KONGU ENGINEERING COLLEGE, PERUNDURAI, ERODE – 638 052
(Autonomous)

M.E. DEGREE IN POWER ELECTRONICS AND DRIVES (FULL TIME)

CURRICULUM
(For the candidates admitted from academic year 2014 – 15 onwards)

SEMESTER – I

Course Code	Course Title	Hours/ Week			Credit	Maximum Marks		
		L	T	P		CA	ESE	Total
	THEORY							
14AMT18	Applied Mathematics for Electrical Engineers	3	1	0	4	40	60	100
14AET12	System Theory	3	1	0	4	40	60	100
14PET11	Modeling and Analysis of Electrical Machines	3	1	0	4	40	60	100
14PET12	A.C. Converters	3	0	0	3	40	60	100
14PET13	Power Semiconductor Devices and D.C. Converters	3	0	0	3	40	60	100
14AET15	Computational Intelligence Techniques	3	1	0	4	40	60	100
	PRACTICAL							
14PEL11	Modern Power Electronics Laboratory	0	0	3	1	100	0	100
				Total	**23**			

CA - Continuous Assessment, ESE – End Semester Examination

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M.E. DEGREE IN POWER ELECTRONICS AND DRIVES (FULL TIME)

CURRICULUM
(For the candidates admitted from academic year 2014 – 15 onwards)

SEMESTER – II

Course Code	Course Title	Hours/ Week			Credit	Maximum Marks		
		L	T	P		CA	ESE	Total
	THEORY							
14PET21	Solid State DC Drives	3	1	0	4	40	60	100
14PET22	Solid State AC Drives	3	1	0	4	40	60	100
14PET23	Power Electronics for Renewable Energy Systems	3	0	0	3	40	60	100
	Elective-I (Professional)	3	0	0	3	40	60	100
	Elective-II (Professional)	3	0	0	3	40	60	100
	Elective-III (Professional)	3	0	0	3	40	60	100
	PRACTICAL							
14PEL21	Modern Drives Laboratory	0	0	3	1	100	0	100
14PEL22	Computer Aided Simulation Laboratory	0	0	3	1	100	0	100
				Total	**22**			

CA - Continuous Assessment, ESE – End Semester Examination

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M.E. DEGREE IN POWER ELECTRONICS AND DRIVES (FULL TIME)

CURRICULUM
(For the candidates admitted from academic year 2014 – 15 onwards)

SEMESTER – III

Course Code	Course Title	Hours/ Week			Credit	Maximum Marks		
		L	T	P		CA	ESE	Total
	THEORY							
	Elective-IV (Professional)	3	0	0	3	40	60	100
	Elective-V (Professional)	3	0	0	3	40	60	100
	Elective-VI (Open)	3	0	0	3	40	60	100
	PRACTICAL							
14PEP31	Project Work – Phase I	0	0	12	6	50	50	100
				Total	**15**			

CA - Continuous Assessment, ESE – End Semester Examination

SEMESTER – IV

Course Code	Course Title	Hours/ Week			Credit	Maximum Marks		
		L	T	P		CA	ESE	Total
	PRACTICAL							
14PEP41	Project Work – Phase II	0	0	24	12	100	100	200
				Total	**12**			

CA - Continuous Assessment, ESE – End Semester Examination

Total Credits: 72

KONGU ENGINEERING COLLEGE, PERUNDURAI, ERODE – 638 052
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M.E. DEGREE IN POWER ELECTRONICS AND DRIVES (PART TIME)

CURRICULUM

(For the candidates admitted from academic year 2014 – 15 onwards)

SEMESTER – I

Course Code	Course Title	Hours/ Week			Credit	Maximum Marks		
		L	T	P		CA	ESE	Total
	THEORY							
14AMT18	Applied Mathematics for Electrical Engineers	3	1	0	4	40	60	100
14AET12	System Theory	3	1	0	4	40	60	100
14PET13	Power Semiconductor Devices & D.C. Converters	3	0	0	3	40	60	100
				Total	**11**			

CA - Continuous Assessment, ESE – End Semester Examination

SEMESTER – II

Course Code	Course Title	Hours/ Week			Credit	Maximum Marks		
		L	T	P		CA	ESE	Total
	THEORY							
14PET21	Solid State DC Drives	3	1	0	4	40	60	100
14PET22	Solid State AC Drives	3	1	0	4	40	60	100
14PET23	Power Electronics for Renewable Energy Systems	3	0	0	3	40	60	100
	PRACTICAL							
14PEL21	Modern Drives Laboratory	0	0	3	1	100	0	100
				Total	**12**			

CA - Continuous Assessment, ESE – End Semester Examination

KONGU ENGINEERING COLLEGE, PERUNDURAI, ERODE – 638 052
(Autonomous)

M.E. DEGREE IN POWER ELECTRONICS AND DRIVES (PART TIME)

CURRICULUM

(For the candidates admitted from academic year 2014 – 15 onwards)

SEMESTER – III

Course Code	Course Title	Hours/ Week			Credit	Maximum Marks		
		L	T	P		CA	ESE	Total
	THEORY							
14PET11	Modeling and Analysis of Electrical Machines	3	1	0	4	40	60	100
14PET12	A.C. Converters	3	0	0	3	40	60	100
14AET15	Computational Intelligence Techniques	3	1	0	4	40	60	100
	PRACTICAL							
14PEL11	Modern Power Electronics Laboratory	0	0	3	1	100	0	100
				Total	**12**			

CA - Continuous Assessment, ESE – End Semester Examination

SEMESTER – IV

Course Code	Course Title	Hours/ Week			Credit	Maximum Marks		
		L	T	P		CA	ESE	Total
	THEORY							
	Elective-I (Professional)	3	0	0	3	40	60	100
	Elective-II (Professional)	3	0	0	3	40	60	100
	Elective-III (Professional)	3	0	0	3	40	60	100
	PRACTICAL							
14PEL22	Computer Aided Simulation Laboratory	0	0	3	1	100	0	100
				Total	**10**			

CA - Continuous Assessment, ESE – End Semester Examination

KONGU ENGINEERING COLLEGE, PERUNDURAI, ERODE – 638 052
(Autonomous)

M.E. DEGREE IN POWER ELECTRONICS AND DRIVES (PART TIME)

CURRICULUM
(For the candidates admitted from academic year 2014 – 15 onwards)

SEMESTER – V

Course Code	Course Title	Hours/ Week			Credit	Maximum Marks		
		L	T	P		CA	ESE	Total
	THEORY							
	Elective-IV (Professional)	3	0	0	3	40	60	100
	Elective-V (Professional)	3	0	0	3	40	60	100
	Elective-VI (Open)	3	0	0	3	40	60	100
	PRACTICAL							
14PEP31	Project Work – Phase I	0	0	12	6	50	50	100
				Total	**15**			

CA - Continuous Assessment, ESE – End Semester Examination

SEMESTER – VI

Course Code	Course Title	Hours/ Week			Credit	Maximum Marks		
		L	T	P		CA	ESE	Total
	PRACTICAL							
14PEP41	Project Work – Phase II	0	0	24	12	100	100	200
				Total	**12**			

CA - Continuous Assessment, ESE – End Semester Examination

Total Credits: 72

LIST OF ELECTIVES					
Course Code	Course Title	Hours/Week			Credit
		L	T	P	
14GEE01	Project Management	3	0	0	3
14MME06	Virtual Instrumentation	3	0	0	3
14PEE01	PWM Techniques and its Applications	3	0	0	3
14PEE02	Optimal Control Theory	3	1	0	4
14AEE01	Data Communication Networks	3	0	0	3
14PEE03	Modern Power System Protection	3	0	0	3
14PEE04	Switched Mode Power Converters	3	0	0	3
14PEE05	Computer Aided Design of Electrical Machines	3	0	0	3
14PEE06	Computer Aided Simulation and Design of Power Electronic Systems	3	0	0	3
14PEE07	DSP Processor based Electromechanical Motion Control	3	0	0	3
14PEE08	Electromagnetic Interference and Compatibility for Electrical Systems	3	0	0	3
14PEE09	Embedded System and Applications *	3	0	0	3
14PEE10	Energy Conservation, Management and Auditing *	3	0	0	3
14PEE11	Microcontroller Applications in Power Electronics	3	0	0	3
14PEE12	Electric Hybrid Vehicles and Energy Storage Systems	3	0	0	3
14PEE13	Power Electronic Applications in Power Systems	3	0	0	3
14PEE14	Power Quality Engineering	3	0	0	3
14PEE15	Smart Grid Technologies	3	0	0	3
14PEE16	Special Electrical Machines and Control	3	0	0	3
14PEE17	Industrial Drives	3	0	0	3
14CIE17	Programmable Logic Controllers	3	0	0	3
14CIE18	SCADA and DCS	3	0	0	3

*-Open Elective

14AMT18 APPLIED MATHEMATICS FOR ELECTRICAL ENGINEERS

(Common to Applied Electronics & Power Electronics and Drives)

3 1 0 4

UNIT – I **9**

Matrix Theory: Matrix factorizations – LU decomposition – The Cholesky decomposition – QR factorization – Least squares method – Generalized inverses – Singular value decomposition – Toeplitz matrices and Circulant matrices.

UNIT – II **9**

Calculus of Variations: Concept of variation – Euler equation – Variational problems with fixed boundaries – Variational problems involving several unknown functions – Functional involving first and second order derivatives – Functional involving several independent variables – Isoperimetric problems – Direct methods – Ritz method – Kantorowich method.

UNIT – III **9**

Stochastic Process: Definition – Classification of Stochastic Processes – Markov Chain -Transition Probability Matrices – Chapman Kolmogorov Equations - Classification of States – Continuous Time Markov Chains – Poisson Process - Birth and Death Processes.

UNIT – IV **9**

Queuing Models: Markovian queues – Single and Multi-server Models – Little's formula – Machine Interference Model - Non- Markovian Queues – Pollaczek Khintchine Formula.

UNIT – V **9**

Graph Theory: Introduction of graphs – Isomorphism – Subgraphs – Walks, paths and circuits – Connected graphs – Eulerian Graphs – Hamiltonian Paths and circuits – Digraph –Some types of digraphs – Connectedness – Adjacency matrix and incidence matrix of graphs – Shortest path algorithms – Dijkstra's algorithm – Warshall's algorithm – Trees – Properties of trees – Spanning trees – Minimal spanning trees – Prim's Algorithm – Kruskal's algorithm.

Lecture: 45, Tutorial: 15, TOTAL: 60

REFERENCE BOOKS

1. Richard Bronson, "Matrix Operations", Schaum's outline series, 2nd Edition, McGraw Hill, 2011.
2. Gupta, A.S., Calculus of Variations with Applications, Prentice Hall of India Pvt. Ltd., New Delhi, 1997.
3. Roy D.Yates and David J Goodman, "Probability and Stochastic Processes – A friendly Introduction for Electrical and Computer Engineers", John Wiley & Sons, 2005.
4. Donald Gross and Carl M. Harris, "Fundamentals of Queueing Theory", 2nd edition, John Wiley and Sons, New York,1985.
5. Narsingh Deo, "Graph Theory with Applications to Engineering and Computer Science", Prentice Hall, 2005.

Course Outcomes:

On completion of the course the students will be able to

- apply matrix computations in signal processing
- solve variational problems
- adopt Markov process and queuing models in engineering problems
- use graph structures in electrical networks

14AET12 SYSTEM THEORY

(Common to Applied Electronics & Power Electronics and Drives)

3 1 0 4

Pre-requisites: Control Systems

UNIT - I **9**

Introduction to Digital Control System: Elements of Digital control system- Classifications of discrete time signals – Time domain models for discrete time systems.

Sampling and reconstruction of signals –Frequency domain representation of sampling theorem-Nyquist rate, Aliasing. Mathematical model of sample and hold circuits-Practical aspects of choice of sampling rate

UNIT - II **9**

Z-Plane Analysis of Discrete-Time Control Systems: Review of Z transform- Relationship between s plane and z plane **-** Difference equation representation of discrete time system-Pulse transfer function -Modified Z transform- Digital PID controllers– Zeigler – Nichols tuning method

UNIT - III **9**

State Space Analysis and its Solution: Review of state space representation**-** Conversion of continuous state model to discrete state model – State diagram-Solution of discrete time state model: autonomous, non-autonomous systems – State transition matrix –Controllability and Observability – Multi variable discrete systems

UNIT - IV **9**

State Feedback Control: Design of state feedback controller – Design of reduced and full order observers – Steady state error in state space-PI feedback- Digital compensator design– Digital filter properties– Kalman's filter.

UNIT - V **9**

Stability Analysis: BIBO stability-Effect of sampling rate on stability-Jury's stability test-Root Locus analysis –Asymptotic stability-Liapunov Stability Analysis of discrete time systems: Linear and Non-linear systems- Direct,Indirect method-Construction of Liapunov energy function.

Lecture: 45, Tutorial: 15, TOTAL: 60

REFERENCE BOOKS:

1. Gopal, M., "Digital Control and State Variable Methods", 4th editionTata McGraw-Hill, New Delhi, 2012.
2. Kuo, B.C., "Digital Control Systems", 2nd edition Oxford University Press, Oxford, 2007.
3. Ogata, K., "Discrete Time Control Systems", second edition Prentice Hall, New Jersey, 2011.
4. M.Sami Fadali, Antonio Visioli, "Digital control Engineering Analysis and design" Elsevier, 2012.

Course Outcomes:

On completion of the course the students will be able to

- understand mathematical models of linear discrete-time control systems using transfer functions and state-space models
- analyze transient and steady-state behaviors of linear discrete-time control systems
- design controllers for linear discrete-time control systems as per the design criteria

14PET11 MODELING AND ANALYSIS OF ELECTRICAL MACHINES

3 1 0 4

Pre-requisite: Electrical Machines, Applied Mathematics for Electrical Engineers

UNIT-I **9**

Generalized Theory: Essential of Rotating Electrical Machines – Conventions – The Basic Two Pole Machine – Invariance of Power – Transformations from Three Phase to Two Phase – Electrical Torque – Restriction of the Generalized Theory of Electrical Machines.

UNIT - II **9**

Modeling of DC Machines:Theory of Operation – Induced EMF – Equivalent Circuit – Electromagnetic Torque– Electromechanical Modeling – Mathematical Modeling of DC Machine- Field Excitation- Steady state Analysis of three Phase Converter Controlled and Chopper controlled DC motor drive- Dynamic characteristics of permanent magnet and shunt dc motor drive.

UNIT - III **9**

Modeling of Induction Machines: Three Phase Induction Motor – Reference frame Theory – Dynamic d-q model-Axes Transformation –Kron Equation -Generalized model in arbitrary reference frames-electromagnetic torque-derivation of commonly used induction motor models-voltage and torque equation in arbitrary reference frame variables.

UNIT - IV **9**

Modeling of Synchronous Machines: Voltage and Torque equations in machine variables-stator voltage equation in arbitrary reference frame variables – voltage equation in rotor reference frame variables.

UNIT - V **9**

Special Machines: Permanent Magnet and Characteristics – Synchronous Machine with Permanent magnets: Machine Configuration – Variable Reluctance Machine: Basics – Analysis – Torque Production in Stepping motors – Linear Induction Motor.

Lecture : 45, Tutorial : 15, TOTAL : 60

REFERENCE BOOKS

1 Bimal K Bose, "Modern Power Electronics and AC Drives", PHI Learning, First Edition, 2011.
2 R Krishnan, "Electric Motor Drives: Modeling, Analysis, and Control", PHI Learning, First Edition, 2011.
3 P S Bimbhra, "Generalized Theory of Electrical Machines", Khanna Publishers, 5th Edition, 2012.
4 Paul C Krause, "Analysis of Electric Machinery", McGraw Hill Book Company, 2nd Edition, 2011
5 Charles Kingsley Jr., A.E. Fitzgerald and Stephen D.Umans, "Electric Machinery", New York, McGraw-Hill Higher Education, 2010.

Course Outcomes:

On completion of the course the students will be able to

- analyse the various electrical parameters in mathematical form
- determine the electrical machine equivalent circuit parameters and modeling of electrical machines
- design and develop the mathematical model of various AC and DC machines using different types of reference frame theories and transformation relationships

14PET12 AC CONVERTERS

3 0 0 3

Pre-requisites : Applied Mathematics for Electrical Engineers, Power semiconductor Devices and DC converters

UNIT – I **9**

AC Voltage Controllers :Principle of On off control and phase control – single phase bidirectional controllers with resistive and inductive loads – Three phase bidirectional delta connected controllers - different Configurations- Analysis with pure R and L loads- Cycloconverters- Principle of operation - single phase and three phase cyclo converters- Control circuit strategies.

UNIT - II **9**

Three phase inverters :180^o and 120^o conduction mode of inverters with star and delta connected loads - Voltage control of three phase inverters- Current source inverters- Operation of six- step thyristor inverter– inverter operation modes– load commutated inverters– ASCI – current pulsations– comparison of CSI and VSI.

UNIT - III **9**

Multilevel Inverters :Multilevel concept – diode clamped – flying capacitor – cascade type multilevel inverters –Switching techniques for multilevel inverters - Comparison of multilevel inverters – applications of multilevel inverters – Design and analysis of multilevel inverters for renewable energy applications

UNIT -IV **9**

Resonant Inverters: Resonant inverters -Series and Parallel resonant inverters - Voltage control of resonant inverters – Class E resonant inverter – resonant DC-link inverters - Introduction to matrix converter.

UNIT - V **9**

Single phase Inverters :Principle of operation of half and full bridge inverters- Performance parameters- Voltage control of single phase inverters using various PWM techniques- various harmonic elimination techniques.

TOTAL : 45

REFERENCE BOOKS:

1. Rashid M.H, “Power Electronics Circuits, Devices and Applications ", Pearson,Third Edition, New Delhi, 2003.
2. Bimal K.Bose,“Modern Power Electronics and AC Drives”, Prentice Hall India, Second Edition,2005.
3. Ned Mohan,Undeland and Robbin, “Power Electronics: converters, Application and design” Wiley, Newyork, Third Edition, 2012.
4. P.S.Bimbra, “Power Electronics”, Khanna Publishers, Fifth Edition, 2012.
5. P.C. Sen, “Modern Power Electronics”, S.Chand, Second Edition 2005.

Course Outcomes:
On completion of the course the students will be able to

- explain and select the dc-to-ac and ac-to-ac converters for industrial applications
- develop efficient system using resonant and soft switching converters
- analyze and design multilevel inverters for Renewable Energy sources

14PET13 POWER SEMICONDUCTOR DEVICES AND DC CONVERTERS

3 0 0 3

Pre-requisites: Applied Mathematics for Electrical Engineers, Electron Devices and Power Electronics

UNIT – I **9**

Power Semiconductor Characteristics: Steady state, transient characteristics and the parameters of the various devices from typical manufacturer's catalogues : Power diode , SCR, TRIAC, MOSFET, IGBT, GTO, MCT,IGCT and silicon carbide devices – various Protection circuits-Device voltage and current ratings – Calculation of losses . Thermal resistance and Design of heat sinks for the required loading- Safe Operating Area(SOA) for transistors - Comparison and application of different power devices.

UNIT – II **9**

Phase controlled AC-DC Converter Basics: Different configurations of rectifier connections based on number of phases, connection methods, full and half control, output pulses, quadrants of operation - input and output equations for voltages and currents for R, R-L, R-L-E loads - conditions for continuous and discontinuous output currents - critical speed and torque conditions for continuous conduction - True RMS value, harmonics, ripple, distortion, power factor – Effect of source impedance and overlap - Reactive power and power balance in converter circuits- Software simulation of single phase, three phase controlled rectifiers.

UNIT – III **9**

Single and Three Phase AC-DC Converter: Single and Three phase - half controlled and fully controlled converters with R, R-L, R-L-E loads with and without freewheeling diodes – design of devices for converters of different ratings for single ,three, six and twelve pulse converters- Output voltage waveforms for various firing Angles for continuous and discontinuous currents for both single and three phase , full and half controlled converters; Dual converter - performance parameters - Firing pulse generation circuits for Phase Control for single and three phase converters.

UNIT – IV **9**

DC-DC Converters: Principle of DC Chopper control strategies: Time ratio and current limit control – step up and step down choppers – Various chopper configurations for single, two and four quadrant operations – Output voltage equation , output voltage and current wave forms- Control of DC-DC converters.

UNIT – V **9**

Switching Mode Regulators: Analysis and design of DC to DC converters- Buck converters, Boost converters, Buck-Boost converters, Cuk converters; Switched mode regulators for SMPS; ZVS, ZCS - Software simulation of choppers.

TOTAL : 45

REFERENCE BOOKS:

1. Mohan N, Undeland and Robins, "Power Electronics – Concepts, Applications and Design", John Wiley and sons, Singapore, 2012.
2. Rashid M.H, "Power Electronics circuits, Devices and Applications", Pearson, Eleventh Edition, 2012.
3. M.D. Singh and K.B.Khanchandani, "Power Electronics", Tata McGraw Hill, Second Edition, 2006.

4. P.C Sen, " Modern Power Electronics", S.Chand, Second Edition, 2005.
5. P.S.Bimbra, "Power Electronics", Khanna Publishers, Fifth Edition, 2012.
6. Bill Drury ,"Control Technique Drives and Controls Handbook", Second Edition, IET Power and Energy Series 57.

Course Outcomes:

On completion of the course the students will be able to

- select various power semiconductor devices for rectifier and chopper application
- select / Design power converter modules (single phase & three phase) for different industry application
- analyze and design DC to DC Converters for motors and regulators

14AET15 COMPUTATIONAL INTELLIGENCE TECHNIQUES

(Common to Applied Electronics, Power Electronics and Drives & Mechatronics)

3 1 0 4

Pre-requisites: Numerical methods

UNIT – I **9**

Artificial Neural Networks: Introduction to Soft computing – Neural Networks – Model – activation functions – architecture – Supervised learning – Perceptrons – Adaline and Madaline – Back propagation algorithm – Radial Basis Function Networks – Unsupervised Learning and Other Neural Networks – Competitive Learning Networks – Kohonen Self Organizing Networks – Learning Vector Quantization – Hebbian Learning.

UNIT – II **9**

Fuzzy logic: Fuzzy Sets – Basic Definition and Terminology – Set theoretic operations – Membership function formulation and parameterization - Extension principle and Fuzzy Relations- Fuzzy if-then Rules – Fuzzy Reasoning – Fuzzy Inference Systems – Mamdani Fuzzy Models –Sugeno Fuzzy Models –Tsukamoto Fuzzy Models – Input Space Partitioning - Fuzzy Modeling.

UNIT – III **9**

Optimization techniques: Derivative based Optimization: Descent Methods –The Method of steepest Descent – Classical Newton's Method – Step Size Determination – Derivative free Optimization: Genetic Algorithms – Simulated Annealing – Particle swarm Optimization - Ant colony optimization.

Unit – IV **9**

Neuro Fuzzy modeling: Adaptive Neuro Fuzzy Inference Systems – Architecture – Hybrid learning Algorithm –learning methods that Cross-fertilize ANFIS and RBFN – Coactive Neuro fuzzy Modeling – Framework – Neuron Functions for Adaptive Networks – Neuro Fuzzy spectrum.

UNIT – V **9**

Applications: Printed Character Recognition – Inverse kinematics Problem – Applications of soft computing techniques for power electronics: MPPT, speed control for electrical machines, harmonic elimination techniques in power converters.

Lecture:45, Tutorial:15, TOTAL: 60

REFERENCE BOOKS:

1. J.S.R Jang, C.T.Sun and E.Mizutani, "Neuro-Fuzzy and Soft Computing", PHI, Pearson Education, 2004.
2. Laurene V. Fausett, "Fundamentals of Neural Networks: Architectures, Algorithms and Applications", Pearson Education, III Edition, 2008
3. Timothy J. Ross, "Fuzzy Logic with Engineering Applications" Wiley India.
4. David E.Goldberg, "Genetic Algorithms: Search, Optimization and Machine Learning", Addison Wesley, New York, 1989.
5. Bimal K Bose, "Neural Network Applications in Power Electronics and Motor Drives-An Introduction and Perspective" , IEEE Transactions on Industrial Electronics, Vol.54, Issue: 1, pp.14-33,February 2007.
6. Whei-Min Lin , Chih-Ming Hong and Chiung-Hsing Chen, "Neural Network Based MPPT Control of a Stand Alone Hybrid Power Generation System" IEEE Transactions on Power Electronics, Vol.26, Issue: 12, pp.3571 – 3581,December 2011.

Course Outcomes:

On completion of the course the students will be able to

- describe the characteristics and algorithms of intelligent systems
- design intelligent controllers and its hybrid topology for various applications
- gain fundamental knowledge on optimization techniques and its implementation procedures

14PEL11 MODERN POWER ELECTRONICS LABORATORY

0 0 3 1

LIST OF EXPERIMENTS :

1. Design of snubber circuits, semi conductor fuses, dv/dt and di/dt protection, gate signal generation and driver circuits
2. Design of DC to DC converter for single quadrant operation
3. Design of Voltage Source Inverter using SCR
4. Design of AC to AC converter using SCR
5. Design and operation of single phase four quadrant converter
6. Design and operation of three phase four quadrant converter

TOTAL : 45

Course Outcomes:

On completion of the course the students will be able to

- design various power semiconductor protective circuits
- design and operate power electronic modules for variable DC output applications
- design and operate power electronic modules for variable voltage and frequency applications

14PET21 SOLID STATE DC DRIVES

3 1 0 4

Pre-requisite: Power Electronics, Electrical machines, Electric Drives and Control

UNIT – I **9**

Review of Conventional DC Drives : Different techniques of speed control and methods of braking of series and separately excited DC motors - Ward-Leonard Speed control - Models and transfer function of series and Separately excited DC motors.

UNIT – II **9**

Converter Control of DC Motors: Analysis of separately excited DC motor with single phase and Three phase converters operating in different modes , configurations and firing angles - Problems on DC machines fed by controlled rectifier, MATLAB simulations

UNIT – III **9**

Closed loop Control of DC Separately excited motor : Drive Control system with discrete analog cards- Features of DC Digital drives -Phase Locked Loop- structure of digital drive software- core and application software for time critical and non-time critical applications- digital speed and current feed back; Configuring with typical control blocks and parameters for applications- PI closed loop of current, speed control loops for armature and spillover control loop for field- feed forward controls; Various operational and protective limits for drive parameters- Diagnostics in digital drives - Achieving 4-quadrant operation - Field reversal for jogging and inching.

UNIT – IV **9**

Chopper Control of DC Motors: Analysis of series and separately excited DC motors fed from different types of Choppers operating in one, two and four quadrants- effect of saturation in series motors CLC and TRC strategies – Problems on DC machines fed by chopper supplies; MATLAB simulations

UNIT – V **9**

Closed Loop Control of chopper based drives: Analysis of the drive system with Series motor and chopper based power source - Linear Transfer function model of chopper - Sensing and feedback elements - Closed loop – current and speed PI loops;. Special requirements to achieve torque and - current controls - Analysis of the speed and current controllers - Application of chopper for motion control applications like crane drives, battery operated vehicles.

Lecture : 45, Tutorial : 15 TOTAL :60

REFERENCE BOOKS:

1. Gopal K Dubey, “Power Semiconductor controlled Drives”, Prentice Hall Inc., New Jersy, 1989.
2. Buxbaum, A.Schierau, K.and Staughen, "A Design of control System for d.c Drives ", Springer-Verlag, berlin, 1990.
3. R.Krishnan, “Electric Motor Drives – Modelling, Analysis and Control”, Prentice-Hall of India Pvt. Ltd., New Delhi, 2003.
4. Bimal K.Bose , “Modern Power Electronics and AC Drives”, Pearson Education (Singapore) Pte.Ltd., New Delhi, 2003.
5. P.C Sen ,”Thyristor DC Drives”, John Wiley and Sons, New York, 1981.

6. Fundamentals of Electrical Drives , Gopal K. Dubey,Second Edision Narosa Publishing House (2012)
7. AVTRON ,USA Digital Drive manual , KEC Power Electronics Lab .

Course Outcomes:

On completion of the course the students will be able to

- model and analyze the performance of DC separately excited Motors and series motors
- solve application problems for DC separately excited Motors and series motors
- operate and evaluate performance of variable speed drives using closed loop control system, controlled rectifiers and choppers
- configure a modern digital drive control system and utilize their features for application

14PET22 SOLID STATE AC DRIVES

3 1 0 4

Pre-requisites:, Power Electronics, Electrical machines, Electric Drives and Control

UNIT – I **9**

Introduction to Induction Motors: Steady state performance equations – Rotating magnetic field – torque production - Equivalent circuit– Variable voltage, constant frequency operation – Constant voltage, variable frequency operation - constant Volt/Hz operation - Drive operating regions - variable stator current operation - different braking methods.

Conventional Control of Induction Motors: Performance of the machine with variable voltage - rotor resistance variation - pole changing and cascaded induction – slip power recovery schemes.

UNIT – II **9**

Induction Motor Speed Control Techniques: A.C. voltage controller fed induction machine operation - energy conservation issues - V/f operation theory - requirement for slip and stator voltage compensation – Regenerative braking of VSI fed drives - CSI fed induction machine - operation and characteristics – six step inverter voltage control-closed loop variable frequency PWM inverter with dynamic braking-CSI fed IM variable frequency drives comparison.

UNIT– III **9**

Rotor Controlled Induction Motor Drives: Static rotor resistance control - power factor considerations - Injection of voltage in the rotor circuit - Static Kramer drive - Static scherbius drives: sub and super synchronous speed of operation.

UNIT – IV **9**

Field Oriented Control and Direct Torque Control: Field oriented control of induction machines – Theory – DC drive analogy – Direct and Indirect methods – Flux vector estimation - Direct torque control of Induction Machines – Torque expression with stator and rotor fluxes, DTC control strategy.

UNIT – V **9**

Synchronous Motor Drives: Wound field cylindrical rotor motor – Equivalent circuits – performance equations of operation from a voltage source – Power factor control and V curves – starting and braking, self control – Load commutated Synchronous motor drives - Brush and Brushless excitation.

Lecture:45, Tutorial:15, TOTAL: 60

REFERENCE BOOKS:

1. Dubey G.K, "Power Semiconductor Controlled Drives", Prentice Hall inc, A division of Simon and Schester England cliffs, New Jersey 1989
2. R.Krishnan, Electric Motor Drives , “Modeling, Analysis and Control”, Prentice-Hall of India Pvt.Ltd,New Delhi, 2002.
3. Bimal K Bose, “Modern Power Electronics and AC Drives”, Prentice Hall of India Pvt.Ltd, Second Edition, 2005.
4. W.Leonhard, “Control of Electrical Drives”, Springer, 2012.
5. Dubey G.K, “Fundamentals of Electric Drives”, Narosa Book Distributors Pvt Ltd, Second Edition, 2012.

Course Outcomes:
On completion of the course the students will be able to

- analyze the steady state performance of AC drives
- develop suitable speed control technique for AC drive
- select suitable speed control method for AC drives for industrial applications

14PET23 POWER ELECTRONICS FOR RENEWABLE ENERGY SYSTEMS

3 0 0 3

Pre-requisites: Electrical Machines, Power Electronics

UNIT – I **9**

Analysis of Solar Energy: Trends in energy consumption - Energy sources and their availability - Photovoltaic Energy Conversion and applications: Solar radiation and measurement - Solar cells and their characteristics - Influence of insolation and temperature - PV arrays - Introduction to flexible solar cells - Electrical storage with batteries.

UNIT – II **9**

Solar Energy Conversion and Applications: Switching devices for solar energy conversion – Array sizing- Boost and buck boost converters - battery sizing - Selection of inverter – Stand alone inverters - Charge controllers - Water pumping and Street lighting-Grid integrated solar system - Analysis of PV Systems.

UNIT – III **9**

Analysis of Wind Energy: Basic Principle of wind Energy conversion - Nature of Wind - Power in the wind - Components of Wind Energy Conversion System (WECS) - Performance of Induction Generators for WECS -Classification of WECS.

UNIT – IV **9**

Wind Energy Conversion: Self Excited Induction Generator (SEIG) for isolated Power Generators - Theory of self excitation - Capacitance requirements - Controllable DC Power from SEIGs - Grid connectors concepts - Wind farm and its accessories- Grid related problems - Generator control - Performance improvements - Different schemes - AC voltage controllers - Harmonics and PF improvement.

UNIT – V **9**

Hybrid Systems and Power Converters : Need for Hybrid systems-Wind / Solar PV integrated systems - Selection of power conversion ratio - Optimization of system components - Storage - Reliability evolution - Power conditioning schemes: DC Power conditioning Converters - Maximum Power point tracking algorithms - AC Power conditioners - Line commutated inverters - Synchronized operation with grid supply-Grid interactive inverters.

TOTAL : 45

REFERENCE BOOKS:

1. Chetan Singh Solanki, “Solar Photovoltaics : Fundamentals, Technologies and Applications”, Second Edition,PHI Learning Pvt. Ltd., 2011.
2. Tiwari.G, “Fundamentals, Design, Modeling and Applications of Solar Energy”, Narosa Publishers, 7^{th} reprint 2010.
3. Thomas Markvart and Luis Castaser, “Practical Handbook of Photovoltaics”, Elsevier Publications, UK, 2003
4. Roger A. Messenger, Jerry Ventre, “Photovoltaic System Engineering”, CRC Press, 2004.
5. Daniel, Hunt, V., "Wind Power - A Handbook of WECS", Van Nostrend Co., New York, 1998.
6. Mukund R Patel, “ Wind and Solar Power Systems, “Design,analysis and operation”,Second Edition,CRC Press,2006.

Course Outcomes:
On completion of the course the students will be able to

- understand the modern power converters for renewable energy power harnessing
- know the basic characteristics, working and application of PV cells
- acquire knowledge on of fundamental of wind power, detailed model of the Wind Energy components and its control systems
- illustrate about the modeling of hybrid systems
- summarize stand - alone systems and Grid connected systems

14PEL21 MODERN DRIVES LABORATORY

0 0 3 1

LIST OF EXPERIMENTS :

1. Analysis of Dual converter fed DC motor drive
2. DSP controlled AC drive
3. Analysis of vector controlled Induction motor Drive
4. Harmonic analysis of Converter fed Drive
5. Microcontroller based speed control of VSI fed three phase Induction motor
6. DSP based speed control of BLDC motor
7. FPGA based speed control of SRM motor
8. Microcontroller based speed control of stepper motor
9. V/f controlled Induction motor Drive
10. Condition monitoring of three phase induction motor under fault condition (Simulation)

TOTAL : 45

Course Outcomes:

On completion of the course the students will be able to

- analyze the performance of Special Electric drives in Simulation Environment
- apply modern digital control technique for speed control of various electric motors
- monitor the operation of electrical drives under fault conditions

14PEL22 COMPUTER AIDED SIMULATION LABORATORY

0 0 3 1

LIST OF EXPERIMENTS:

1. Modeling of DC motor using MATLAB
2. Modeling of Servomotors using MATLAB
3. Dynamic modeling of Induction motor using MATLAB
4. Simulation of Four quadrant operation of three phase induction motor
5. Simulation of Automatic Voltage Regulation of three phase Synchronous Generator
6. Simulation of PWM inverter for motor load using PSIM
7. Simulation of Single Phase Fully controlled Converter for RLE Load using PSPICE
8. Simulation of Single Phase Dual Converter using PSIM
9. Simulation of Three Phase Full Bridge Inverter using PSIM
10. Simulation of Three Phase AC Voltage Controller using PSPICE

TOTAL : 45

Course outcomes:

On completion of the course the students will be able to

- model and simulate various electrical machines using simulation software packages
- design and simulate the Power Electronic circuits for controlling the Electrical Machines

14GEE01 PROJECT MANAGEMENT

(Common to Applied Electronics & Power Electronics and Drives)

3 0 0 3

UNIT – I **9**

Philosophy and Concepts: Need – Goals- Evolution-Different Forms -Project Management in Manufacturing, Service and Government Sectors; Systems Development Cycle – Conception phase: proposal, contracting – Definition phase – Execution phase: production / build, implementation – Operation phase- System Development in Industries, service and government sectors - case study.

UNIT – II **9**

Planning Fundamentals: Planning Steps – Project master plan - Tools for project planning – work break down structure, responsibility matrix, events and mile stones- Gantt charts. Network Scheduling – the critical path – early & late times – slack –float – calendar scheduling.

UNIT – III **9**

PERT: Time estimates – probability of finishing by target completion date – criticisms of PERT - CPM – Time cost relationship – reducing project duration – shortest duration – total project cost; Scheduling with Resource Constraints – resource loading and leveling – constrained resources; Introduction to GERT network - case studies in PERT/CPM.

UNIT – IV **9**

Project Cost Estimation: Process – classification-expert opinion, analogy estimate, parametric estimate, cost engineering, Contingency amount - Elements of budgets and Estimates – direct labour, direct non- labour, overhead, general and administrative expenses, profit and total billing.Project cost accounting – budgeting using cost accounts - cost summaries, cost schedules and forecasts – case study. Project Management Information Systems (PMIS): Functions – Computer based PMI Systems – Web-Based project management

UNIT – V **9**

Project Control : Cost accounting systems- project control process - Project control emphasis- Performance Analysis – cost, schedule, work package analysis, performance indices, updating time estimates, technical performance measurement- Performance Index monitoring – variance limits, controlling changes, contract administration, control problems, case study.

Project Evaluation: Review meetings, reporting, terminating, termination responsibilities, closing the contract, project extensions, project summary evaluation.

TOTAL : 45

REFERENCE BOOKS:

1. Nicholas, John M., "Project Management for Business and Technology", Prentice Hall India, New Delhi, 2011.
2. Pagnoni, Anastasia., "Project Engineering: Computer Oriented Planning and Operational Decision Making", Springer-Verlag, Berlin, 2012
3. Pannerselvam R, "Project Management"' PHI Learning Pvt, Ltd ,2010.

Course outcomes:

On completion of the course the students will be able to

- develop a system development cycle for their technical/business project
- develop an understanding of managing project management system
- develop a procedure for planning, scheduling, budgeting for project activities, analyzing, controlling and evaluating the work to achieve project goal in the work place

14MME06 VIRTUAL INSTRUMENTATION

(Common to Mechatronics, Applied Electronics & Power Electronics and Drives)

3 0 0 3

Pre-requisites: Sensors and Instrumentation

UNIT – I **9**

Introduction to Virtual Instrumentation: Historical perspective and traditional bench top instruments, advantages of virtual instrument, block diagram of virtual instrument, physical quantities and analog interfaces - User Interfaces and architecture of a virtual instrument and its relation to the operating system.

UNIT – II **9**

LabVIEW Programming Basics –I: Front panel - Block diagram, Tools, Control and Function palette, modular programming - VI and sub VI –structures –FOR – WHILE loops, Case, Sequence Structures, event structures- Formula nodes- local and global variables.

UNIT – III **9**

LabVIEW Programming Basics –II: Arrays, Clusters, string and File – High level and Low level file I/O – Time and Dialog control- Waveform- graph- chart operations- string functions- Report generation and publishing measurement data in web.

UNIT – IV **9**

Data Acquisition System: Instrument control – GPIB – VISA – instrument drivers-serial port communication. Data Acquisition review: Review of Transducer and Signal conditioning, DAQ hardware- AI- AO- DI/O- DAQ assistant and configurations.

UNIT – V **9**

Applications of Virtual Instrumentation: Networking basics for office and industrial applications - Development of process database management system – Simulation of system using VI - Image acquisition and processing – Motion control.

TOTAL : 45

REFERENCE BOOKS:

1. Jeffery Travis and Jim kring, “LabVIEW for Everyone: Graphical Programming Made Easy and Fun”, Third Edition, Pearson Education, India, 2009.
2. Gupta, Joseph, John, “Virtual Instrumentation using LabVIEW”, Second Edition, Tata McGraw Hill, 2010.
3. Wells, Lisa K. Travis and Jeffrey, “LabVIEW for Everyone”, Prentice Hall of India, New Delhi, 2009.
4. Bruce mihure, Austin and Texas, “LabVIEW for data acquisition”, Prentice Hall of India, New Delhi, 2001.
5. LabVIEW Basics I and II Manual, National Instruments, India, 2013.
6. Barry E. Paton, “Sensor, Transducers and LabVIEW”, Prentice Hall of India, New Delhi, 2000.

Course Outcomes:

On completion of the course the students will be able to

- illustrate the fundamentals of Virtual Instrumentation
- develop LabVIEW programming
- interface data acquisition system with real-time applications

14PEE01 PWM TECHNIQUES AND ITS APPLICATIONS

3 0 0 3

Pre-requisites: Power Electronics, AC converters

UNIT – I **9**

Fundamentals of PWM: Concept of PWM - Evaluation of PWM Schemes - Double Fourier Integral Analysis of a Two-Level PWM waveform - Naturally Sampled PWM - PWM Analysis by Duty Cycle Variation - Regular Sampled PWM- Direct modulation.

UNIT – II **9**

PWM types: Integer versus non integer frequency ratios- Review of PWM variations – Optimized spaced vector PWM- Harmonic elimination PWM –Performance index for optimality –optimum PWM – Minimum loss PWM.

UNIT – III **9**

Inverter Topology: Topology of a Single Phase Inverter-Three level Modulation of a Single Phase Inverter-Analytic Calculation of Harmonic Losses-Sideband Modulation-Switched Pulse Position-Switched Pulse Sequence - Topology of a Three Phase VSI-Three Phase Modulation with Sinusoidal References.

UNIT – IV **9**

Harmonics and control: Third Harmonic Reference Injection-Analytic Calculation of Harmonic Losses-Discontinuous Modulation Strategies-Triplen Carrier Ratios and Sub harmonics- Multilevel converter alternatives - Harmonic Elimination applied to multilevel inverters- Minimum Harmonic distortion.

UNIT – V **9**

Space vector modulation: Space Vector Modulation-Phase Leg References for SVM-Naturally Sampled SVM-Analytical Solution for SVM Harmonic Losses for SVM-Placement of the Zero Space Vector-Discontinuous Modulation- SVM for multilevel inverters- discontinuous modulation in multilevel inverters.

TOTAL : 45

REFERENCE BOOKS:

1. Dorin O. Neacsu, " Power Switching Converters", CRC Press," Taylor & Francis, 2006.
2. Grahame Holmes D. and Thomas A. Lipo, "Pulse width Modulation for Power Converters", IEEE Press series on Power Engineering, Wiley-Interscience, John Wiley&Sons,Inc., 2003
3. Mohammed H.Rashid, "Power Electronics-Circuits, Devices and Applications", Eastern Economy Edition, Third Edition 2004

Course Outcomes:

On completion of the course the students will be able to

- evaluate the different types of pulse width modulation techniques
- design PWM for inverter topologies and its corresponding analysis for various applications
- gain fundamental knowledge on space vector modulation and improving power quality profile in power electronic circuits through PWM techniques

14PEE02 OPTIMAL CONTROL THEORY

3 1 0 4

UNIT – I **9**

Introduction: Review: state space representation, matrix theory, static optimization with and without constraints. Calculus of variations-basic concepts- functionals of a single function and several functions - necessary conditions and boundary conditions.

UNIT – II **9**

Optimal control formulation: The performance measures for optimal control problems-Hamiltonian approach-necessary conditions for optimal control-and Linear regulator problem-infinite time regulator problem-, Regulators with a prescribed degree of stability.

UNIT – III **9**

The Minimum (Maximum) Principle: Pontryagin's minimum principle and state inequality constraints, Minimum time problem, Minimum control energy problems. Singular intervals in optimal control.

UNIT – IV **9**

Numerical Techniques: Numerical solution of two-point boundary value problem –Gradient method and Quasi Linearisation method - solution of Ricatti equation by iterative method.

UNIT – V **9**

Dynamic Programming: Principle of optimality - recurrence relation of dynamic programming for optimal control problem - computational procedure for solving optimal control problems - characteristics of dynamic programming solution - dynamic programming application to discrete and continuous systems - Hamilton Jacobi Bellman equation. Relationship between Dynamic Programming and Minimum Principle.

Lecture: 45, Tutorial: 15, TOTAL: 60

REFERENCE BOOKS:

1. Kirk Donald, "Optimal Control Theory", Prentice Hall, New Jersey,1970
2. Anderson B.D.O. and Moore J.B., "Optimal Control: Linear Quadratic Methods", Prentice Hall, New Jersey,1979
3. Desineni Subburam Naidu, "Optimal Control Systems", CRC Press,2003

Course Outcomes:

On completion of the course the students will be able to

- apply the optimal control functions to solve the stability related problems
- analyze the problems using minimum (maximum) principles and numerical techniques
- understand the concept of dynamic programming and use it to solve optimal control problems

14AEE01 DATA COMMUNICATION NETWORKS

(Common to Applied Electronics & Power Electronics and Drives)

3 0 0 3

Pre-requisites: Computer Networks

UNIT – I **9**

Introduction: Definition of Networks – Classification of Networks – LAN, MAN, WAN, internet – Network Topology – Protocols and Standards – Network Models – OSI, TCP/IP Models of networking – Internet

UNIT – II **9**

Physical Layer: Review of Signals – Data Rate Limits – Performance Issues – Bandwidth, Throughput, Latency, Bandwidth-Delay Product, Jitter. Digital Transmission and Analog Transmission: Line coding techniques, PCM and Delta Modulation techniques – ASK, FSK, PSK, and QAM Techniques – Bandwidth Utilization: Multiplexing and Spreading

UNIT– III **9**

Communication Media and Data Link Layer: Data Transmission using Telephone Networks – Dial-up MODEMS, Digital Subscriber Line (DSL).Error Detection and Correction techniques – Data Link Control: Framing, Flow and Error Control – HDLC and PPP protocols. Multiple Access Techniques – CSMA, CSMA/CD, CSMA/CA – Channelization – TDMA, FDMA, and CDMA

UNIT– IV **9**

Wired LANs and WANs: Wired LANs– IEEE 802 standards - Ethernet – IEEE 802.3 MAC Frame – Token Ring LAN - IEEE 802.5 MAC Frame – Wireless LANs – IEEE 802.11 standard – Bluetooth Technology – Interconnection of LANs.

Wired WANs: Wired WANs **-**Circuit-Switched Networks, Datagram Networks, Virtual Circuit-ched Networks, Structure of Circuit and Packet Switches - Wireless WANs – Introduction to Cellular Telephone and Satellite networks

UNIT – V **9**

Internetworking: Internetworking – tunneling – IP Addressing Scheme – Structure of IP Datagram – IP Routing – TCP as Transport Layer Protocol – Structure of TCP Segment – TCP Connection: Establishment and Closing – SMTP Protocol for E- Mail Application.

TOTAL : 45

REFERENCE BOOKS:

1. Forouzan Behrouz A., “Data Communications and Networking”, Fourth Edition, Tata McGraw-Hill, New Delhi, 2006.
2. Peterson Larry L. and Davie Bruce S., “Computer Networks: A Systems Approach”, Fourth Edition, Elsevier Publications, New Delhi, 2007.
3. Rowe Stanford H. and Schuh Marsha L., “Computer Networking”, Pearson Education, New Delhi 2005.
4. Kurose James and Ross Keith,” Computer Networking: Top Down Approach featuring the Internet”, Pearson Education, New Delhi,2002

Course outcomes:

On completion of the course the students will be able to

- acquire the knowledge of basic concepts of networking
- acquire the knowledge of various performance parameters and modulation techniques
- identify the network components and illustrate the functions of data link layer
- classify various IEEE standards of wireless networks
- manipulate the addressing scheme and summarize the operations of TCP/IP

14PEE03 MODERN POWER SYSTEM PROTECTION

3 0 0 3

Pre-requisites: Mathematics, Circuit Theory, Power System Protection and Switch Gear

UNIT – I **9**

Introduction : General philosophy of protection – Characteristic functions of protective relays – basic relay elements and relay terminology – Classification of Relays – Construction and operation of Electromagnetic relays – A review of conventional protection schemes for Transmission lines and station apparatus (Qualitative treatment only)

UNIT – II **9**

Static relays – Solid state devices used in static protection – Amplitude comparator and phase comparator – Static Over current relays: Non-directional, Directional - Synthesis of Mho relay, Reactance relay, Impedance relay and Quadrilateral Distance relay using Static comparators, Differential relay.(Qualitative treatment only)

UNIT – III **9**

Microprocessor Based Relays : Hardware and software for the measurement of voltage, current, frequency, phase angle – Microprocessor implementation of over current relays – Inverse time characteristics – Directional relay – Impedance relay– Mho relay, Differential relay – Numerical relay algorithms – SCADA Interfacing.(Qualitative treatment only)

UNIT – IV **9**

Modern Protective Devices: Introduction to Digital Signal Processing - Logic devices and systems – Signal Processing Filters – DSP based relays – DSP based Algorithms - Traveling wave relays: Amplitude comparison relay, phase comparison relay, Directional comparison relay, Fault location. (Qualitative treatment only)

UNIT – V **9**

Modern Trends in Protective Relaying : Pilot relay protection: Wire pilot relaying, Carrier current pilot relaying, Microwave pilot relaying – Fibre-optic based relaying – Apparatus Protection: Digital protection of generators, Digital protection of Transformers – Protection of Long and short lines– Protection based on Artificial Intelligence – SCADA: Architecture, Use of SCADA in interconnected power systems.(Qualitative treatment only)

TOTAL : 45

REFERENCE BOOKS:

1. Y.G.Paithankar , S.R.Bhide, “ Fundamentals of Power System Protection”, Prentice – Hall India, 2004.
2. A.G.Phadke, J.S.Thorpe, “Numerical relaying for Power Systems”, John-Wiley and Sons, 1988
3. T.S.M.Rao, “Digital / Numerical Relays”, Tata McGraw Hill,2005
4. Badri Ram and DN Vishwakarma, “Power system protection and Switchgear “, Tata McGraw

   NewDelhi, 2003.
5. Ravindar P. Singh, “Digital Power System Protection”, PHI, New Delhi, 2007
6. L.P.Singh, “Digital protection, Protective Relaying from Electromechanical to Microprocessor”, John Wiley & Sons, 1995
7. J.L. Blackburn, “Protective Relaying: Principles and Applications”, Marcel Dekker, New York 7

Course Outcomes:

On completion of the course the students will be able to

- outline the basic concepts of protective schemes and relays
- know the working of microprocessor based relays for various industrial application
- understand the modern relaying for erection and commissioning

14PEE04 SWITCHED MODE POWER CONVERTERS

3 0 0 3

Pre-requisites: Power System Analysis, Power Electronics

UNIT – I **9**

Resonant Converters : Zero voltage and Zero current switching : Classification of resonant converters - Basic resonant circuit concepts - Load resonant converters - Resonant switch converters - Zero voltage switching, clamped voltage topologies -Resonant DC link Inverters and Zero voltage switching - High frequency link integral half cycle converters – Applications in SMPS and lighting

UNIT – II **9**

Electric Utility Interface and Applications: Generation of current harmonics – Current harmonics and power factor - Harmonic standards and recommended practices - Need for improved utility interface - Improved single phase utility interface - Improved three phase utility interface - Interconnection of renewable energy source and energy storage system to the utility grid – Electromagnetic interference.

UNIT – III **9**

Emerging Devices : Power Junction Field Effect Transistors - Field Controlled Thyristors - JFET based devices Vs other power devices - MOS controlled thyristors -. Integrated Gate commutated Thyristor (IGCT) - Switching and steady state characteristics - Intelligent power modules- Power integrated circuits - New semiconductor materials for power devices.

UNIT – IV **9**

Snubber Circuits : Function and Types of Snubber Circuits- Diode Snubbers - Snubber Circuits for Thyristors-Need for Snubbers with Transistors- Turn-Off Snubber - Overvoltage Snubber - Turn-On Snubber - Snubbers for Bridge Circuit Configurations- GTO Snubber Considerations.

UNIT – V **9**

Gate and Base Drive Circuits : Preliminary Design Considerations - dc-Coupled Drive Circuits - Electrically Isolated Drive Circuits - Cascade-Connected Drive Circuits - Thyristor Drive Circuits - Power Device Protection in Drive Circuits - Circuit Layout Considerations.

TOTAL : 45

REFERENCE BOOKS:

1. Ned Mohan., Undeland and Robbins, " Power Electronics: Converters, Applications and Design ", John Wiley and Sons (Asia) Pte Ltd, Singapore, 2003.
2. Rashid, M.H., “Power Electronics : Circuits, Devices and Applications”, Pearson education (Singapore) Pte. Ltd, Prentice Hall of India, New Delhi, 2004.
3. Joseph Vithayathil., “Power Electronics”, Mc-Graw Hill series in Electrical and Computer Engineering, USA, 1995.
4. Mohan Mathur P, Rajiv K Varma, “Thyristor – Based Facts Controllers for Electrical Transmission Systems”, John Wiley and Sons Inc., IEEE Press,USA, 2002.
5. Roger C Dugan, Maric F Mcgranaghan, “Electrical Power System Quality”, Mc-Graw Hill Inc, New York, 1996.
6. Bimal K Bose, “Modern Power Electronics – Evolution, Technology and application”, Jaico Publishing House, Mumbai, 2006.

Course Outcomes:
On completion of the course the students will be able to

- apply knowledge gained from undergraduate engineering discipline to identify, formulate, solve problems and challenges in advanced power electronics and drives
- understand the Resonant converters for ZVS and ZCS and Harmonic Reduction in power electronic converters
- gain the knowledge about the advanced design of emerging devices its characteristics
- acquire the knowledge about Snubber Circuits ,Gate and Base Drive Circuits

14PEE05 COMPUTER AIDED DESIGN OF ELECTRICAL MACHINES

3 0 0 3

Prerequisite: Electromagnetic Theory, Circuit Theory, Electrical Machines

UNIT– I **9**

Introduction :Conventional design procedures – Limitations - Need for field analysis based design - Development of torque/force - Electromagnetic Field Equations.

UNIT – II **9**

Mathematical formulation of Field problems: Magnetic Vector/Scalar Potential - Electrical Vector/Scalar potential - Stored energy in field problems – Inductances - Laplace and Poisson's Equations – Energy functional - Principle of energy conversion.

UNIT – III **9**

Philosophy of FEM: Mathematical Models - Differential/Integral equations - Finite Difference method - Finite Element Method - Energy minimization - Variational method - 2D Field problems – Discretisation – Shape functions - Stiffness matrix -Solution techniques.

UNIT – IV **9**

CAD Packages: Elements of a CAD System - Preprocessing – Modelling - Meshing - Material properties - Boundary Conditions - Setting up solution – Post processing**.**

UNIT – V **9**

Design Applications: Design of Solenoid Actuator - Induction Motor - Switched Reluctance Motor – Synchronous Machines.

TOTAL: 45

REFERENCES BOOKS:

1. Silvester and Ferrari, “Finite Elements for Electrical Engineers” Cambridge University press, 1983.
2. S.R.H.Hoole,” Computer- Aided, Analysis and Design of Electromagnetic Devices”, Elsevier, New York, Amsterdam, London, 1989.
3. D.A. Lowther and P.P.Silvester, “Computer Aided Design in Magnetics”, Springer Verlag, New York, 1956.
4. S.J.Salon, "Finite Element Analysis of Electrical Machines" Kluwer Academic Publishers, London, 1995.
5. C. W. Trowbridge, "An Introduction to Computer Aided Electromagnetic Analysis”, Vector Field Ltd.
6. User Manuals of MAGNET, MAXWELL & ANSYS- Software Packages.

Course Outcomes:

On completion of the course the students will be able to

- formulate mathematical expressions for the electromagnetic field problems
- solve the field problems using finite element method
- design simple applications using CAD Packages

14PEE06 COMPUTER AIDED SIMULATION AND DESIGN OF POWER ELECTRONIC SYSTEMS

3 0 0 3

Pre-requisites: AC Converters, Power Electronics

Unit – I **9**

Introduction PSPICE and MATLAB : Importance of simulation – Challenges in simulation - General purpose circuit analysis – Methods of analysis of power electronic systems – Review of power electronic devices and circuits. PSpice : File formats - Description of circuit elements - Circuit description – Output variables - Dot commands - SPICE models of Diode, Thyristor, Triac, BJT, Power MOSFET, IGBT and MCT. MATLAB and Simulink : Toolboxes of MATLAB - Programming and file processing in MATLAB – Model definition and model analysis using SIMULINK - S-Functions - Converting S Functions to blocks.

UNIT – II **9**

Modeling of Power Electronic Devices : Review of numerical methods - Application of numerical methods to solve transients in DC switched R, L, R-L, R-C and R-L-C circuits - Extension to AC circuits - Modeling of diode in simulation - Diode with R, R-L, R-C and R-L-C load with ac supply .

UNIT – III **9**

Simulaton of Power Electronic Devices and Machines : Modeling of SCR, TRIAC, IGBT and Power Transistors in simulation - Simulation of gate/base drive circuits, simulation of snubber circuits. State space modeling and simulation of linear systems - Introduction to electrical machine modeling: induction, DC, and synchronous machines - simulation of basic electric drives, stability aspects.

UNIT – IV **9**

Simulation of Converters: Diode rectifiers -Controlled rectifiers - AC voltage controllers - DC choppers – PWM inverters – waveform control - Voltage source and current source inverters - Space vector representation - Resonant pulse inverters - Zero current switching and zero voltage switching inverters.

UNIT – V **9**

Simulation of Drives : Simulation of power factor correction schemes Simulation of speed control schemes for DC motors – Rectifier fed DC motors – Chopper fed DC motors – VSI and CSI fed AC motors – DC link inverter.

TOTAL: 45

REFERENCE BOOKS:

1. Muhammad H. Rashid, Hasan M. Rashid, "SPICE for power electronics and electric power", CRC Press,2006.
2. Rashid, H. Muhammad, "Introduction to PSPICE using Orcad for Circuits and Electronics", third edition, Pearson/Prentice Hall,2004.
3. Rashid, M., "Simulation of Power Electronic Circuits using PSPICE", PHI, 2006.
4. Rajagopalan, V. "Computer Aided Analysis of Power Electronic systems"-Marcell –Dekker Inc., 1987.
5. Ned Mohan, "Power Electronics: Computer Simulation Analysis and Education using PSPICE", Minnesota Power Electronics Research and Education, USA,1992.

6. Chee-Mun Ong, "Dynamic Simulation of Electric Machinery : Using MATLAB/ Simulink", Prentice Hall PTR, New Jersey, 1998.
7. Bimal K Bose, "Power Electronics and Variable Frequency Drives", IEEE Press, New Jersey, 1996.
8. Partha S. Mallick, "MATLAB and SIMULINK: Introduction to Applications", Scitech Publications (India), 2006
9. MATLAB / Simulink Reference Manual , Math works, USA

Course Outcomes:

On completion of the course the students will be able to

- understand the model electrical systems
- handle the software packages like MATLAB SIMULINK, PSPICE and the process of interfacing MATLAB/SIMULINK with m-file using S function blocks
- understand the close relationship between hardware and simulation models of actual systems

14PEE07 DSP PROCESSOR BASED ELECTROMECHANICAL MOTION CONTROL

3 0 0 3

Prerequisite: Electrical Machines, Power Electronics, Digital Signal Processing

UNIT– I **9**

Introduction to TMSLF2407 DSP controller and architecture :

Introduction to DSP controllers – Peripherals - types of physical memory - memory - addressing modes.

UNIT – II **9**

DSP CPU and Instruction Set :

software tools - DSP Core – code generation –components – mapping external devices - peripheral interface - system configuration registers – assembly programming Instruction set - General purpose input / output functionality.

UNIT – III **9**

Interrupts:

Introduction to interrupts - interrupt hierarchy - interrupt control registers - initializing and servicing interrupt.

UNIT – IV **9**

Event manager :

Overview of the event manager - event manager interrupts - general purpose timers - compare Units - capture units.

UNIT – V **9**

Case study :

Space vector pulse width modulation - stepper motor – PMSM - PMBLDC motor - vector control of induction motor - Switch reluctance motor

TOTAL: 45

REFERENCE BOOKS :

1. Hamid A. Toliyat, Steven Campbell, "DSP based electromechanical motion control", CRC press, New York, Washington Dc, 2004.
2. Krishnan R, "Electric Motor Drives: Modelling, Analysis and Control", Prentice Hall of India Pvt. Ltd, New Delhi, 2002
3. John G. Proakis, Dimitris G.Manolakis, "Digital Signal Processing: Principles, Algorithms and Applications", Prentice Hall India, 1996.
4. B.Venkatramani & M.Bhaskar, "Digital Signal Processors architecture, Programming and Applications", Tata McGraw-Hill Education, 2002.
5. S. Bejerke, "Digital Signal Processing Solutions for Motor Control Using the TMS320F240 DSP-Controller", SPRA345, ESIEE, Paris, Texas Instruments, September 1996.

Course Outcomes:

On completion of the course the students will be able to

- understand the architecture and addressing modes of DSP controller
- develop the interrupt programming and customize the timers of DSP controller for the power electronics applications
- implement the space vector pulse width modulation technique and DSP based drives control using DSP controller

14PEE08 ELECTROMAGNETIC INTERFERENCE AND COMPATIBILITY FOR ELECRICAL SYSTEMS

3 0 0 3

Pre-requisites: Electromagnetic theory, Digital signal processing, Power Quality

UNIT - I **9**

Introduction: EMI/EMC concepts and definitions – Sources of EMI – conducted and radiated EMI – Characteristics – Transient EMI, Time domain Vs Frequency domain EMI – Units of measurement parameters – EMC regulation- typical noise path- use of network theory- methods of eliminating interferences.

UNIT - II **9**

EMI Coupling Principles: Conducted, Radiated and Transient Coupling – Common Impedance Ground Coupling –Radiated Common Mode and Ground Loop Coupling – Radiated Differential Mode Coupling – Near Field Cable to Cable Coupling – Power Mains and Power Supply coupling.

UNIT - III **9**

EMI Control Techniques: Shielding: Shielding Material-Shielding integrity at discontinuities, Filtering: Characteristics of Filters-Impedance and Lumped element filters-Telephone line filter, Power line filter design, Filter installation and Evaluation. Grounding: Measurement of Ground resistance-system grounding for EMI/EMC-Cable shielded grounding, Bonding, Isolation transformer, Transient suppressors, Cable routing, Signal control. EMI gaskets.

UNIT - IV **9**

EMC Design of PCBs: EMI Suppression Cables:-Absorptive, ribbon cables.Devices:Transient protection hybrid circuits, Component selection and mounting – PCB trace impedance – Routing – Cross talk control-Electromagnetic Pulse-Noise from relays and switches, Power distribution decoupling – Zoning – Motherboard Designs and propagation delay performance model.

UNIT - V **9**

EMI Measurements and EMI/EMC Standards: Open area test site – TEM cell – EMI test shielded chamber and shielded ferrite lined anechoic Chamber – Tx /Rx Antennas, Sensors, Injectors / Coupler and coupling factors –Civilian standards – FCC, CISPR, IEC, EN, Military standards – MIL STD 461D/462, EMI Test Instruments /Systems – EMI Shielded– Military Test Method and Procedures.

TOTAL: 45

REFERENCE BOOKS:

1. Henry W.Ott, "Noise Reduction Techniques in Electronic Systems", Second Edition, John Wiley and Sons, NewYork. 1988.
2. C.R.Paul, “Introduction to Electromagnetic Compatibility”, Second Edition, John Wiley and Sons,Inc, 2010.
3. Bernhard Keiser, “Principles of Electro-magnetic Compatibility”, Second Edition, Artech House, Inc.(685 canton street, Norwood, MA 020062 USA) 1987.
4. V.P.Kodali, "Engineering EMC Principles, Measurements and Technologies", IEEE Press, 1996
5. Bernhard Keiser, "Principles of Electromagnetic Compatibility", Artech house, Third Edition, 1987.

Course Outcomes:

On completion of the course the students will be able to

- understand the concepts, standards and regulations of Electromagnetic Interference, Electromagnetic Compatibility and its best practices
- recognize the latest EMC Tests and measurements techniques in the Test Laboratory
- apply the general EMC diagnostic techniques and design approaches

14PEE09 EMBEDDED SYSTEM AND APPLICATIONS

3 0 0 3

Pre-requisites: Microprocessors and Microcontrollers

UNIT – I **9**

Introduction : Introduction to Embedded systems – Von Neumann and Harvard architecture – Need of Microcontrollers – selection criterion - PIC Microcontroller 16F87X: Architecture – Features – Resets –Memory Organisations: Program Memory, Data Memory – Instruction Set – Simple programs using Assembly language Instruction sets – Interrupts.

UNIT – II **9**

Physical Interface Support Using PIC: PIC Peripherals – I/O Parallel Ports – Timers – Capture/Compare/PWM (CCP) Modules - Control registers – Serial ports – Master Synchronous serial Port (MSSP) in I^2C mode and in SPI mode – USART – Interfacing of PIC: Analog-to-digital Converter (ADC) – Registers associated with the peripherals – Initializing the Peripheral modules using Assembly language.

UNIT – III **9**

ARM Processor and Programming : General concepts - ARM7 - Instruction Set Architecture, Levels in architecture, Functional description - processor and memory organization - Introduction to RISC architecture, pipelining, Instruction issue and execution - Instruction formats - Addressing modes - Data alignment and byte ordering – Simple programs using Assembly language Instruction sets.

UNIT – IV **9**

Embedded Programming :Programming in Assembly Language (ALP) Vs High level language – C Program elements, Macros and Functions – Use of pointers – NULL pointers – use of function calls – Multiple function calls in a cyclic order in the main function pointers – Function queues and interrupt Service Routines queues pointers. C program compilers – Cross compiler – optimization of memory codes.

UNIT – V **9**

System Design – Case Study Applications Interfacing LCD Display – Keypad Interfacing - Generation of Gate signals for converters and Inverters - Motor Control – Controlling AC appliances – Measurement of frequency - Standalone Data Acquisition System.

TOTAL : 45

REFERENCE BOOKS:

1. Ajay V Deshmukh, "Microcontrollers: Theory and Applications, Tata McGraw Hill, New Delhi, 2007.
2. Raj Kamal, "Embedded Systems Architecture, Programming and Design", Tata McGraw-Hill, New Delhi, 2007.
3. Wayne Wolf., "Computers as Components: Principles of Embedded Computing System Design", Morgan Kaufman Publishers, San Francisco, second edition, 2001.
4. Vahid, Frank and Givargi, Tony, "Embedded System Design: A Unified Hardware/Software Introductions", John Wiley & Sons, New York, 2001.
5. Muhammad Ali Mazidi, Rolin D. Mckinlay, Danny Causey "PIC Microcontroller and Embedded Systems using Assembly and C for PIC18", Pearson Education 2008.
6. John Iovine, "PIC Microcontroller Project Book", McGraw Hill, 2000.

Course Outcomes:

On completion of the course the students will be able to

- illustrate the basic architecture and interfacing concepts of PIC16 microcontroller and ARM processor
- apply the programming skills for peripheral interfacing and real time applications
- apply the system design concepts for various applications

14PEE10 ENERGY CONSERVATION, MANAGEMENT AND AUDITING

(Common to Power Electronics and Drives & Applied Electronics)

3 0 0 3

Pre-requisites: Transmission and Distribution, Electric Power Utilization and Energy Auditing

UNIT – I **9**

Energy: Energy Scenario – India and World – Energy Resources Availability in India– Energy consumption – Pattern, Energy Conservation Potential – Various Industries and Commercial Establishments, Energy Intensive Industry .

UNIT – II **9**

Energy Conservation and Energy Efficiency – Needs and Advantages. Characteristic Method Employed in Certain Energy Intensive Industries –Various Energy Conservation measures in Steam Systems – Losses in Boiler – Methodology of upgrading Boiler program – Energy Conservation in Refrigeration and Air- conditioning Systems.

UNIT– III **9**

Energy Management: Importance of Energy Management, Energy Economics – Discount Rate, Payback Period, Internal Rate of Return, Life Cycle Cost, risk and Sensitivity Analysis, Financing Options, Energy Performance Contract and Role of ESCOS– Energy Consumption, Production, Cumulative sum of differences (CUSUM).

UNIT – IV **9**

Energy Management In Power System: Captive Power Generation Systems – Biomass, Wind and Diesel Power Generation – KVA Demand Estimation – Wheeling and Banking Concept – EB Bill detailing. Basics of Monitoring and Targeting – Elements of Monitoring and Targeting, Data and Information Analysis Techniques

UNIT – V **9**

Energy Audit: Energy Auditing – Principle, Types, Methodologies, Barriers, Role of Energy, Manager and Auditor – Energy Audit Questionnaire – Energy Conservation Act 2003. Purpose and Methodology with respect to Process Industries, Power Plants, Boilers etc. –Performance Evaluation of (i) Transformers (ii) Energy Distribution - Cable Selection and Cable losses (iii) Capacitors (iv) Electric Motors (v) Electrical Heating and Lighting Systems

TOTAL: 45

REFERENCE BOOKS:

1. Hamies, "Energy Auditing and Conservation; Methods, Measurements, Management & Case Study", Hemisphere, Washington, 1980
2. CB Smith, "Energy Management Principles", Pergamon Press, New York, 1981
3. Write, Larry C, "Industrial Energy Management & Utilization", Hemisphere Publishers, Washington, 1998
4. Trivedi, P.R., and Jolka, K.R, "Energy Management, Common Wealth Publication", New Delhi, 1997
5. "Handbook on Energy Efficiency", TERI, New Delhi, 2001.
6. Bureau of Energy Efficiency Exam Materials Volume I,II,III and IV

Course Outcomes:

On completion of the course the students will be able to

- apply energy management and energy conservation schemes in electrical systems
- perform economic analysis and load management on Electrical Systems

14PEE11 MICROCONTROLLER APPLICATIONS IN POWER ELECTRONICS

3 0 0 3

Pre-requisites: Microprocessor and Microcontrollers, Power Electronics

UNIT – I **9**

Introduction To Microcontroller: Evolution of microcontrollers - comparison between microprocessor and microcontrollers - Embedded systems and their characteristics - steps in Designing microcontroller based system - Instruction pipelining & advanced concepts. Architecture & programming Intel 8051, and PIC mid range microcontroller - Different types of addressing modes. Selection of Microcontrollers for suitable application and clock pulse generation.

UNIT – II **9**

Input Interfacing Devices: Interfacing LCD Display –Keypad Interfacing -–Controlling DC/ AC appliances –Measurement of frequency -Stand alone Data Acquisition System- Interfacing external hardware like Driver ICs, sensors and actuators - Practical aspects- Interfacing of relay circuit-Interfacing of 7 segment LED displays-Interfacing Matrix Keyboards

UNIT – III **9**

Output Interfacing Devices: Measurement of voltage, current, and speed, power and power factor using microcontrollers- Power quality/power factor correction-AC load control –-Motor Control- PID control of DC motor – stepper motor control – brush less DC motor control. Practical Aspects-Implementation in electromechanical system for stepper motor- Typical applications in the control of power electronic converter for power supplies.

UNIT – IV **9**

Microcontrollers In Power Electronic Systems: Gate firing control of converters and inverters-PWM implementation- Feedback control and processing of feedback signals- Implementation of digital controllers and filters- Monitoring, sequencing, diagnostics and miscellaneous computation and control-Control of AC/DC electric drives- Solar Power Conditioning (MPPT)-Remote Control-UPS Applications.

UNIT – V **9**

I/O Programming: Software Debugging-Hardware Test-Assembly language programming for -Zero crossing detectors – square wave generation -firing pulse generation for typical single- phase &Three Phase converters and inverters-ADC program-PWM Techniques.

TOTAL : 45

REFERENCE BOOKS:

1. John B. Peatman, “Design with Microcontrollers”, Mc-GrawHill International Addition, 1988.
2. Martin P. Bates,” Interfacing PIC Microcontrollers: Embedded Design by Interactive Simulation”, Second Edition, - Newness Publisher ,2013.
3. Rajkamal,”Microcontrollers -Architecture, Programming, Interfacing & system Design”, second edition, Pearson, 2012.
4. Mazidi and Mazidi, "The 8051 microcontroller and embedded systems", Pearson education 5th edition Indian reprint, 2003.
5. Kenneth Ayala, "The 8051 microcontroller and its programming", Thomson - Delmar learning, 2004

Course Outcomes:

On completion of the course the students will be able to

- understand the basic interfacing techniques
- apply the Programming knowledge for real time applications

14PEE12 ELECTRIC HYBRID VEHICLES AND ENERGY STORAGE SYSTEMS

3 0 0 3

Pre-Requisite : Power Electronics, Electrical Machines

UNIT – I **9**

Introduction to EHV: History of hybrid and electric vehicles - social and environmental importance of hybrid and electric vehicles, impact of modern drive-trains on energy supplies- Basics of vehicle performance, vehicle power source characterization, transmission characteristics, mathematical models to describe vehicle performance.

UNIT - II **9**

Hybrid Traction: Basic concept of hybrid traction, Introduction to various hybrid drive-train topologies-power flow control in hybrid drive-train topologies - Basic concept of electric traction-Introduction to various electric drive-train topologies- fuel efficiency analysis

UNIT - III **9**

Electric Components& Drives: Introduction to electric components used in Hybrid and Electric vehicles, Configuration and control of DC Motor drives – Introduction to Motor drives : configuration and control of Permanent Magnet Motor drives, Configuration and control of Switch Reluctance Motor drives, drive system efficiency

UNIT - IV **9**

Batteries: Performance, charging and discharging- storage density, energy density, and safety issues, classical batteries -Lead Acid, Nickel-Cadmium, Zinc Manganese dioxide and modern batteries -Zinc-Air, Nickel Hydride, Lithium Battery

UNIT - V **9**

Fuel cells-direct energy conversion -maximum intrinsic efficiency of an electrochemical converter, physical interpretation, carnot efficiency factor in electrochemical energy convertors - types of fuel cells -hydrogen oxygen cells, hydrogen air cell, alkaline fuel cell, and phosphoric fuel cell

TOTAL : 45

REFERENCE BOOKS:

1 Sira -Ramirez, R. Silva Ortigoza, “Control Design Techniques in Power Electronics”,2006
2 Tetsuya Osaka, Madhav Datta, “Energy Storage Systems in Electronics”, Gordon and Breach Science Publishers, 2000
3 R. M. Dell, D.A.J. Rand, “Understanding Batteries”, RSC Publications, 2001
4 James Larminie, Andrew Dick, “Fuel Cell System Explained”, J. Wiley, 2003
5 Mehrdad Ehsani, Yimin Gao, Ali Emadi, “Modern Electric,Hybrid Electric and Fuel Cell Vehicle”,CRC Publisher,2010.

Course Outcomes:

On completion of the course the students will be able to

- understand the configuration and types of EHV
- understand the usage of components and Drives in EHV
- analyze and understand the various aspects and performance of Batteries and Fuel Cells

14PEE13 POWER ELECTRONIC APPLICATIONS IN POWER SYSTEM

3 0 0 3

Pre-requisites: Power Electronics, Power System Analysis and Stability, Power System Protection and Switchgear and Power Quality

UNIT – I **9**

HVDC Transmission : Introduction –Comparison of AC and DC transmission- Application of DC transmission-Description of DC transmission system-Configuration of HVDC links Modem trend in DC transmission-detailed analysis of twelve pulse converters-General principle of DC link control-Converter control characteristics –System control hierarchy-Firing angle control-CEA control.

UNIT – II **9**

MTDC systems and Filtering approach: Introduction to MTDC –potential application of MTDC systems-Types of MTDC systems-control and protection of MTDC systems-DC smoothening reactor-DC breakers-Generation of Harmonic and Filtering-power control-Higher level controllers.

UNIT – III **9**

Static Shunt Compensators: Objectives and Principles of Shunt Compensation-Methods of Controllable VAR generation - Static VAR Compensators: SVC and STATCOM-Comparison between SVC and STATCOM-Static VAR Systems

Static Series Compensator: Objectives and Principles of Series Compensation- Variable Impedance Type Series Compensators-GCSC, TSSC, TCSC- Switching Converter Type Series Compensators – SSSC-External Control of Series Reactive Compensators- Characteristics and Features of Series Compensators.

UNIT – IV **9**

Static Voltage and Phase Angle Regulators: Objectives of Voltage and Phase Angle Regulators – Functional Requirements – Thyristor-Controlled Voltage and Phase Angle Regulators (TCVRs and TCPARs) – Switching Converter based Voltage and Phase Angle Regulators- Hybrid Phase Angle Regulators.

Combined Compensators: Introduction – Unified Power Flow Controller (UPFC) – Operating Principle-Conventional control capabilities-Real and reactive Power Flow Control- -– Interline Power Flow Controller (IPFC)- Principles and Characteristics – Control Structure- Generalized and Multifunctional FACTS Controllers.

UNIT – V **9**

Mitigation of Harmonics

Power quality problems, harmonics, harmonic creating loads, harmonic power flow and mitigation of harmonics, filters, passive filters, active filters, shunt, series and hybrid filters.

TOTAL : 45

REFERENCE BOOKS:

1. Narain G.Hingorani and Laszlo Gyugyi, "Understanding FACTS Concepts and Technology of Flexiable AC Transmission Systems", Wiley -Technology and Engineering, 2000.
2. K.R.Padiyar, "HVDC Power Transmission System", New Academic science Ltd., second
3. J.Arrillaga, "High Voltage Direct Current Transmission," IEEE, 2nd Revised Edition,1998.
4. P.Mohan Mathur, Rajiv k Varma, "Thyristor-Based Facts controller for electrical Transmission system", John Wiley and sons Inc., IEEE Press, USA, 2012.

5. Ned Mohan, Undeland and Robins, “Power Electronics: converters, Applications and Design”, Wiley India (P) Ltd., 2012.

Course Outcomes:

On completion of the course the students will be able to

- understand the concept of HVDC transmission systems and acquire knowledge on various firing angle control scheme
- analyze and design the various FACTs controllers to improve the stability of power system
- illustrate the basic concepts of harmonic filtering techniques

14PEE14 POWER QUALITY ENGINEERING

3 0 0 3

Pre-requisites: Electric Power Utilization and Energy Auditing, Power Quality, Power Electronics for Renewable Energy Systems

UNIT - I **9**

Power Quality Definitions and Fundamentals of Harmonics: Introduction – Power Quality definitions: Transients, Short Duration and Long Duration Voltage variations, Voltage imbalance, Waveform distortion, Voltage fluctuations. Power frequency variation: common power frequency disturbances, Curves for low – frequency disturbances, power acceptability curves (CBEMA and ITI). – Introduction to Harmonic standards.

UNIT - II **9**

Waveform distortions: Harmonic indices, inter-harmonics, voltage unbalance, flicker, Harmonic sources from commercial and industrial, Standards on harmonics. System response characteristics: System impedance, capacitor impedance, parallel resonance, series resonance loads, effects of resistance and resistive load. Effects of harmonic distortion: Impact on capacitors, transformers, motors and telecommunication circuits.

UNIT - III **9**

Waveform Processing Techniques and Monitoring: Fundamental frequency characterization: Curve – fitting algorithm, implementation, frequency estimation, R.M.S Error assessment, Fourier analysis: Convolution of harmonic phasors, sampled time functions, DFT, Efficiency of FFT algorithms, Wavelet transform, automation of disturbance reorganization.

UNIT - IV **9**

Wiring, Grounding and Power quality measurement equipment: Definitions, Reasons for grounding. Typical Wiring and grounding problems: Problems with conductors and connectors, missing safety ground, multiple neutral-to-ground connections, ground loops, Solutions to wiring and grounding problems: proper grounding practices, Rod, separately derived systems. Grounding techniques for signal reference – Types of instruments, wiring and grounding testers, disturbance analyzers, spectrum and harmonic analyzer, flicker meter, smart power quality monitor, transducer requirements

UNIT - V **9**

Power Quality Assessment, Improvement and Harmonic Filters: Assessment of power quality measurement data: Off – line, On – line data assessment, Application of Intelligent systems – Active, Passive 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.

TOTAL: 45

REFERENCE BOOKS:

1. Dugan, Roger C, “Electrical Power Systems Quality”, New Delhi, Tata Mcgraw Hill, 2012, 3rd Edition.
2. Arillaga J, “Power System Quality Assessment”, New Delhi, Wiley India Pvt Ltd. 2011.
3. Sankaran C, “Power Quality”, CRC Press, 2011

4. Arindam Ghosh "Power Quality Enhancement Using Custom Power Devices", Kluwer Academic Publishers, 2002.
5. G.T.Heydt, "Electric Power Quality", Stars in a Circle Publications, 1994(2nd edition).
6. Power electronic converter harmonics – Derek A. Paice,1999

Course Outcomes:

On completion of the course the students will be able to

- outline the terminologies of power quality disturbances, their causes, detrimental effects and its solutions
- describe the harmonic sources, filters, standards and equipments
- analyze the power quality problems and its mitigation methods

14PEE15 SMART GRID TECHNOLOGIES

3 0 0 3

Pre-requisites: Power System Operation and Control, Measurements and Instrumentation

UNIT - I **9**

Smart Power Grids: Introduction - Solar Energy - Wind energy -Micro grid of Renewable and Green (MRG) Power Grids - Control Operation of Interconnected Network Bulk Power Grids - Smart Power Grid - Cyber Controlled Smart Power Grids - Research Issues.

UNIT - II **9**

Operation and Control of Micro Grid: Introduction - Overview of MG Operation - Micro Grids Dynamic Modeling- Fuel Cells - Solid Oxide Fuel Cell Modeling- Micro-wind Turbines - Photovoltaic Panels - Micro Grids Emergency Control Strategies - Frequency Control - Exploiting Low Voltage Micro Grids for Service Restoration - Micro Grid Black Start - General Requirements & Sequence of Actions for Micro Grid Black Start .

UNIT - III **9**

Micro grid Load Frequency Control: Introduction - Angle Droop Control for VSC Interfaced DGs - Angle Droop Control and Power Sharing - Angle Droop and Frequency Droop Controller - Systems with Lower Droop Gains - System Stability with High Droop Gain - Power Quality Enhanced Operation of a Micro grid - Load Sharing of the DGs with Utility- Change in Power Supply from Utility - Power Supply from Micro grid to Utility.

UNIT - IV **9**

Voltage Regulation on Micro grid: Introduction - Voltage regulation in Conventional Distribution Network - Voltage regulation on Micro grid - Worst Case Voltage regulation - Mitigation of Voltage Variation Based on Worst Case Scenario – Mitigation methods of Voltage regulation: Regulating Primary DS Voltage (VS), Reducing Line Resistance using Reactive Power Control - Voltage Level and Connection Cost.

UNIT - V **9**

Advanced Metering Infrastructure (AMI): Smart meters – benefits and applications of smart metering – AMI architecture – components overview - Smart meter requirements and technology: Neighborhood Area Network (NAN) – Home Area Network topology (HAN) – power line carriers – HAN gateways – Field Area Networks (FAN) - requirements, IP based networks – overview of smart metering.

TOTAL: 45

REFERENCE BOOKS:

1. Ali Keyhani and Muhammad Marwali , "Smart Power Grids 2011" ,Springer Publications , 2011.
2. Fereidoon.P.sioshansi, "Smart grid – integrating renewable, distributed and efficient energy", academic press 2011.
3. Janaka Ekanayake , Nick Jenekins , "Smart grid : technology and applications", John wiley and sons Canada ,2011.
4. Christine Hertzog, "Smart Grid Dictionary" , Springer publications, 2009.
5. Tony Flick, Justin morehouse ,"Securing the smart grid : Next generation power grid security", Elsevier ,2010.

Course Outcomes:

On completion of the course the students will be able to

- analyse Smart Grid technologies, different smart meters and advanced metering infrastructure
- investigate the power quality management issues in Smart Grid
- realize the high performance computing for Smart Grid applications

14PEE16 SPECIAL ELECTRICAL MACHINES AND CONTROL

3 0 0 3

Pre-requisites: DC Machines and Transformers, Synchronous and Induction Machines

UNIT – I **9**

Permanent Magnet Synchronous Motors – Classifications – PMSM – Construction - Principle of operation – EMF and torque equations – Reactance – Phasor diagram – Power controllers - Converter - Volt-ampere requirements – Locus diagram and torque speed characteristics - Microprocessor based control.

UNIT – II **9**

Synchronous Reluctance Motors – Constructional features – Types – Axial and Radial motors – Operating principle – Reluctance torque – Torque equation - Phasor diagram - Characteristics – Introduction to Vernier motor –Construction and Operating principle.

UNIT – III **9**

Permanent Magnet Brushless D.C. Motors: Construction - Principle of operation – Types – Comparison between conventional DC and PMBLDC – Electronic commutation – EMF and torque equations – Speed Torque relations – Sensors used for Rotor position – Power controllers – Motor characteristics and Computer control.

UNIT – IV **9**

Switched Reluctance Motors : Constructional features – Principle of operation – Torque prediction – Inductance profile – Simple Application problem – Analysis – Types of Power controllers and converter topologies used – Current control schemes – Torque Speed Characteristics – Hysteresis and PWM – Phase current analysis for low, Medium and High speed operation – Microprocessor based control.

UNIT – V **9**

Stepping Motors : Stepper – Constructional features – motor – Types – Principle of operation – Permanent Magnet motor – Variable reluctance motor – Hybrid motor – Single and multi-stack configurations – Theory of torque predictions – Characteristics – Simple problems.

TOTAL : 45

REFERENCE BOOKS:

1. Miller T.J.E., "Brushless Permanent Magnet and Reluctance Motor Drives", Clarendon Press, Oxford, 1989.
2. Aearnley P. P., "Stepping Motors" A Guide to Motor Theory and Practice", Peter Perengrinus, London, 1982.
3. Kenjo T. and Nagamori S., "Permanent Magnet and Brushless DC Motors", Clarendon Press, London, 1988.
4. Kenjo T., "Stepping Motors and Their Microprocessor Controls", Clarendon Press, London, 1984.

Course Outcomes:

On completion of the course the students will be able to

- describe the construction, operation and performance of special electrical machines
- select special drives for specific applications
- recognize the importance of special drives for enhanced performance

14PEE17 INDUSTRIAL DRIVES

3 0 0 3

Pre-requisites: Power Electronics and Electrical Machines, Solid State DC Drives,Solid State AC Drives

UNIT – I **9**

Basic Requirements of Industrial Applications such as Metal Industries, machine tools, plastics and Rubber, chemical applications, material handling including lifts and hoists, fans, blowers and pumps, paper & tissue applications, printing, wire & cable applications, test rigs for Electric generators and motors, food Industries - Preferred -Drive characteristics- Selection of converters and motors for different applications- their advantages and limitations - Duty cycles and cyclic duration factor.

UNIT – II **9**

Typical Drive functions to address applications : Speed / frequency reference setting- speed ramps- speed PI control- v/f Control systems - torque and current control systems – scalar, vector direct torque control- self tuning system, analog and digital inputs and outputs- drive interlocks, protections and trips- drive programming and user defined functionalities- safety aspects and standards for drives.

UNIT – III **9**

Special techniques used in modern drives : Speed reference corresponding to linear motion in paper and continuous metal industries - centralized cascade speed controls incorporating area factor - S- type ramp control for smooth landing of lifts and hoists - cut to length applications and stop length- torque feed forward control for large inertia loads for faster acceleration- registration system for printing applications - master and helper drives and load sharing - load sharing by paired DC and AC motors – common speed control and individual current controls - tension controls using position transducer - Tension and Winder control - Centre driven winders and surface driven winders with variable inertia compensation - high frequency inverter driven applications for man made fibres, glass engraving - diamond polishing etc.

UNIT – IV **9**

Specific Industry Applications : HVAC system and building automation ; Cranes and hoists ; port and gantry cranes - elevators and lifts - metal forming and rolling applications - sectional paper machine applications including load sharing and surface winding - two and three drum winders for finishing paper reels ,coating, plating and galvanizing lines- extruder drives for plastic industries - cement and sugar mill applications.

UNIT – V **9**

Industry Environment : AC supply - power factor and harmonics- Interaction between drives and motors -Thermal managements of motors and drives - Power supply management - EMC - Protection to Drives - Other miscellaneous requirements – vibration, critical speed, safety of Installation.

TOTAL : 45

REFERENCE BOOKS:

1. Bill Drury,"Control Technique Drives and Controls Handbook", Second Edition, IET Power and Energy Series 57.
2. Werner Leonhard, "Control of Electrical Drives", Third Edition, Springer, 2003 Reprint

3. W.Shepherd, L.N.Hulley and D.T.W. Liang, “Power Electronics and Motor Control”, Second Edition, Cambridge University Press.
4. V.R.Moorthi, “Power Electronics-Devices, Circuits and Industrial Applications”, First Edition (11th Impression 2011), Oxford University Press.

Course Outcomes:

On completion of the course the students will be able to

- know the basic requirements of the drive for various applications
- acquire idea of the various drive functions and modern techniques available to address different applications
- gain basic knowledge of the specific applications of important application areas
- skill set to implement the drive solution compatible with the specific plant environment

14CIE17 PROGRAMMABLE LOGIC CONTROLLERS

(Common to Applied Electronics & Power Electronics and Drives)

3 0 0 3

UNIT – I **9**

Introduction to Programmable Logic Controller: Overview of Programmable Logic Controller - Parts of a PLC – Principles of operation - modifying the operation - PLC vs Computer - PLC Size and applications - I/O Modules: Discrete, Analog, Special – I/O Specifications – CPU – Memory design and types – Programming devices – Recording and Retrieving data – PLC Workstations

UNIT – II **9**

Basic PLC Programming: Fundamentals of Logic – Processor Memory Organization – Program Scan – PLC programming languages – Relay-Type Instructions - Instruction addressing – Branch and Internal relay instructions – Entering the Ladder diagram – Electromagnetic Control relays – Contactors – Motor Starters – Manual operated switches and Mechanically operated switches

UNIT – III **9**

Advanced PLC Programming: Programming Timers – Programming Counters – Program Control Instructions – Data Manipulation Instructions – Math Instructions – Sequencer and Shift Register Instructions.

UNIT – IV **9**

PLC Installation and Troubleshooting: PLC Enclosures – Electrical Noise – Leaky Inputs and Outputs – Grounding – Voltage Variations and Surges – Program Editing – Programming and Monitoring – Preventive Maintenance – Connecting PC and PLC – Process Control: Types of processes – structure of control system – Controllers – Data Acquisition Systems

UNIT – V **9**

PLC Communication and its Applications : Computer Fundamentals – Computer-Integrated Manufacturing – Data Communications – Computer numeric control – Robotics - PLC Applications: Bottle filling system – pneumatic stamping system – material handling system – PLC in Individual process – Continuous process – Container filling system – liquid heating system.

TOTAL : 45

TEXT BOOKS:

1. Frank D. Petruzella, "Programmable Logic Controllers" Tata McGraw-Hill Edition, New Delhi,2010
2. Webb John W and Reis Ronald A., "Programmable Logic Controllers", Prentice Hall Publications, New Delhi, 2005
3. Bolton W, "Programmable Logic Controllers", ELSEVIER , New York, 2006
4. Rockwell Automation, "Logix 5000 Controllers" – system reference

Course Outcomes:

On completion of the course the students will be able to

- understand the basics of PL hardware and PLC programming
- design a PLC system, component, or process to meet a set of specifications
- apply the PLC in various industrial applications

14CIE18 SCADA AND DCS

(Common to Applied Electronics & Power Electronics and Drives)

3 0 0 3

Pre-requisites: Digital Logic Circuits

UNIT – I **9**

Automation: Fundamentals of industrial automation, need and role of automation, evolution of automation. HMI systems, Text display – operator panels – Touch panels – Panel PCs – Integrated displays (PLC & HMI), Rack installation, Grounding and shielding, physical, electrical, maintenance requirements-Troubleshooting.

UNIT – II **9**

SCADA: Concept of SCADA systems, Programming techniques for : Creation of pages, Sequencing of pages, Creating graphics & animation, Dynamos programming with variables, Trending, Historical data storage & Reporting, Alarm management, reporting of events and parameters. Comparison of different SCADA packages. Application Development using SCADA system.

UNIT – III **9**

DCS Introduction: Location of DCS in Plant, functions, advantages and limitations, Comparison of DCS with PLC. DCS components/ block diagram, Architecture, Functional requirements at each level. Layout of DCS, Controller Details, Redundancy, I/O Card Details, Junction Box and Marshalling Cabinets.

UNIT – IV **9**

Distributed Control System: Distributed Control Systems (DCS) – Difference between SCADA system and DCS –local control unit – programming language – communication facilities – operator interface – engineering interfaces.

UNIT – V **9**

Applications: Applications of SCADA & DCS – Case studies of Process plants using SCADA & DCS – Advanced features / options in SCADA & DCS – Role of PLC in DCS and SCADA – comparison – field devices (Transducers, drives etc) in DCS / SCADA.

TOTAL : 45

REFERENCE BOOKS:

1. Lukas, Michael P., "Distributed Control Systems", Van Nostrand Reinfold Company, 2002.
2. Dobrivojie Popovic, Vijay P. Bhatkar, "Distributed Computer Control for Industrial Automation", CRC Press, 1990
3. WiNCC Software Manual, Siemens, 2003.
4. RS VIEW 32 Software Manual, Allen Bradly, 2005.
5. CIMPLICITY SCADA Packages Manual Fanuc India Ltd, 2004.

Course Outcomes:

On completion of the course the students will be able to

- understand the basics of SCADA and DCS programming
- design a DCS and SCADA system for a process to meet a set of specifications
- apply the SCADA and DCS in various industrial applications