANENT MAGNET MACHINE: Power Electronics Control of Permanent magnet synchronous machine, Brushless DC machine, Surface permanent magnet machine and interior.

COMPATIBILITY OF MOTOR & DRIVES: Effects of drives on motor - dV/dt, THD, Common Mode Voltage, Shaft Voltage and Bearing Current, Sound & Vibration

Laboratory Work: Closed loop current-speed control of AC & DC drives, Variable voltage−variable frequency control, Vector control mechanism, Position control of stepper motor, Direct field orientation of AC drives, Static Scherbius & Kramer method of slip power recovery, PWM based VSI control of induction drive, Converter based Four quadrant operation of DC and AC drives.

Course Learning Outcome: On the completion of the course, the student will be able

- To acquire the knowledge of selection of drives as per practical operational industrial requirement.
- To apply their knowledge to prepare control schemes as per different types of motors used in industries.
- To estimate & solve harmonic and power factor related problems in controlling AC and DC drives.

Recommended Books

1. *Mohan, N., Electric Drives: An Integrative Approach, MNPERE (2001).*
2. *Mohan, N., Advanced Electric Drives: Analysis, Control, and Modeling Using Simulink, MNPERE (2001).*
3. *Krishnan, R., Electric Motor & Drives: Modeling, Analysis & Control, PHI Pvt. Ltd. (2001).*
4. *Bose B.K., Modern Power Electronics & AC Drives, PHI Pvt. Ltd., (2001)*
5. *Leonard, W., Control of Electric Drives, Springer-Verlag, New York, (1985)*
6. *Miller, T.J.E., Brushless Permanent Magnet and Reluctance Motor Drives, Oxford Science, Oxford (1989).*

Evaluation Scheme:

S. No.	**Evaluation Elements**	**Weightage (%)**
1.	MST	25
2.	EST	40
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes etc.)	35

PPE203DIGITAL DRIVES

L	T	P	Cr
3	1	2	4.5

Course objectives: To learn about microcontrollers, PLC and other interfacing peripherals etc., and to impart knowledge about development of system. Foir control of drive.

8051 ARCHITECTURE : Architecture , memory organization , addressing modes , instruction set , Timers -,Interrupts ,I/O ports, Interfacing I/O Devices , Serial Communication.

8051 PROGRAMMING : Assembly language programming ,Arithmetic Instructions , Logical Instructions, Single bit Instructions , Timer Counter Programming, Serial Communication Programming Interrupt Programming , RTOS for 8051, RTOS Lite, Full RTOS, Task creation and run, LCD digital clock/thermometer using Full RTOS

PIC MICROCONTROLLER : Architecture, memory organization, addressing modes, instruction set, PIC programming in Assembly & C, I/O port, Data Conversion, RAM & ROM Allocation, Timer programming.

PERIPHERAL OF PIC MICROCONTROLLER : Timers – Interrupts, I/O ports- I2C bus-A/D converter, ART,CCP modules ,ADC, DAC and Sensor Interfacing ,Flash and EEPROM memories.

DIGITAL SIGNAL PROCESSORS: Computer Architecture for signal processing : Harvared Architecture, Pipelining , Hardware MAC unit, special instructions to DSP, Architecture of TMS320C5X , replication , On chip memory. Assembly language Instructions of TMS320C5X : Syntax ,Addressing modes, Instruction set

PROGRAMMABLE LOGIC CONTROLLER: Architecture, PLC programming, familiarisation of PLC external modules.

SYSTEM DESIGN : Interfacing LCD Display , Keypad Interfacing - Generation of Gate signals for converters and Inverters , Motor Control , Practical Aspects of Implementing Closed Loop Current control- Controlling DC/ AC appliances, Measurement of phase angle and frequency , Stand alone Data Acquisition System, Implementation of DSP algorithms on general purpose and special purpose digital signal processors: FIR digital filtering , IIR digital filtering-, FFT processing. PID controllers , implementation issues , motor control disk drive servo control , Stabilization/ pointing systems Microcontroller/DSP processor based controller, Micro Computer implementation for drives and its reversal. PLC based controller for drives.

Course Outcomes: After the completion of course the students may be able to

- To develop microcontroller based drive circuit of converters.
- To assemble drive system with control through DSPs,
- To devlop drive control application using PLC
- To analyse and validate the designed system

Recommended Books:

1. *Muhammad Ali Mazidi, Rolin D. Mckinlay, Danny Causey ‘ PIC Microcontroller and Embedded Systems using Assembly and C for PIC18’, Pearson Education 2008*
2. *John Iovine, ‘PIC Microcontroller Project Book ’, McGraw Hill 2000*
3. *Muhammad Ali Mazidi, Janice G. Mazidi and Rolin D. McKinlay, ‘The 8051 Microcontroller and Embedded Systems’ Prentice Hall, 2005*
4. *John.G.Proakis, Dimitrias.G. and Manolakis. “DSP principles Algorithms 3. Sanjit K.Mitra, “Digital Signal Processing A computer Based approach” TataMcGrawHill, Fourth Edition,2010.*

5. *Farzad Nekoogar, Gene moriarty. "Digital Control Using Digital Signal Processing" P.H.International Inc.New Jersey.1999.*

Evaluation Scheme:

S. No.	Evaluation Elements	Weightage (%)
1.	MST	25
2.	EST	35
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes etc.)	40

PPE204SYSTEM SIMULATION LABORATORY

L	T	P	Cr
0	**0**	**4**	**2.0**

To analyze, design and simulate different power converters studied in the core courses on power converters, Inverters and dynamics of electrical machines.

1. Simulation of single phase half and full wave controlled converter fed RLE load.
2. Simulation of single phase half and fully controlled converter fed RL/RLE load.
3. Simulation of three phase half and fully controlled converter fed RL/RLE load
4. Simulation of Single phase Dual converter in circulating and non circulating mode operation
5. Simulation of single phase ac phase controlled fed R/RL load (lighting and fan control)
6. Simulation of single phase VSI fed RL/RC load
7. Single phase full bridge inverter using PWM techniques
8. Simulation of i) LC tank circuit resonance Basic / modified series inverter
9. Series loaded series resonant inverter
10. Simulation of single phase current source inverter fed induction heating load.
11. Three phase inverter (120^0mode & 180^0mode)
12. Simulation of three phase to single phase cyclo - converter fed RL load
13. Three phase inverter fed induction motor drive
14. Simulation of Cascaded multilevel inverter and other topologies
15. Open loop and closed loop control of single phase semi converter fed dc drive
16. Open loop and closed loop control of chopper fed dc drive
17. Four quadrant operation of three-phase induction motor
18. Micro controller based speed control of Converter/Chopper fed DC motor
19. Micro controller based speed control of VSI fed three-phase induction motor
20. Simulation of converters through fuzzy logic controllers, Neural controllers.
21. Simulation of FACTS controller for power flow control
22. Simulation of dynamics of armature plunger / relay contactor arrangement.
23. Numerical solution of ordinary differential equations.
24. Numerical solution of partial differential equations.
25. System validation using dspace
26. System validation using pSpice/LTspice
27. Filter design using webench/nuhertz.

Evaluation Scheme:

S. No.	Evaluation Elements	Weightage (%)
1.	MST (Lab simulation)	10
2.	EST	35
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes etc.)	40

PPE DATA STRUCTURES USING OBJECT ORIENTED PROGRAMMING

L	T	P	Cr
3	**0**	**2**	**4.0**

urse Objectives: To learn about programming concepts, various data structures, searching d sorting of data techniques**,**

JECT ORIENTED PROGRAMMING: Overview of C++; Structures, Class Scope and Accessing Class Members, Reference Varial alization, Member Functions and Classes , Dyynamic Memory Allocation, Overloading: Function overloading and Operator Overloadi

IERITANCE & POLYMORPHISM : Base Classes and Derived Classes, Protected Members , Casting Class pointers and Mer ctions , Overriding , Public, Protected and Private Inheritance , Constructors and Destructors in derived Classes , Implicit Derived , C ect To Base ,Class Object Conversion ,Composition Vs. Inheritance , Virtual functions , Pointer

EAR DATA STRUCTURES: Arrays, Records, Strings and string processing, References and aliasing, Linked lists, Strategies osing the appropriate data structure, Abstract data types and their implementation: Stacks, Queues, Priority queues, Sets, Maps.

ic Analysis: Differences among best, expected, and worst case behaviours of an algorithm, Asymptotic analysis of upper and expe plexity bounds, Big O notation: formal definition and use, Little o, big omega and big theta notation, Complexity classes, such as cons rithmic, linear, quadratic, and exponential, Time and space trade-offs in algorithms, Recurrence relations, Analysis of iterative rsive algorithms.

ARCHING AND SORTING: Linear Search, Binary Search, Bubble Sort, Selection Sort, Insertion Sort, Shell Sort, Quick Sort, Heap S ge Sort, Counting Sort, Radix Sort.

GORITHMIC STRATEGIES WITH EXAMPLES AND PROBLEM SOLVING: Brute-force algorithms with examples, Gre rithms with examples, Divide-and-conquer algorithms with examples, Recursive backtracking, Dynamic Programming with examp nch-and-bound with examples, Heuristics, Reduction: transform-and-conquer with examples.

N-LINEAR DATA STRUCTURES AND SORTING ALGORITHMS: Hash tables, including strategies for avoiding and resol sions , Binary search trees, Common operations on binary search trees such as select min, max, insert, delete, iterate over tree, Graphs h algorithms, Representations of graphs, Depth- and breadth-first traversals, Heaps, Graphs and graph algorithms, Shortest-path algorit kstra and Floyd), Minimum spanning tree (Prim and Kruskal).

OBLEM CLAUSES: P, NP, NP- Hard and NP-complete, deterministic and non-deterministic polynomial time algorithm approxima algorithm for some NP complete problems. Introduction to parallel algorithms, Genetic algorithms, intelligent algorithms.

BORATORY WORK: Implementation of Arrays, Recursion, Stacks, Queues, Lists, Binary trees, Sorting techniques, Searching niques. Implementation of all the algorithmic techniques.

ommended Books

1. *Corman, Leiserson & Rivest, Introduction to Algorithms, MIT Press (2009), 3rd ed.*
2. *Langsam, Y. and Augenstein, M.J., Data Structures Using C and C++, Dorling Kindersley, 2008, 2nd ed.*
3. *Trembley, J.P., Sorenson, P.G., An introduction to data structures with applications, Tata McGraw Hill, 2008, 2nd ed.*
4. *Sahni, Sartaj, Data Structures, Algorithms and Applications in C++, Universities Press 2005, 2nd ed.*

luation Scheme:

No.	Evaluation Elements	Weightage (%)
1.	MST (Lab simulation)	10
2.	EST	35
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes etc.)	40

PVL FPGA BASED SYSTEM DESIGN

L	T	P	Cr
3	**0**	**2**	**4.0**

requisite: Digital Electronics

duction: Concepts of Hardware Description Languages and logic synthesis. (2L)

synthesis: Design cycle, types of synthesizers, design testing and verification, design optimization techniques, technology map L design hierarchy, objects, types and subtypes, design organization, VHDL design cycle. (5

binational Logic: Design units, entities and architectures, simulation and synthesis model, signals and ports, simple signal assignn tional signal and ents, selected signal assignment. (5L)

s and Operators: Synthesizable types, standard types, standard operators, scalar types, records, arrays, attributes, standard oper tor precedence, Boolean operators, comparison operators, arithmetic operators, concatenation operators. (5L)

age std_logic_arith: std_logic_arith package, making the package visible, content s of std_logic_arith, resize functions, operators, ions, type conversions, constant values, mixing types in expressions, numeric packages. (3L)

ential VHDL: Processes, signal assignments, variables, if statements, case statements. (3L)

sters: Simulation and synthesis model of register, register templates, clock types, gated registers, resettable registers, simulation moc hronous reset, asynchronous reset templates, registered variables. (3L)

archy: Role of components, using components, component instances, component declaration, Configuration specifications, default bin ng process, component packages, generate statements. (4

programs: Functions, type conversions, procedures, declaring subprograms. (3L)

Benches: Test benches, verifying responses, clocks and resets, printing response values, ng data files, reading standard types, error handling. (3L)

aries: Standard libraries, organising files, library names, library work, incremental compilation. (2L)

: Moore and Mealy machine modelling (3L)

A: Introduction, Logic Block Architecture, Routing Architecture, Programmable, Interconnection, Design Flow, Xilinx Vir itecture), Boundary Scan, Programming FPGA's, Constraint Editor, Static Timing Analysis, One hot encoding, Applications, Tools, , Xilinx Virtex II Pro.. (4L)

ratory Work: Modeling and simulation of all VHDL constructs using ModelSim, their testing by modeling andsimulating test ben Synthesis using FPGA Advantage, Mapping on FPGA Boards. (15)

T BOOKS

. Charles H. Roth, Digital System Design Using VHDL , Jr.,Thomson, (2008)2nd Ed.
. Bhaskar, J., A VHDL Primer, Pearson Education/ Prentice Hall (2006)3rd Ed.

ERENCE BOOKS

. Rushton, A., VHDL for Logic Synthesis, Wiley (1998) 2ed.
. Ashenden, P., The Designer's Guide To VHDL, Elsevier (2008) 3rd ed.

PEE DIGITAL SIGNAL PROCESSING AND APPLICATION

L	T	P	Cr
3	1	2	4.5

view: Concept of frequency in continuous and discrete time signals, A–D Conversion process, Sampling Theorem, Introductio
fication of discrete time signals and systems, Analysis of discrete linear time-invariant (LTI) systems, Convolution and correlati
ete time signals, Implementation of discrete time systems.

ansform: Z-Transform and inverse z-transform, rational z-transform, Analysis of Linear Time Invariant (LTI) systems in z-domain.

uency Analysis of Signals and System: Frequency analysis of continuous and discrete time signals, Fourier series and Fourier Tran
screte and continuous periodic and non periodic signals.

ete Fourier Transform: Frequency domain sampling, Discrete Fourier Transform (DFT), Linear filtering methods based on
uency analysis of signals using DFT, Fast Fourier Transform (FFT), FFT algorithms, Methods and Applications of FFT algorithms.

al Filter Design: Digital filter, filter design, Infinite Impulse Filter (IIR), finite Impulse filters (FIR)

irate Signal Processing: Decimation and Interpolation, Sample rate conversion by Integer and Non-Integer factors.

dom Signals: Random variables, random process, auto-correlation functions, power spectrum density, filtering random signals, wi ion, wavelet transform, spectrum analysis of random signals.

ications to Drive Systems : DSP applications to power systems such as measurement of frequency, measurement of harmonic onic analysis, static and digital relays, digital protection, power metering, magnetic field measurement.

Processor: Architecture and instruction set of TMS 320C 54X and examples.

ratory: Determination of Z, Fourier transform, Design of FIR and IIR Filters, Realization of Prediction, equalizer and compre ithms, use of wavelet transform,

mmended Books

. *Proakis, J.G., and Manolakis D.G., Digital Signal Processing, Prentice Hall of India Private Limited, (1996).*
. *Rabiner, C.R., and Gold, B., Theory and Applications of Digital Signal Processing, Prentice Hall of India Private Limited (2000).*
. *Helmut, U., Wilibald, W. and Andrzej, W., Protection Techniques in Electrical Energy Systems, CRC Press, New York (1995).*
. *Oppenhein, A.V., and Schafer, R.W., Discrete Time Signal Processing, Prentice Hall of India Private Limited (2001).*
. *Antoniou, A., Digital Filters: Analysis, Design and Application, Tata McGraw–Hill Publishing Company (1999).*

PEE216 DIGITAL CONTROL SYSTEMS

L	T	P	Cr
3	1	0	3.5

rse Objectives: To review the discrete control system and their mathematical modeling and impart learning about s-plane and z-plane transform derstand the state diagrams and their analysis, To know about the stability criteria in control systems

oduction: Review of discrete data control system, Signal conversion and processing, mathematical modeling of convolution integra ling process, S-plane properties

ansform: Definition, relation between Laplace and z-transform, s-plane and z-plane, inverse z-transform, z-transform theorems, diffe ion solutions, delayed and modified z-transform.

ysis of Digital Control Systems: Transfer functions, block diagrams andsignal flow graph, closed loop system characteristic equ -rate discrete data system, state equations and state transition equations, Eigen values and eigen-vector, state diagram and decomposit ete data transfer functions, controllability and observability.

ility Analysis: Steady state error analysis of digital control systems, Root locus for digital control systems, effect of addition of pole , polar plot of GH(z), Jury's stability test, Nyquist stability criteria, Lyapunov stability criteria, concept of relative stability

gn of discrete data control system: Digital PID controller, design in z-plane using Root-locus, Design of robust control systems, al control with energy constraints. Principle of optimality and dynamic programming, adaptive control systems.

rse Learning Outcome: On the completion of the course, the student will be able

o learn about the discrete digital control system
o perform the stability analysis using various techniques,
o design and develop of PID controller

mmended Books

Kuo B.C., Digital Control Systems, Oxford univ. press, 2nd ed., (2009)
Ogatta, K., Discrete time control systems, Prentice Hall, Int. ed., (1987)

Franklin G.F., Powell J.D., & Workman M.L., *Digital Control of Dynamic Systems*, 2nd ed., Addison-Wesley, Reading, (1990)
Gopal M., *Modern Control System Theory*, Wiley Eastern 2nd ed., (1993)

uation Scheme:

No.	Evaluation Elements	Weightage (%)
.	MST	30
2.	EST	45
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes etc.)	25

PPE SENSORS AND SIGNAL CONDITIONING

L	T	P	Cr
2	1	2	3.5

requisite(s): None

SORS/TRANSDUCERS:TRANSDUCERS PRINCIPLES: Classification, static and dynamic characteristic of transducers, classific nsducers, resistive strain gauges, capacitive transducer, inductive, Piezoelectric transducer, Temperature transducers: RTD, Therm mocouple, Encoders, Absolute and incremental encoders, Tacho meters, Torque measurement, MEMS (torque, speed etc.), accelerom mity sensors.

NAL CONDITIONING: Nature of signal and noise, frequency domain analysis of signals, types of noise, interfering and modifying sig ational Amplifiers and signal conditioning circuits, instrumentation amplifier and their transfer characteristics, wheat stone bridge circui ducers, analog to digital and digital to analog circuits, , voltage to frequency and frequency to voltage converters, PWM based firing con ts

DGE CIRCUITS: Null type bridge, Voltage sensitive deflection type bridge, Current sensitive deflection type bridge, bridge circui ducers.

TERS AND CIRCUITS: Introduction, Frequency and time domain analysis of low pass, high pass, band pass, and band stop filters. - Butterworth, Chebyshev, Bessel, Elliptic. Design of active high-pass, low pass, band-stop, and all-pass filters. Frequency discrimin ators, linear voltage regulator, , First order, Second order and higher order filters, introduction to Digital filters.

LICATIONS OF SIGNAL CONDITIONING TO ELECTRIC DRIVES: Selection of sensors, Wheatstone bridge circuits, Active n using standard approaches, GUI design for condition monitoring of drive systems

ORATORY : Measurement of electrical parameters**,** Speed and torque measurement, design of firing and control circuits for convert applications.

mmended Books

. *Doebelin, E.O. and manic, D.N., Measurement Systems: Applications and Design, McGraw–Hill (2004) 5th ed.*
. *Nakra, B.C. and Chaudhry, K.K., Instrumentation, Measurement and Analysis, Tata McGraw Hill (2003).*
. *Murthy, D.V.S., Transducers and Instrumentation, Prentice Hall of India (2003).*
. *Sawhney, A.K. and Sawhney, Puneet, A Course in Electrical and Electronic Measurements and Instrumentation, Dhanpat Rai (2008 ed.*
. *Mohan. N et al.,"Power Electronics: Converters, Applications and Design", John Wiley and Sons, Newyork, Third Edition,2002.*

uation Scheme:

No.	**Evaluation Elements**	**Weightage (%)**
.	MST	25
2.	EST	35
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes etc.)	40

PEE309 POWER QUALITY & CUSTOM POWER

L	T	P
3	1	0

rse Objectives: To understand the basics and need of power quality indices, non linear and unbalanced loads and their characteristics, measurem ical quantities and their analysis in frequency and time domain, remedial techniques for improvement in power quality

oduction: Introduction – Characterisation of Electric Power Quality: Transients, short duration and long duration voltage variations, Vo ance, waveform distortion, Voltage fluctuations, Power frequency variation, Power acceptability curves – power quality problems: power factor, Non-linear and unbalanced loads, DC offset in loads, Notching in load voltage, Disturbance in supply voltage – Power q ards.

-Linear Loads: Single phase static and rotating AC/DC converters, Three phase static AC/DC converters, Battery chargers, Arc furn escent lighting, Induction lamp, HID ballast, pulse modulated devices, Adjustable speed drives.

surement And Analysis Methods: Voltage, Current, Power and Energy measurements, power factor measurements and defini recorders, Measurement Error – Analysis: Analysis in the periodic steady state, Time domain methods, Frequency domain met ce's, Fourier and Hartley transform – The Walsh Transform – Wavelet Transform.

ysis And Conventional Mitigation Methods: Analysis of power outages, Analysis of unbalance: Symmetrical components of p ities, Instantaneous symmetrical components, Instantaneous real and reactive powers, Analysis of distortion: On–line extractio amental sequence components from measured samples – Harmonic indices – Analysis of voltage sag: Detorit Edison sag score, Voltag y, Voltage Sag Lost Energy Index (VSLEI)- Analysis of voltage flicker, Reduced duration and customer impact of outages, Classical cing problem: Open loop balancing, Closed loop balancing, current balancing, Harmonic reduction, Voltage sag reduction.

er Quality Improvement: Utility-Customer interface – Harmonic filters: passive, Active and hybrid filters –Custom power dev ork reconfiguring Devices, Load compensation using DSTATCOM, Voltage regulation using DSTATCOM, protecting sensitive loads , UPQC – control strategies: P-Q theory, Synchronous detection method – Custom power park – Status of application of custom p es. Difference in role of FACTS devices in transmission and distribution networks.

rse Learning Outcome: On the completion of the course, the student will be able

To understand power quality standards.
To identify linear and non linear loads.
To know about various measurement techniques of voltage and current paparmeters.
To analyse harmonics and their mitigation
To acquire knowledge of custom power devices and their role in T&D system.

ecommended Books

Ghosh, A. and Ledwich, G., Power Quality Enhancement using Custom Power Devices, Kluwer Academic Publishers (2002).
G.T.Heydt, "Electric Power Quality", 2nd Ed, , Stars in a Circle Publications, (1994).
C. Sankaran, "Power Quality", CRC Press, 2002.
Derek A. Paice, Power electronic converter harmonics, Prentice Hall Int., 2003

uation Scheme:

Io.	**Evaluation Elements**	**Weightage (%)**
.	MST	30
2.	EST	45
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes etc.)	25

PEE308 RENEWABLE ENERGY SYSTEMS

L	T	P	Cr
2	1	2	3.5

duction: Energy resources: renewable energy: solar, wind, hydropower, biomass, geothermal, ocean wave; benefit, costs, and polic wable energy; Environmental issues of energy services, renewable sources integration – overcoming intermittence; centralized vs. distri ation.

lamentals of Wind Energy Conversion System Control : Speed and Power Relations, Power Extracted from the Wind, Horizontal cal-Axis Wind Turbines, Fixed-and Variable-Speed Turbine, Aerodynamic Power Control: Passive Stall, Active Stall, and Pitch Contro d Ratio, Wind Generators.

er Converters in Wind Energy Conversion Systems : Wind Energy System Configurations**,** Fixed-Speed Induction Generator WE ble-Speed Wind Energy Systems with Squirrel Cage and Doubly Fed Induction Generator (DFIG)) Based WECS, Variable-Speed gy Systems with Synchronous, Permanent Magnet Generator (PMG). Control of DFIG & PMG

r Photovoltaic Power System: Solar PV cell panel, operation, design of solar thermal System, MPPT algorithm

l-alone & Grid connected systems: Optimal economic coordinated operation of conventional and renewable sources, Operational issue enges

gy storage systems and their applications; Energy Storage systems, Fuel Cells, Superconducting magnetic systems, Pumped storage pressed Air storage unit, Plug-in Hybrid Electric Vehicle (PHEV)

mmendedBooks

. *Simon , Christopher A., Alternate Source of Energy, Rowman and Little Field Publishers Inc.(2007).*
. *Patel, M. R., Wind and Solar Power Systems. Boca Raton, FL: CRC Press, (1999)*
. *Venikov, V.A. and Putyain, E.V., Introduction to Energy Technology, Mir Publishers (1990).*
. *Masters G. M., Renewable And Efficient Electric Power Systems, John Wiley & Sons, (2004).*

PPE331POWER SYSTEM HARMONICS AND FILTERS

L	T	P	Cr
3	1	0	3.5

Course Objectives: To impart knowledge about harmonics, their sources, limits and their effect in power converter circuits and to learn about filters

HARMONIC ANALYSIS: Representation of harmonics, Fourier series and Coefficients, Measures of harmonic distortion namely voltage and current distortion factors, active and reactive power, apparent power, distortion power, power factor, displacement power factor, current and voltage crest factors, Harmonic Voltage Factor, Series and parallel resonance.

LIMITS OF HARMONIC DISTORTION: Voltage harmonic distortion limits: IEEE limits, IEC limits EN limits and NORSOK limit. Current harmonic distortion limits: IEEE limits IEC limits and NORSOK limits.

SOURCE OF HARMONICS: Introduction to harmonics, Types of Loads, Source of harmonics: Electromagnetic Interference, Stray Harmonic Torque and Pulsating Harmonic Torque in AC Drive, Power Quality Indices, Traditional and future sources of harmonics, Standardization of harmonics levels, Harmonic in transformers and inrush current, Harmonic in rotating Machines (mmf distribution of ac windings, slot harmonics, voltage harmonics produced by synchronous machines, rotor saliency effects, voltage harmonics produced by induction motors. Distortion caused by arcing devices: Electric arc furnaces and discharge type lighting. Distortion caused by dc power supplies.

EFFECTS OF HARMONICS: Effects on power system equipment, communication system, Solid state Devices etc. Thermal losses in harmonic environment, Harmonic amplification in capacitor banks, Effects of harmonics in transformers, Effects of harmonics in rotating machines, Harmonic interference with power system protection, harmonic problems during fault conditions, Effects of harmonics on consumer equipment, Interference with Communications.

HARMONICS ELIMINATION TECHNIQUE: Modulation based harmonics elimination technique, optimal PWM technique, Tuned and damped passive filters, Series and parallel connection of passive & active filters, Role of power converters, transformers, rotating machines and capacitor banks in reduction of harmonics, design of Series tuned filters and second order damped filters. Series Active Filtering in Harmonic Isolation Mode, Dynamic Voltage Restorer and its control, Power Quality Conditioner, Shunt Current Injection Type Filter and its Control. Three Phase three-wire and four-wire Shunt Active Filtering and their control using p-q theory and d-q modelling. Hybrid Filtering using Shunt Active Filters . Series Active Filtering in Harmonic Cancellation Mode .

HARMONIC MEASUREMENT AND ANALYSIS: THD and DIN**,** Methods of harmonics measurement & analysis in different PCC. Harmonic source representation, Harmonic Propagation facts, flux of harmonic currents, Interrelation between AC system and Load Parameters Analysis methods

Course Outcomes: After the completion of course the student may be able

- To conceptualize harmonics and their effect
- To measure harmonic components
- To analyse the harmonics in a circuit
- To develop the active filter circuit

Recommended Books:

1. *Francisco C. De La Rosa, Harmonics and Power systems,Taylor& Francis group, CRC Press*
2. *J. Arrillaga, N.R. Watson, Power System Harmonics, Second Edition, John Wiley & Sons.*
3. *Deare A Paice, Power Electronics Converter Harmonics, IEEE Press.*
4. *Hirofumi Akagi, Instantaneous Power Theory and Application to Power Conditioning IEEE Press.*
5. *Power Systems Harmonics, George J. Wakileh, Springer*

Evaluation Scheme:

S. No.	Evaluation Elements	Weightage (%)
1.	MST	30
2.	EST	45
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes etc.)	25

PPE SWITCHED MODE POWER SUPPLIES & UPS

L	T	P	Cr
3	**1**	**0**	**3.5**

Course Objectives: To understand development of switched mode power supplies
DC-DC CONVERTERS: Principles of step-down and step-up converters – Analysis and state space modeling of Buck, Boost, Buck- Boost and Cuk converters.

SWITCHING MODE POWER CONVERTERS: Analysis and state space modeling of flyback, Forward, Half bridge and full bridge converters, control circuits and PWM techniques.

RESONANT CONVERTERS: Introduction- classification- basic concepts- Resonant switch, Load Resonant converters, ZVS , Clamped voltage topologies, DC link inverters with Zero Voltage Switching- Series and parallel Resonant inverters, Voltage control .

DC-AC CONVERTERS: Single phase and three phase inverters, control using various (sine PWM, SVPWM and advanced modulation) techniques, various harmonic elimination techniques, Multilevel inverters, Concepts , Types: Diode clamped, Flying capacitor, Cascaded types, Applications.

POWER CONDITIONERS, UPS & FILTERS: Introduction- Power line disturbances- Power conditioners, UPS: offline UPS, Online UPS, Applications, Filters: Voltage filters, Series-parallel resonant filters, filter without series capacitors, filters for PWM VSI, current filter, DC filters , Design of inductor and transformer for PE applications , Selection of capacitors.
Course outcomes: After the completion of course the student may be able

- To analyse dc dc buck-boost converters
- To realise control strategies of resonant converters
- To realise harmonic elimination using PWM techniques
- To design and develop active and passive filters

Recommended Books

1. *M.H. Rashid – Power Electronics handbook, Elsevier Publication, (2001)*
2. *Kjeld Thorborg, "Power Electronics – In theory and Practice", Overseas Press, First Indian Edition (2005).*
3. *Philip T Krein, " Elements of Power Electronics", Oxford University Press*
4. *Ned Mohan, Tore. M.. Undeland, William. P. Robbins, Power Electronics converters, Applications and design- Third Edition- John Wiley and Sons. (2006)*
5. *M.H. Rashid – Power Electronics circuits, devices and applications- third edition Prentice Hall of India New Delhi, (2007).*

Evaluation Scheme:

S. No.	Evaluation Elements	Weightage (%)
1.	MST	30
2.	EST	45
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes etc.)	25

PPE341 DIGITAL INSTRUMENTATION AND ITS APPLICATIONS

L	T	P	Cr
3	1	2	4.5

Prerequisite(s):

DATA ACQUISITION SYSTEMS : Overview of A/D converter, types and characteristics – Sampling , Errors. Objective –Building blocks of Automation systems –Counters – Modes of operation- Frequency,Period, Time interval measurements, Prescaler, Heterodyne converter for frequency measurement, Single and Multi channel Data Acquisition systems.

INTERFACING AND DATA TRANSMISSION : Data transmission systems – 8086 Microprocessor based system design – Peripheral Interfaces – Time Division Multiplexing (TDM) – Digital Modulation – Pulse Modulation – Pulse Code Format – Interface systems and standards – Communications.

INSTRUMENTATION BUS : Introduction, Modem standards, Basic requirements of Instrument Bus standards, Bus communication, interrupt and data handshaking , Interoperability, interchangeability for RS-232, USB, RS-422, RS-485. PCMCIA, VXI, SCXI, PXI, CAN etc., Networking basics for office and industrial applications, VISA and IVI, Motion Control.

VIRTUAL INSTRUMENTATION : Block diagram and Architecture – Data flow techniques – Graphical programming using GUI – Real time Embedded system –Intelligent controller – Software and hardware simulation of I/O communication blocks-peripheral interface – ADC/DAC – Digital I/O Counter , Timer.

CASE STUDIES: PC based DAS, Data loggers, PC based Electric drive monitoring and control system, Interfacing development

Recommended Books:

1. *A.J. Bouwens, "Digital Instrumentation" , TATA McGraw-Hill Edition, 1998.*
2. *N. Mathivanan, "Microprocessors, PC Hardware and Interfacing", Prentice-Hall India,2005.*
3. *H S Kalsi, "Electronic Instrumentation" Second Edition, Tata McGraw-Hill,2006.*
4. *Joseph J. Carr, "Elements of Electronic Instrumentation and Measurement" Third Edition, Pearson Education, 2003.*
5. *Buchanan, "Computer busses", Arnold, London,2000.*
6. *Jonathan W Valvano, "Embedded Microcomputer systems", Asia Pvt. Ltd., Brooks/Cole, Thomson, 2001.*
7. *Johnson, G., LabVIEW Graphical Programming, McGraw Hill (2006) 4th ed.*

Evaluation Scheme:

S. No.	Evaluation Elements	Weightage (%)
1.	MST	25
2.	EST	35
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes etc.)	40

PPE342DISTRIBUTED GENERATION AND MICROGRID

	L	T	P	Cr
	3	**1**	**0**	**3.5**

Course Objectives: To impart knowledge about distributed generation technologies, their interconnection in grid, to understand relevance of power electronics in DG, to understand concept of microgrid

DISTRIBUTED GENERATION (DG) TECHNOLOGIES : Introduction, Comparative study between conventional and non-conventional methods of power generation: energy crisis due to scarcity of fossil fuel, distributed generation (DG) overview and technology trend. Working principle, architecture and application of renewable DG technologies: Solar PV, bioenergy, wind energy, hydroelectricity, tidal power, wave energy, geothermal energy etc. Non-conventional technology based DGs: Fuel cells, CHP based microturbine, IC engines, etc. Storage based DGs: Storage technology: Battery, super capacitor, flywheel etc.

INTERCONNECTION ISSUES AND STANDARDS OF DGs. : Concept of distributed generations (DG) or distributed energy resources (DERs), topologies, selection of source, dependence on storage facilities, regulatory standards/ framework, standards for interconnecting DGs to electric power systems: IEEE 1547. DG installation classes, security issues in DG implementations. Grid code and Islanding & non-islanding system

OPERATIONAL FEATURES OF GRID CONNECTED DG SYTEMS : Grid interconnection issues for grid connected operation of various types of DG systems. Constraints on operational parameters: voltage, frequency, THD, response to grid abnormal operating conditions, islanding issues. Reliability, stability and power quality issues involved in grid connected operation of various DGs.

POWER ELECTRONICS AND DG SYSTEMS : Relevance of power electronics in DG applications, Power quality requirements and source switching using SCR based static switches, Distribution system loading, line drop model, series voltage regulators and on line tap changers, power converter topologies, model and specifications for DG applications, issues filter designs, harmonic reduction, Control of DG inverters, phase locked loops, current control and DC voltage control for stand alone and grid parallel operations. Protection of converters, power quality implication, acceptable ranges of voltage and frequency, reactive power compensation and active filtering.

OPERATION, CONTROL AND MODELLING OF MICROGRID : Concept and definition of microgrid, review of sources of microgrids, typical structure and configuration of a microgrid, microgrid implementation in Indian and international scenario, AC and DC microgrids, Power Electronics interfaces in DC and AC microgrids, communication infrastructure, modes of operation and control of microgrid: grid connected and islanded mode operation, anti-islanding schemes. Control techniques for voltage, frequency, active and reactive power control of microgrid system, Computer aided Modelling of microgrid.

INTRODUCTION TO RELIABILITY AND MARKET ISSUES OF MICROGRID: Power quality issue, THD reduction techniques, protection and stability analysis of microgrid, regulatory standards, introduction to microgrid reliability. Features of microgrid economy and market. LVDC Microgrid.

Recommended Books:

1. *Renewable Energy- Power for a sustainable future, third edition, Edited by Godfrey Boyle, Oxford University Press, 2013.*
2. *Amirnaser Yezdani, and Reza Iravani, "Voltage Source Converters in Power Systems: Modeling, Control and Applications", IEEE John Wiley Publications, 2009.*
3. *Dorin Neacsu, "Power Switching Converters: Medium and High Power", CRC Press, Taylor & Francis, 2006. New Delhi.*
4. *Microgrids: Architectures and Control, Nikos Hatziargyriou (Editor), ISBN: 978-1-118-72068-4, 340 pages, December 2013, Wiley-IEEE Press*
5. *Microgrids and Active Distribution Networks, S. Chowdhury, S.P. Chowdhury and P. Crossley, The Institution of Engineering and Technology, London, U.K, 2009.*
6. *Technical literatures- research papers published in power system and power electronics related reputed journals and IEEE standards.*

Evaluation Scheme:

S. No.	Evaluation Elements	Weightage (%)
1.	MST	30
2.	EST	45
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes etc.)	25

PEE309 POWER QUALITY & CUSTOM POWER

L	T	P	Cr
3	1	0	3.5

Course Objectives: To understand the basics and need of power quality indices, non linear and unbalanced loads and their characteristics, measurement of electrical quantities and their analysis in frequency and time domain, remedial techniques for improvement in power quality

Introduction: Introduction – Characterisation of Electric Power Quality: Transients, short duration and long duration voltage variations, Voltage imbalance, waveform distortion, Voltage fluctuations, Power frequency variation, Power acceptability curves – power quality problems: poor load power factor, Non-linear and unbalanced loads, DC offset in loads, Notching in load voltage, Disturbance in supply voltage – Power quality standards.

Non-Linear Loads: Single phase static and rotating AC/DC converters, Three phase static AC/DC converters, Battery chargers, Arc furnaces, Fluorescent lighting, Induction lamp, HID ballast, pulse modulated devices, Adjustable speed drives.

Measurement And Analysis Methods: Voltage, Current, Power and Energy measurements, power factor measurements and definitions, event recorders, Measurement Error – Analysis: Analysis in the periodic steady state, Time domain methods, Frequency domain methods: Laplace’s, Fourier and Hartley transform – The Walsh Transform – Wavelet Transform.

Analysis And Conventional Mitigation Methods: Analysis of power outages, Analysis of unbalance: Symmetrical components of phasor quantities, Instantaneous symmetrical components, Instantaneous real and reactive powers, Analysis of distortion: On–line extraction of fundamental sequence components from measured samples – Harmonic indices – Analysis of voltage sag: Detorit Edison sag score, Voltage sag energy, Voltage Sag Lost Energy Index (VSLEI)- Analysis of voltage flicker, Reduced duration and customer impact of outages, Classical load balancing problem: Open loop balancing, Closed loop balancing, current balancing, Harmonic reduction, Voltage sag reduction.

Power Quality Improvement: Utility-Customer interface – Harmonic filters: passive, Active and hybrid filters –Custom power devices: Network reconfiguring Devices, Load compensation using DSTATCOM, Voltage regulation using DSTATCOM, protecting sensitive loads using DVR, UPQC – control strategies: P-Q theory, Synchronous detection method – Custom power park – Status of application of custom power devices. Difference in role of FACTS devices in transmission and distribution networks.

Course Learning Outcome: On the completion of the course, the student will be able

- To understand power quality standards.
- To identify linear and non linear loads.
- To know about various measurement techniques of voltage and current paparmeters.
- To analyse harmonics and their mitigation
- To acquire knowledge of custom power devices and their role in T&D system.

Recommended Books

5. *Ghosh, A. and Ledwich, G., Power Quality Enhancement using Custom Power Devices, Kluwer Academic Publishers (2002).*
6. *G.T.Heydt, “Electric Power Quality”, 2nd Ed, , Stars in a Circle Publications, (1994).*
7. C. Sankaran, “Power Quality”, CRC Press, 2002.
8. *Derek A. Paice, Power electronic converter harmonics, Prentice Hall Int., 2003*

Evaluation Scheme:

S. No.	Evaluation Elements	Weightage (%)
1.	MST	30
2.	EST	45
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes etc.)	25

PEE308 RENEWABLE ENERGY SYSTEMS

L	T	P	Cr
3	1	2	3.5

Course Objectives: To impart knowledge about renewable energy resources, their control, Modes of operation and other energy storage systems

Introduction: Energy resources: renewable energy: solar, wind, hydropower, biomass, geothermal, ocean wave; benefit, costs, and policies of renewable energy; Environmental issues of energy services, renewable sources integration – overcoming intermittence; centralized vs. distributed generation.

Fundamentals of Wind Energy Conversion System Control : Speed and Power Relations, Power Extracted from the Wind, Horizontal- and Vertical-Axis Wind Turbines, Fixed-and Variable-Speed Turbine, Aerodynamic Power Control: Passive Stall, Active Stall, and Pitch Control, Tip Speed Ratio, Wind Generators.

Power Converters in Wind Energy Conversion Systems : Wind Energy System Configurations**,** Fixed-Speed Induction Generator WECS , Variable-Speed Wind Energy Systems with Squirrel Cage and Doubly Fed Induction Generator (DFIG)) Based WECS, Variable-Speed Wind Energy Systems with Synchronous, Permanent Magnet Generator (PMG). Control of DFIG & PMG

Solar Photovoltaic Power System: Solar PV cell panel, operation, design of solar thermal System, MPPT algorithm

Stand-alone & Grid connected systems: Optimal economic coordinated operation of conventional and renewable sources, Operational issues and challenges

Energy storage systems and their applications; Energy Storage systems, Fuel Cells, Superconducting magnetic systems, Pumped storage unit, Compressed Air storage unit, Plug-in Hybrid Electric Vehicle (PHEV)

Course Outcome: after the completion of the course the student may be able to

- To identify various renewable energy resources
- To realize their control strategies
- To analyse wind and solar dc system
- To conceptualize operation of renewable sources in standalone mode and grid connected mode

RecommendedBooks

1. *Simon , Christopher A., Alternate Source of Energy, Rowman and Little Field Publishers Inc.(2007).*
2. *Patel, M. R., Wind and Solar Power Systems. Boca Raton, FL: CRC Press, (1999)*
3. *Venikov, V.A. and Putyain, E.V., Introduction to Energy Technology, Mir Publishers (1990).*
4. *Masters G. M., Renewable And Efficient Electric Power Systems, John Wiley & Sons, (2004).*

Evaluation Scheme:

S. No.	Evaluation Elements	Weightage (%)
1.	MST	25
2.	EST	35
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes etc.)	40

PEE305 LOAD AND ENERGY MANAGEMENT

L	T	P	Cr
3	1	0	3.5

Course Objectives: To understand the basics of load forecasting and need of forecasting , method of forecasting, To know the steps involved in load management , different tariff structure in our country .impacts of load management and understanding through different case studies, benchmarking in energy management.

Load Forecasting: Classification and characterization of loads, Approaches to load forecasting, Forecasting methodology, Energy forecasting, Peak demand forecasting, Non–weather sensitive forecast and Weather sensitive forecast, Total forecast, Annual and monthly peak demand forecasts, Applications of state estimation to load forecasting.

Load Management: Introduction to Load management, Electric energy production and delivery system structure (EEPDS), Design alternatives for EEPD systems, Communication/control techniques for load management, Tariff structure and load management, principles of macro and microeconomics and energy pricing strategies, Assessing the impacts of load management.

Energy Demand Forecasting: Static and dynamic analysis of energy demand, Elements of energy demand forecasting, Methodologies and models for energy demand forecasting, Techno–economic approach in energy demand forecasting.

Energy auditing, Energy management, Power Pools and Energy Banking

Trends And Case Studies: Energy management strategy, Symbiotic relation between information, Energy models and decision making, Case studies like industrial energy forecasting, Transportation energy forecasting, Residential, Commercial and agricultural energy forecasting

Course Learning Outcome: On the completion of the course, the student will be able

- To be familiar with different load forecasting method used in power system,
- To understand different phase of load management and impacts of load management
- To understand the concept of energy demand and method to satisfy meet the energy demand
- To understand the measurement of energy conservation and its case studies
- To be familiar with ways of saving electricity in different utilities. Different phase of energy audit.
- To understand the role of energy management and energy forecasting

Recommended Books

2. *Martino J., Technological Forecasting for Decision Making", Elsevier Press (1972).*
3. *Gellings C.W. and Penn Well P.E. "Demand Forecasting in the Electric Utility Industry", Fairmount Press (1992).*
4. *Makridakis S., "Forecasting Methods and Applications", John Wiley and Sons (1997).*
5. *Brown, R.G., Smoothing, forecasting and prediction of discrete time series, PHI Int. (1963)*

Evaluation Scheme:

S. No.	Evaluation Elements	Weightage (%)
1.	MST	30
2.	EST	45
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes etc.)	25

PEE322 HVAC AND HVDC TRANSMISSION SYSTEMS

L	T	P	Cr
3	1	0	3.5

Course Objectives: To know modern transmission systems using HVDC and HVAC, to understand study static VAr system, corona and radio & TV interference and to learn design filters for harmonics reduction.

Overview: Comparison of EHVAC and HVDC transmission, Description of DC transmission systems, Modern trends in AC and DC transmission.

HVAC System: Limitations of extra long AC transmission, Voltage profile and voltage gradient of conductor, Electrostatic field of transmission line, Reactive Power planning and control, Traveling and standing waves, EHV cable transmission system.

Static VAr System: Reactive VAr requirements, Static VAr systems, SVC in power systems, Design concepts and analysis for system dynamic performance, Voltage support, Damping and reactive support.

HVDC System: Converter configurations and their characteristics, DC link control, Converter control characteristics, Monopolar operation, Converter with and without overlap, Smoothing reactors, Transients in DC line, Converter faults and protection, HVDC breakers.

Corona and Interference: Corona and corona loss due to HVAC and HVDC, Radio and TV interference due to HVAC and HVDC systems, Methods to reduce noise, Radio and TV interference.

Harmonic Filters: Generation of harmonics, Design of AC filters, DC filters.

Power Flow Analysis in AC/DC Systems: Modelling, Solution of DC load flow, Solution techniques of AC/DC power flow equations, Parallel operation of HVDC/AC systems, Multi terminal systems.

Course Learning Outcome: On the completion of the course, the student will be able

- To learn HVAC and HVDC transmission systems.
- To analyse system dynamic performance and reactive power requirements.
- To know about corona and radio & TV interference.
- To design filters for reduction of harmonics.
- To solve power flow equations.

Recommended Books

1. *Arrillaga, J., HVDC Transmission, IEE Press (2007).*
2. *Arrillaga, J. and Smith, B.C., AC to DC Power System Analysis, IEE Press (2008).*
3. *Begamudre, R..D., EHVAC Transmission Engineering, New Age International (P) Limited, Publishers (2006).*
4. *Edwart, K., Direct Current Transmission (Vol. 1), John Wiley and Sons (2008).*
5. *Padiyar, K.R., HVDC Power Transmission Systems, New Age International (P) Limited, Publishers (2008).*

Evaluation Scheme:

S. No.	Evaluation Elements	Weightage (%)
1.	MST	30
2.	EST	45
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes etc.)	25