

**DHANALAKSHMI SRINIVASAN ENGINEERING COLLEGE
(AN AUTONOMOUS INSTITUTION)
PERAMBALUR-621212**

**M.E. POWER ELECTRONICS AND DRIVES
REGULATIONS – 2020
CHOICE BASED CREDIT SYSTEM
I to IV SEMESTERS (FULL TIME) CURRICULUM AND SYLLABI**

SEMESTER I

SL. NO	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1	P20MA103	Applied Mathematics for Electrical Engineers	FC	4	4	0	0	4
2	P20PE101	Advanced Power Semiconductor Devices	PC	3	3	0	0	3
3	P20PE102	Analysis of Electrical Machines	PC	3	3	0	0	3
4	P20PE103	Analysis and Design of Power Converters	PC	3	3	0	0	3
5	P20PE104	Analysis and Design of Inverters	PC	3	3	0	0	3
6		Professional Elective I	PE	3	3	0	0	3
PRACTICALS								
7	P20PE105	Power Electronics Circuits Lab	PC	4	0	0	4	2
TOTAL				23	19	0	4	21

SEMESTER II

SL. NO	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1	P20PE201	Electrical Vehicles and Energy Storage Systems	PC	3	3	0	0	3
2	P20PE202	Solid State AC Drives	PC	3	3	0	0	3
3	P20PE203	Digital Control and Controller Design	PC	3	3	0	0	3
4	P20PE204	Power Quality Improvement Techniques	PC	3	3	0	0	3
5		Professional Elective II	PE	3	3	0	0	3
6		Professional Elective III	PE	3	3	0	0	3
PRACTICALS								
7	P20PE205	Electrical Drives Laboratory	PC	4	0	0	4	2
8	P20PE206	Mini Project	EEC	4	0	0	4	2
TOTAL				26	18	0	8	22

SEMESTER III

SL. NO	COURSE CODE	COURSETITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1		Professional Elective IV	PE	3	3	0	0	3
2		Professional Elective V	PE	3	3	0	0	3
3		Professional Elective VI	PE	3	3	0	0	3
PRACTICALS								
4	P20PE301	Project Work (Phase I)	EEC	12	0	0	12	6
TOTAL				21	9	0	12	15

SEMESTER IV

SL. NO	COURSE CODE	COURSETITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
PRACTICALS								
1	P20PE401	Project Work (Phase II)	EEC	24	0	0	24	12
TOTAL				24	0	0	24	12

TOTAL NUMBER OF CREDITS: 70

FOUNDATION COURSES (FC)

S.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	P20MA103	Applied Mathematics for Electrical Engineering	FC	4	4	0	0	4

PROFESSIONAL CORE (PC)

S.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	P20PE101	Advanced Power Semiconductor Devices	PC	3	3	0	0	3
2.	P20PE102	Analysis of Electrical Machines	PC	3	3	0	0	3
3.	P20PE103	Analysis and Design of Power Converters	PC	3	3	0	0	3
4.	P20PE104	Analysis and Design of Inverters	PC	3	3	0	0	3
5.	P20PE201	Electrical Vehicles and Energy Storage Systems	PC	5	3	2	0	4
6.	P20PE202	Solid State AC Drives	PC	5	3	2	0	4
7.	P20PE203	Digital Control and Controller Design	PC	3	3	0	0	3
8.	P20PE204	Power Quality Improvement Techniques	PC	3	3	0	0	3
9.	P20PE105	Power Electronics Circuits Lab	PC	4	0	0	4	2
10.	P20PE205	Electrical Drives Laboratory	PC	4	0	0	4	2

EMPLOYABILITY ENHANCEMENT COURSES (EEC)

S.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	P20PE206	Mini Project	EEC	4	0	0	4	2
2.	P20PE301	Project Work - Phase I	EEC	12	0	0	12	6
3.	P20PE401	Project Work - Phase II	EEC	24	0	0	24	12

SUMMARY

M.E., Power Electronics and Drives							
S. No	Subject Area	Credits per Semester				Credits Total	Percentage %
		I	II	III	IV		
1.	Foundation Courses	4	-	-	-	4	5.71
2.	Professional Cores	14	14	-	-	28	40.00
3.	Professional Electives	3	6	9	-	18	25.71
4.	Employability Enhancement Courses		2	6	12	20	28.57
Total		21	22	15	12	70	100

Professional Elective I (PE) (SEMESTER I)

SL. NO	COURSE CODE	COURSETITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.	P20PE111	Soft Computing Techniques	PE	3	3	0	0	3
2.	P20PE112	Electromagnetic Field Computation and Modelling	PE	3	3	0	0	3
3.	P20PE113	Microcontroller Based System Design	PE	3	3	0	0	3
4.	P20PE114	Embedded And Real Time Systems	PE	3	3	0	0	3
5.	P20PE115	Special Electrical Machines	PE	3	3	0	0	3

Professional Elective II (PE) (SEMESTER II)

SL. NO	COURSE CODE	COURSETITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.	P20PE221	Modern Control Theory	PE	3	3	0	0	3
2.	P20PE222	Distributed Generation and Micro grids	PE	3	3	0	0	3
3.	P20PE223	Energy Management and Auditing	PE	3	3	0	0	3
4.	P20PE224	Solid State DC Drives	PE	3	3	0	0	3
5.	P20PE225	Modern Power Electronic Converters	PE	3	3	0	0	3

Professional Elective III (PE) (SEMESTER II)

SL. NO	COURSE CODE	COURSETITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.	P20PE321	Power Electronics for Renewable Energy Systems	PE	3	3	0	0	3
2.	P20PE322	Intellectual Property Rights	PE	3	3	0	0	3
3.	P20PE323	Flexible AC Transmission Systems	PE	3	3	0	0	3
4.	P20PE324	FPGA based architecture design	PE	3	3	0	0	3
5.	P20PE325	MEMS Technology	PE	3	3	0	0	3

Professional Elective IV (PE) (SEMESTER III)

SL. NO	COURSE CODE	COURSETITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.	P20PE431	OptoElectronic Devices	PE	3	3	0	0	3
2.	P20PE432	Electromagnetic Interference and Compatibility	PE	3	3	0	0	3
3.	P20PE433	High Voltage Direct Current Transmission	PE	3	3	0	0	3
4.	P20PE434	PWM Techniques for Power Converters	PE	3	3	0	0	3

Professional Elective V (PE) (SEMESTER III)

SL. NO	COURSE CODE	COURSETITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.	P20PE531	Electric Vehicles and Power Management	PE	3	3	0	0	3
2.	P20PE532	Power Electronics in Power System	PE	3	3	0	0	3
3.	P20MG533	Research Methodology	PE	3	3	0	0	3
4.	P20PE534	Solar Photovoltaic Systems	PE	3	3	0	0	3

Professional Elective VI (PE) (SEMESTER III)

SL. NO	COURSE CODE	COURSETITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.	P20PE631	Diagnosis and Protection for Solid State Systems	PE	3	3	0	0	3
2.	P20PE632	IOT for Smart Grids	PE	3	3	0	0	3
3.	P20PE633	Electric Vehicles Charging Technologies	PE	3	3	0	0	3
4.	P20PE634	Wind Energy Conversion System	PE	3	3	0	0	3

3. Elsgolc, L. D. "Calculus of Variations", Dover Publications, New York, 2007.
4. Johnson, R.A., Miller, I and Freund J., "Miller and Freund's Probability and Statistics for Engineers", Pearson Education, Asia, 8th Edition, 2015.
5. O'Neil, P.V., "Advanced Engineering Mathematics", Thomson Asia Pvt. Ltd., Singapore, 2003.
6. Taha, H.A., "Operations Research, An Introduction", 9th Edition, Pearson education, New Delhi, 2016.

P20PE101	ADVANCED POWER SEMICONDUCTOR DEVICES	L	T	P	C
		3	0	0	3

OBJECTIVES:

To impart knowledge on

- To understand the static and dynamic characteristics of Power Diode and Thyristors.
- To understand the static and dynamic characteristics of current controlled power semiconductor devices.
- To understand the static and dynamic characteristics of voltage controlled power semiconductor devices.
- To enable the students for the selection of devices for different power electronics applications.
- To understand the control and firing circuit for different devices and the selection of devices for different power electronics applications.

UNIT I INTRODUCTION 9

Power switching devices overview – Attributes of an ideal switch, application requirements, circuit symbols; Power handling capability – SOA - Device selection strategy – On-state and switching losses – EMI due to switching - Power diodes - Types, forward and reverse characteristics, switching characteristics – rating.

UNIT II THYRISTORS 9

Thyristors – Physical and electrical principle underlying operating mode, Two transistor analogy – concept of latching- Gate and switching characteristics- commutation of Thyristors - converter grade and inverter grade; series and parallel operation- Models of Thyristors.

UNIT III CURRENT CONTROLLED TRANSISTORS 9

Power BJTs – Construction, static characteristics, switching characteristics; Negative temperature co-efficient and secondary breakdown - comparison of BJT and Thyristor – steady state and dynamic models of BJT.

UNIT IV VOLTAGE CONTROLLED DEVICES 9

Power MOSFETs and IGBTs – Principle of voltage controlled devices, construction, types, static and switching characteristics, steady state and dynamic models of MOSFET and IGBTs - Basics of GTO, MCT, RCT and IGCT.

UNIT V FIRING AND PROTECTING CIRCUITS 9

Necessity of isolation, pulse transformer, opto-coupler – Gate drives circuit: SCR, MOSFET, IGBTs and base driving for power BJT. - Over voltage, over current and gate protections; Design of snubbers. Heat transfer – conduction, convection and radiation, Electrical analogy of thermal components- Thermal resistance and impedance, Guidance for heat sink selection –Mounting types.

TOTAL: 45 PERIODS

OUTCOMES:

At the end of the course, the students will be able to

- Explain the basic principle and operation of Diode.
- Explicate the basic principle and operation of Thyristors.
- Describe the principle and operation of current controlled transistors
- Demonstrate the principle and operation of voltage controlled devices.
- Design and analyze firing and protection circuits.

REFERENCE BOOK:

1. Rashid M.H., "Power Electronics Circuits, Devices and Applications ", Pearson Education, Fourth Edition. 2014.
2. MD Singh and K.B Khanchandani, "Power Electronics", McGraw Hill, third edition, 2008.
3. Ned Mohan, Undeland and Robbin, "Power Electronics: converters, Application and design" John Wiley and sons, 2003.
4. Philip T. krein, "Elements of Power Electronics", Oxford University Press – second edition, 2016.
5. M.S.Jamil Asghar, "Power Electronics", Prentice Hall of India private Ltd -2011.
6. Joseph Vithayathil, Power Electronics: Principles and Applications, Delhi, McGrawHill, 2010

P20PE103**ANALYSIS OF ELECTRICAL MACHINES**

L	T	P	C
3	0	0	3

OBJECTIVES:

- To provide knowledge about the fundamentals of magnetic circuits, energy, force and torque of multi-excited systems.
- To analyze the steady state and dynamic state operation of DC machine through mathematical modeling and simulation in digital computer.
- To provide the knowledge of theory of transformation of three phase variables to two phase variables.
- To analyze the steady state and dynamic state operation of three-phase induction machines and synchronous machines using transformation theory based mathematical modeling and digital computer simulation.

UNIT I PRINCIPLES OF ELECTROMAGNETIC ENERGY CONVERSION 9

Magnetic circuits, permanent magnet, stored magnetic energy, co-energy - force and torque in singly and doubly excited systems – machine windings and air gap mmf - winding inductances and voltage equations.

UNIT II DC MACHINES 9

Elementary DC machine and analysis of steady state operation - Voltage and torque equations – dynamic characteristics of permanent magnet and shunt d.c. motors – Time domain block diagrams - solution of dynamic characteristic by Laplace transformation – digital computer simulation of permanent magnet and shunt D.C. machines.

UNIT III REFERENCE FRAME THEORY 9

Historical background – phase transformation and commutator transformation – transformation of variables from stationary to arbitrary reference frame - variables observed from several frames of reference.

UNIT IV INDUCTION MACHINES 9

Three phase induction machine, equivalent circuit and analysis of steady state operation – free acceleration characteristics – voltage and torque equations in machine variables and arbitrary reference frame variables – analysis of dynamic performance for load torque variations – digital computer simulation.

UNIT V SYNCHRONOUS MACHINES 9

Three phase synchronous machine and analysis of steady state operation - voltage and torque equations in machine variables and rotor reference frame variables (Park's equations) – analysis of dynamic performance for load torque variations – Generalized theory of rotating electrical machine and Krons primitive machine.

TOTAL: 45 PERIODS

OUTCOMES:

- Analyze various single phase and three phase power converters
- Select and design dc-dc converter topologies for a broad range of power conversion applications.
- Develop improved power converters for any stringent application requirements.
- Design ac-ac converters for variable frequency applications.

TEXT BOOKS:

1. Ned Mohan, T.M. Undeland and W.P. Robbins, "Power Electronics: converters, Application and design" John Wiley and sons. Wiley India edition, 2006.
2. Rashid M.H., "Power Electronics Circuits, Devices and Applications ", Prentice Hall India, Third Edition, New Delhi, 2004.
3. P.C. Sen, "Modern Power Electronics", Wheeler Publishing Co, First Edition, New Delhi, 1998.
4. P.S. Bimbhra, "Power Electronics", Khanna Publishers, Eleventh Edition, 2003
5. Simon Ang, Alejandro Oliva, "Power-Switching Converters, Second Edition, CRC Press, Taylor & Francis Group, 2010
6. V. Ramanarayanan, "Course material on Switched mode power conversion", 2007
7. Alex Van den Bossche and Vencislav Cekov Valchev, "Inductors and Transformers for Power Electronics", CRC Press, Taylor & Francis Group, 2005
8. W. G. Hurley and W. H. Wolfe, "Transformers and Inductors for Power Electronics Theory, Design and Applications", 2013 John Wiley & Sons Ltd.
9. Marian K. Kazimierczuk and Dariusz Czarkowski, "Resonant Power Converters", John Wiley & Sons limited, 2011

P20PE105

ANALYSIS AND DESIGN OF INVERTERS

L	T	P	C
3	0	0	3

OBJECTIVES:

- To provide the electrical circuit concepts behind the different working modes of inverters so as to enable deep understanding of their operation.
- To equip with required skills to derive the criteria for the design of power converters for UPS, Drives etc.,
- Ability to analyse and comprehend the various operating modes of different configurations of power converters.
- Ability to design different single phase and three phase inverters.

UNIT I SINGLE PHASE INVERTERS

9

Introduction to self commutated switches : MOSFET and IGBT - 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 – forced commutated Thyristor inverters – Design of UPS

UNIT II THREE PHASE VOLTAGE SOURCE INVERTERS

9

180 degree and 120 degree conduction mode inverters with star and delta connected loads – voltage control of three phase inverters: single, multi pulse, sinusoidal, space vector modulation techniques – Application to drive system

UNIT III CURRENT SOURCE INVERTERS

9

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

6. Modeling and System simulation of basic power electronic circuits using MATLAB SIMULINK/SCILAB
7. AC Source with Single Diode fed Resistive and Resistive-Inductive Load
8. AC source with Single SCR fed Resistive and Resistive-Inductive Load
9. Modeling and System Simulation of SCR based full converter with different types of load using MATLAB- Simulink/SCILAB
10. Full converter fed resistive load
11. Full converter fed Resistive-Back Emf (RE) load at different firing angles
12. Full Converter fed Resistive-Inductive Load at different firing angles
13. Full converter fed DC motor load at different firing angles
14. Circuit Simulation of Voltage Source Inverter and study of spectrum analysis with and without filter using MATLAB/SCI LAB
15. Single phase square wave inverter
16. Three phase sine PWM inverter
17. Generation of PWM gate pulses with duty cycle control using PWM peripheral of microcontroller (TI-C2000 family/ PIC18)
18. Duty cycle control from IDE
19. Duty Cycle control using a POT connected to ADC peripheral in a standalone mode
20. Generation of Sine-PWM pulses for a three phase Voltage Source Inverter with control of modulation index using PWM peripheral of microcontroller (TI C2000 family/PIC 18)
21. Design of Driver Circuit using IR2110
22. Design and testing of signal conditioning circuit to interface voltage/current sensor with microcontroller (TI-C2000 family/ PIC18)
23. Interface Hall effect current sensor with microcontroller and display the current waveform in the IDE and validate with actual waveform in DSO
24. Interface Hall effect Voltage sensor with microcontroller and display the current waveform in the IDE and validate with actual waveform in DSO
25. Design of PI controller using OP-AMP
26. Construction and testing of 500 W, 220 V IGBT based Buck converter with control circuit and its performance Evaluation
27. Measurement of Efficiency at different duty cycle with a resistive load
28. Measurement of Efficiency at different duty cycle with a resistive-inductive load
29. PCB design and fabrication of DC power supply using any PCB design software (open source- KiCAD/students version)

TOTAL: 60 PERIODS

OUTCOMES:

- Comprehensive understanding on the switching behaviour of Power Electronic Switches
- Comprehensive understanding on mathematical modelling of power electronic system and ability to implement the same using simulation tools
- Ability of the student to use microcontroller and its associated IDE* for power electronic applications
- Ability of the student to design and implement analog circuits for Power electronic control applications
- Ability to design and fabricate a power converter circuit at an reasonable power level
- Exposure to PCB designing and fabrication
- IDE – Integrate Development Environment (Code Composer Studio for Texas Instrument/MPLAB for PIC microcontrollers etc)

OBJECTIVES:

- To understand the concepts Hybrid Electric Vehicles.
- To configuration and control of DC motor, AC motor and special electrical motors.
- To sizing the drive systems and concept of energy storage devices .
- To understand the energy management strategies in electric and hybrid vehicles.

UNIT I INTRODUCTION TO HYBRID ELECTRIC VEHICLES 9

Conventional Vehicles. Hybrid Electric Drive-trains and Electric Drive-trains: Basic concept of electric traction, introduction to various electric drive-train topologies, power flow control in electric drive-train topologies, fuel efficiency analysis.

UNIT II ELECTRIC PROPULSION UNIT 9

Introduction to electric components used in hybrid and electric vehicles, Configuration and control of DC Motor drives, Configuration and control of Induction Motor drives, configuration and control of Permanent Magnet Motor drives, Configuration and control of Switch Reluctance Motor drives, drive system efficiency.

UNIT III SIZING THE DRIVE SYSTEM 9

Matching the electric machine and the internal combustion engine (ICE), Sizing the propulsion motor, sizing the power electronics, selecting the energy storage technology, Communications, supporting subsystems.

UNIT IV ENERGY STORAGE 9

Introduction to Energy Storage Requirements in Hybrid and Electric Vehicles. Battery, Fuel Cell, Super Capacitor and Flywheel based energy storage and its analysis, Hybridization of different energy storage devices.

UNIT V ENERGY MANAGEMENT STRATEGIES 9

Introduction to energy management strategies used in hybrid and electric vehicles, classification of different energy management strategies, comparison of different energy management strategies, implementation issues of energy management strategies. Case Studies: Design of a Hybrid Electric Vehicle (HEV), Design of a Battery Electric Vehicle (BEV).

TOTAL: 45 PERIODS

OUTCOMES:

1. Develop the electric propulsion unit and its control for application of electric vehicles.
2. Analyze different power converter topology used for electric vehicle application.

REFERENCES

1. Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press , 2003
2. Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay, Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press , 2004
3. James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley , 2003
4. Chris Mi, M. Abul Masrur, David Wenzhong Gao, Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives, John Wiley & Sons Ltd. , 2011

OBJECTIVES:

- To understand various operating regions of the induction motor drives.
- To study and analyze the operation of VSI & CSI fed induction motor control.
- To understand the speed control of induction motor drive from the rotor side.
- To understand the field oriented control of induction machine.
- To understand the control of synchronous motor drives.

UNIT I INTRODUCTION TO INDUCTION MOTORS 9

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

UNIT II VSI AND CSI FED INDUCTION MOTOR CONTROL 9

AC voltage controller circuit – six step inverter voltage control-closed loop variable frequency PWM inverter with dynamic braking-CSI fed IM variable frequency drives comparison

UNIT III ROTOR CONTROLLED INDUCTION MOTOR DRIVES 9

Static rotor resistance control - injection of voltage in the rotor circuit – static scherbius drives - power factor considerations – modified Kramer drives

UNIT IV FIELD ORIENTED CONTROL 9

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 SYNCHRONOUS MOTOR DRIVES 9

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 .

TOTAL: 45 PERIODS**OUTCOMES**

- The students gain an enhanced knowledge on the perspective and importance of induction motor drives and synchronous motor drives.
- The students will have a clear understanding of AC machines with their control and estimation techniques.

REFERENCES

1. Bimal K Bose, "Modern Power Electronics and AC Drives", Pearson Education Asia 2002.
2. Vedam Subramanyam, "Electric Drives – Concepts and Applications", Tata McGraw Hill, 1994.
3. Gopal K Dubey, "Power Semiconductor controlled Drives", Prentice Hall Inc., New Yersy, 1989.
4. R.Krishnan, "Electric Motor Drives – Modeling, Analysis and Control", Prentice-Hall of India Pvt. Ltd., New Delhi, 2003.
5. W.Leonhard, "Control of Electrical Drives", Narosa Publishing House, 1992.
6. Murphy J.M.D and Turnbull, "Thyristor Control of AC Motors", Pergamon Press, Oxford,1988.

OBJECTIVES:

- Basics of digital control systems
- The modeling of digital control system using state space approach
- The analysis of digital control system for controllability and observability
- The design of controllers using classical and state space approaches
- The stability of dynamic systems using Liapunov method
- To formulate the optimal control problems and solve them

UNIT I INTRODUCTION**9**

Introduction to discrete time control system - Sampling and holding - sample and hold device - D/A, A/D conversion – sampling theorem – data interpolation – Z transform –properties - inverse Z transform – Pulse transfer function.

UNIT II STATE VARIABLE TECHNIQUE**9**

State equations of discrete time systems – solution of state equation – state transition matrix, its properties –state space realization and state diagram – pulse transfer function from state equation - characteristic equation - Eigen values -Eigen vectors - Similarity transformation – transformation into various canonical forms.

UNIT III CONTROLLABILITY, OBSERVABILITY AND STABILITY**9**

Controllability and observability of Linear Time Invariant (LTI) discrete data systems – tests for controllability and observability - relationship between controllability, observability and pulse transfer functions. Stability of LTI discrete time systems - Jury's stability tests – Bilinear transformation method - Lyapunov stability analysis.

UNIT IV CONTROLLER DESIGN – I**9**

Correlation between root locations in Z-plane and time response - direct digital design in Z and W plane (under bilinear transform)PID controllers – proportional, integral and derivative modes – discretization of continuous PID controller – conventional tuning procedures – Reaction curve method of Ziegler Nichols – stability method of Ziegler Nichols.

UNIT V CONTROLLER DESIGN – II**9**

State feedback - Design via pole placement – observer based state feedback -Introduction to digital redesign - optimal controllers – quadratic optimal control –steady state quadratic optimal control – optimal state estimation– Kalman filter -Extended Kalman filter.

TOTAL: 45 PERIODS**OUTCOMES:**

- Understand the digital control concepts
- Model any sampled data system using state space approach
- Analyze the discrete time systems for controllability, observability and stability
- Design classical and pole placement controller and observer for systems modeled in state space
- Solve discrete time optimal control problems

REFERENCES

1. K.Ogata, "Discrete time control systems", Pearson Edu., 2003.
2. Franklin, Powell, workman, "Digital control of Dynamic systems", Pearson Edu., 2002.
3. Kannan M. Moudgalya, "Digital control", John Willy, 2008.
4. M.Gopal, "Digital Control and state variable methods", Tata McGraw Hill, New Delhi, 2003.
5. Aashish Tiwari, "Modern control design with MATLAB and SIMULINK", John Wiley and sons Ltd., 2002
6. Benjin.Kuo, 'Digital Control systems', 2nd Edition, Oxford University, 1992.

OBJECTIVES:

- To understand the various power quality issues.
- To understand the concept of power and power factor in single phase and three phase systems supplying nonlinear loads.
- To understand the conventional compensation techniques used for power factor correction and load voltage regulation.
- To understand the active compensation techniques used for power factor correction.
- To understand the active compensation techniques used for load voltage regulation.

UNIT I INTRODUCTION**9**

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

UNIT II ANALYSIS OF SINGLE PHASE AND THREE PHASE SYSTEM**9**

Single phase sinusoidal, non-sinusoidal source supplying linear and nonlinear loads – Three phase Balance system – Three phase unbalanced system – Three phase unbalanced and distorted source supplying non-linear loads – Concept of PF – Three phase three wire – Three phase four wire system.

UNIT III CONVENTIONAL LOAD COMPENSATION METHODS**9**

Principle of Load compensation and Voltage regulation – Classical load balancing problem : Open loop balancing – Closed loop balancing, Current balancing – Harmonic reduction and voltage sag reduction – Analysis of unbalance – instantaneous real and reactive powers – Extraction of fundamental sequence component.

UNIT IV LOAD COMPENSATION USING DSTATCOM**9**

Compensating single phase loads – Ideal three phase shunt compensator structure – Generating reference currents using instantaneous PQ theory – Instantaneous symmetrical components theory – Generating reference currents when the source is unbalanced – Realization and control of DSTATCOM – DSTATCOM in Voltage control mode.

UNIT V SERIES COMPENSATION OF POWER DISTRIBUTION SYSTEM**9**

Rectifier supported Dynamic Voltage Restorer – DC Capacitor supported DVR – DVR Structure – voltage Restoration – Series Active Filter – Unified Power Quality Conditioner.

TOTAL: 45 PERIODS**OUTCOMES:**

- Ability to formulate, design and simulate power supplies for generic load and machine loads.
- Ability to conduct harmonic analysis and load tests on power supplies and drive systems.
- Ability to understand and design load compensation methods useful for mitigating power quality problems.

REFERENCES

- 1 Jos Arrillaga and Neville R. Watson ,“ Power system harmonics”,Wiley,2003.
- 2 Derek A. Paice , “Power Electronics Converter Harmonics :Multipulse Methods for Clean Power”,Wiley,1999.
- 3 Ewald Fuchs, Mohammad A. S. Masoum Power Quality in Power Systems and Electrical Machines,Elseveir academic press publications,2011.

OBJECTIVES:

- To impart the theoretical and practical knowledge
- To design and analyse the various DC and AC drives.
- To generate the firing pulses for converters and inverters using digital processors
- Design of controllers for linear and nonlinear systems
- Implementation of closed loop system using hardware simulation

LIST OF EXPERIMENTS

1. Speed control of Converter fed DC motor.
2. Speed control of Chopper fed DC motor.
3. V/f control of three-phase induction motor.
4. Micro controller based speed control of Stepper motor.
5. Speed control of BLDC motor.
6. DSP based speed control of SRM motor.
7. Voltage Regulation of three-phase Synchronous Generator.
8. Cycloconverter fed Induction motor drives
9. Single phase Multi Level Inverter based induction motor drive
10. Study of power quality analyzer

TOTAL: 60 PERIODS**OUTCOMES:**

- Ability to simulate different types of machines, converters in a system.
- Analyze the performance of various electric drive systems.
- Ability to perform both hardware and software simulation.

OBJECTIVES:

- To develop the ability to solve a specific problem right from its identification and literature review till the successful solution of the same.
- To train the students in preparing project reports and to face reviews and viva voce examination.

A project to be developed based on one or more of the following concepts.

Rectifiers, DC-DC Converters, Inverters, cycloconverters, DC drives, AC drives, Special Electrical Machines, Renewable Energy Systems, Linear and non-linear control systems, Power supply design for industrial and other applications, AC-DC power factor circuits, micro grid, smart grid and robotics.

TOTAL: 60 PERIODS**OUTCOMES:**

- Acquire practical knowledge within the chosen area of technology for project development
- Identify, analyze, formulate and handle programming projects with a comprehensive and systematic approach
- Contribute as an individual or in a team in development of technical projects
- Develop effective communication skills for presentation of project related activities

OBJECTIVES:

- To expose the concepts of feed forward neural networks.
- To provide adequate knowledge about feedback neural networks.
- To teach about the concept of fuzziness involved in various systems.
- To expose the ideas about genetic algorithm
- To provide adequate knowledge about of FLC and NN toolbox

UNIT I INTRODUCTION AND ARTIFICIAL NEURAL NETWORKS 9

Introduction to intelligent systems- Soft computing techniques- Conventional Computing versus Swarm Computing - Classification of meta-heuristic techniques - Properties of Swarm intelligent Systems - Application domain - Discrete and continuous problems - Single objective and multi-objective problems -Neuron- Nerve structure and synapse- Artificial Neuron and its model- activation functions- Neural network architecture- single layer and multilayer feed forward networks- Mc Culloch Pitts neuron model- perceptron model- Adaline and Madaline- multilayer perception model- back propagation learning methods- effect of learning rule coefficient -back propagation algorithm- factors affecting back propagation training- applications.

UNIT II ARTIFICIAL NEURAL NETWORKS AND ASSOCIATIVE MEMORY 9

Counter propagation network- architecture- functioning & characteristics of counter Propagation network- Hopfield/ Recurrent network configuration - stability constraints associative memory and characteristics- limitations and applications- Hopfield v/s Boltzman machine- Adaptive Resonance Theory- Architecture- classifications- Implementation and training - Associative Memory.

UNIT III FUZZY LOGIC SYSTEM 9

Introduction to crisp sets and fuzzy sets- basic fuzzy set operation and approximate reasoning. Introduction to fuzzy logic modeling and control- Fuzzification inferencing and defuzzification-Fuzzy knowledge and rule bases-Fuzzy modeling and control schemes for nonlinear systems. Self organizing fuzzy logic control- Fuzzy logic control for nonlinear time delay system.

UNIT IV GENETIC ALGORITHM 9

Evolutionary programs – Genetic algorithms, genetic programming and evolutionary programming - Genetic Algorithm versus Conventional Optimization Techniques - Genetic representations and selection mechanisms; Genetic operators- different types of crossover and mutation operators - Optimization problems using GA-discrete and continuous - Single objective and multi-objective problems - Procedures in evolutionary programming.

UNIT V HYBRID CONTROL SCHEMES 9

Fuzzification and rule base using ANN–Neuro fuzzy systems-ANFIS – Fuzzy Neuron - Optimization of membership function and rule base using Genetic Algorithm –Introduction to Support Vector Machine- Evolutionary Programming-Particle Swarm Optimization - Case study – Familiarization of NN, FLC and ANFIS Tool Box.

TOTAL: 45 PERIODS**OUTCOMES:**

- Will be able to know the basic ANN architectures, algorithms and their limitations.
- Also will be able to know the different operations on the fuzzy sets.
- Will be capable of developing ANN based models and control schemes for non-linear system.
- Will get expertise in the use of different ANN structures and online training algorithm.

- Will be knowledgeable to use Fuzzy logic for modeling and control of non-linear systems.
- Will be competent to use hybrid control schemes and P.S.O and support vector Regressive.

TEXT BOOKS:

1. Laurene V. Fausett, "Fundamentals of Neural Networks: Architectures, Algorithms And Applications", Pearson Education.
2. Timothy J. Ross, "Fuzzy Logic with Engineering Applications" Wiley India, 2008.
3. Zimmermann H.J. "Fuzzy set theory and its Applications" Springer international edition, 2011.
4. David E. Goldberg, "Genetic Algorithms in Search, Optimization, and Machine Learning", Pearson Education, 2009.
5. W.T. Miller, R.S. Sutton and P.J. Webrose, "Neural Networks for Control" MIT Press", 1996.
6. T. Ross, "Fuzzy Logic with Engineering Applications", Tata McGraw Hill, New Delhi, 1995.
7. Ethem Alpaydin, "Introduction to Machine Learning (Adaptive Computation and Machine Learning Series)", MIT Press, 2004.
8. Corinna Cortes and V. Vapnik, " Support - Vector Networks, Machine Learning " 1995.

P20PE112 ELECTROMAGNETIC FIELD COMPUTATION AND MODELLING

L	T	P	C
3	0	0	3

OBJECTIVES:

- To refresh the fundamentals of Electromagnetic Field Theory.
- To provide foundation in formulation and computation of Electromagnetic Fields using analytical and numerical methods.
- To impart in-depth knowledge on Finite Element Method in solving Electromagnetic field problems.
- To introduce the concept of mathematical modeling and design of electrical apparatus.

UNIT I INTRODUCTION

9

Review of basic field theory – Maxwell’s equations – Constitutive relationships and Continuity equations – Laplace, Poisson and Helmholtz equation – principle of energy conversion – force/torque calculation.

UNIT II BASIC SOLUTION METHODS FOR FIELD EQUATIONS

9

Limitations of the conventional design procedure need for the field analysis based design, problem definition, boundary conditions, solution by analytical methods-direct integration method – variable separable method – method of images, solution by numerical methods- Finite Difference Method.

UNIT III FORMULATION OF FINITE ELEMENT METHOD (FEM)

9

Variational Formulation – Energy minimization – Discretization – Shape functions –Stiffness matrix – 1D and 2D planar and axial symmetry problems.

UNIT IV COMPUTATION OF BASIC QUANTITIES USING FEM PACKAGES

9

Basic quantities – Energy stored in Electric Field – Capacitance – Magnetic Field – Linked Flux – Inductance – Force – Torque – Skin effect – Resistance.

UNIT V DESIGN APPLICATIONS**9**

Design of Insulators – Cylindrical magnetic actuators – Transformers – Rotating machines

TOTAL: 45 PERIODS**OUTCOMES:**

- Understand the concepts of electromagnetic.
- Ability to formulate the FEM method and use of the package
- Apply the concepts in the design of rotating machines

REFERENCES

1. Matthew. N.O. Sadiku, "Elements of Electromagnetics", Fourth Edition, Oxford University Press, First Indian Edition 2007
2. K.J.Binns, P.J.Lawrenson, C.W Trowbridge, "The analytical and numerical solution of Electric and magnetic fields", John Wiley & Sons, 1993.
3. Nicola Biyanchi , "Electrical Machine analysis using Finite Elements", Taylor and FrancisGroup, CRC Publishers, 2005. 4
4. Nathan Ida, Joao P.A.Bastos , "Electromagnetics and calculation of fields", SpringerVerlage, 1992.
5. S.J Salon, "Finite Element Analysis of Electrical Machines" Kluwer Academic Publishers,London, 1995, distributed by TBH Publishers & Distributors, Chennai, India
6. .Silvester and Ferrari, "Finite Elements for Electrical Engineers" Cambridge University press, 1983.

P20PE113**MICROCONTROLLER BASED SYSTEM DESIGN**

L	T	P	C
3	0	0	3

OBJECTIVES

- To expose the students to the fundamentals of microcontroller based system design.
- To teach I/O and RTOS role on microcontroller.
- To impart knowledge on PIC Microcontroller based system design.
- To introduce Microchip PIC 8 bit peripheral system Design
- To give case study experiences for microcontroller based applications.

UNIT I 8051 ARCHITECTURE**9**

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

UNIT II 8051 PROGRAMMING**9**

Assembly language programming – Arithmetic Instructions – Logical Instructions –Single bit Instructions – Timer Counter Programming – Serial Communication Programming Interrupt Programming – RTOS for 8051 – RTOSLite – FullRTOS – Task creation and run – LCD digital clock/thermometer using FullRTOS.

UNIT III PIC MICROCONTROLLER**9**

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

UNIT IV PERIPHERAL OF PIC MICROCONTROLLER**9**

Timers – Interrupts, I/O ports- I2C bus-A/D converter-UART- CCP modules -ADC, DAC and Sensor Interfacing –Flash and EEPROM memories.

UNIT V SYSTEM DESIGN – CASE STUDY**9**

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

OUTCOMES:

- Understand the concepts of PIC micro controller.
- Ability to design a system using peripherals of micro controller.

REFERENCES:

1. Muhammad Ali Mazidi, Rolin D. Mckinlay, Danny Causey ‘ PIC Microcontroller and Embedded Systems using Assembly and C for PIC18’, Pearson Education 2008
2. John Iovine, ‘PIC Microcontroller Project Book ’, McGraw Hill 2000
3. Myke Predko, “Programming and customizing the 8051 microcontroller”, Tata McGraw Hill 2001.
4. Muhammad Ali Mazidi, Janice G. Mazidi and Rolin D. McKinlay, ‘The 8051 Microcontroller and Embedded Systems’ Prentice Hall, 2005.
5. Rajkamal, “.Microcontrollers Architecture, Programming, Interfacing & System Design”, 2ed, Pearson,2012.
6. I Scott Mackenzie and Raphael C.W. Phan, “The Micro controller”, Pearson, Fourth edition2012

P20PE114	EMBEDDED AND REAL TIME SYSTEMS	L	T	P	C
		3	0	0	3

OBJECTIVES

- To know the concept of embedded system
- To understand the architecture of embedded system
- To know the peripherals used in embedded system
- To know the concept of RTOS
- To know the Testing and validation of embedded system

UNIT I INTRODUCTION TO EMBEDDED SYSTEM DESIGN 9

Complex systems and micro processors– Embedded system design process –Design example: Model train controller- Design methodologies- Design flows – Requirement Analysis Specifications- System analysis and architecture design – Quality Assurance techniques -Designing with computing platforms – consumer electronics architecture –platform-level performance analysis.

UNIT II ARM PROCESSOR AND PERIPHERALS 9

ARM Architecture Versions – ARM Architecture – Instruction Set – Stacks and Subroutines – Features of the LPC 214X Family – Peripherals – The Timer Unit – Pulse Width Modulation Unit – UART – Block Diagram of ARM9 and ARM Cortex M3 MCU.

UNIT III EMBEDDED PROGRAMMING 9

Components for embedded programs- Models of programs- Assembly, linking and loading – compilation techniques- Program level performance analysis – Software performance optimization – Program level energy and power analysis and optimization – Analysis and optimization of program size- Program validation and testing.

UNIT IV REAL TIME SYSTEMS 9

Structure of a Real Time System — Estimating program run times – Task Assignment and Scheduling – Fault Tolerance Techniques – Reliability, Evaluation – Clock Synchronisation.

UNIT V PROCESSES AND OPERATING SYSTEMS 9

Introduction – Multiple tasks and multiple processes – Multirate systems- Preemptive real time operating systems- Priority based scheduling- Interprocess communication mechanisms-Evaluating operating system performance- power optimization strategies for processes –Example Real time operating systems-POSIX-Windows CE. – Distributed embedded systems – MPSoCs and shared memory multiprocessors. – Design Example – Audio player, Engine control unit – Video accelerator.

OUTCOMES:

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

- Describe the architecture and programming of ARM processor
- Outline the concepts of embedded systems
- Explain the basic concepts of real time operating system design
- Model real-time applications using embedded-system concepts

TEXT BOOKS:

1. Marilyn Wolf, -Computers as Components - Principles of Embedded Computing System
2. Design, Third Edition -Morgan Kaufmann Publisher (An imprint from Elsevier), 2012.
(UNIT I, II, III, V)
3. Jane W.S.Liu, Real Time Systems, Pearson Education, Third Indian Reprint, 2003.(UNIT IV)

REFERENCES:

1. Lyla B.Das, —Embedded Systems : An Integrated Approach Pearson Education, 2013.
2. Jonathan W.Valvano, —Embedded Microcomputer Systems Real Time Interfacing, Third Edition Cengage Learning, 2012.
3. David. E. Simon, —An Embedded Software Primer, 1st Edition, Fifth Impression, Addison- Wesley Professional, 2007.
4. Raymond J.A. Buhr, Donald L.Bailey, —An Introduction to Real-Time Systems- From Design to Networking with C/C++, Prentice Hall, 1999.
5. C.M. Krishna, Kang G. Shin, —Real-Time Systems, International Editions, Mc Graw Hill 1997
6. K.V.K.K.Prasad, —Embedded Real-Time Systems: Concepts, Design & Programming, Dream Tech Press, 2005.
7. Sriram V Iyer, Pankaj Gupta, —Embedded Real Time Systems Programming, Tata Mc Graw Hill, 2004.

P20PE115	SPECIAL ELECTRICAL MACHINES	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To review the fundamental concepts of permanent magnets and the operation of permanent magnet brushless DC motors.
- To introduce the concepts of permanent magnet brushless synchronous motors and synchronous reluctance motors.
- To develop the control methods and operating principles of switched reluctance motors.
- To introduce the concepts of stepper motors and its applications.
- To understand the basic concepts of other special machines

UNIT I PERMANENT MAGNET BRUSHLESS DC MOTORS 9

Fundamentals of Permanent Magnets- Types- Principle of operation- Magnetic circuit analysis EMF and Torque equations- Characteristics and control

UNIT II PERMANENT MAGNET SYNCHROUNOUS MOTORS 9

Principle of operation – EMF and Torque equations - Phasor diagram - Power controllers – Torque speed characteristics – Digital controllers – Constructional features, operating principle and characteristics of synchronous reluctance motor.

UNIT III SWITCHED RELUCTANCE MOTORS 9

Constructional features –Principle of operation- Torque prediction–Characteristics-Power controllers – Control of SRM drive- Sensor less operation of SRM – Applications.

UNIT IV STEPPER MOTORS 9

Constructional features –Principle of operation –Types – Torque predictions – Linear and Non-linear analysis – Characteristics – Drive circuits – Closed loop control –Applications.

UNIT V OTHER SPECIAL MACHINES**9**

Principle of operation and characteristics of Hysteresis motor – AC series motors – Linear motor- Applications.

TOTAL : 45 PERIODS**OUTCOMES:**

- Understand the open loop and closed loop systems stepper motors.
- Understanding the classifications and characteristics of special machines
- Understanding of the control methods of special motors.
- Ability to select the suitable motor for a certain job under given conditions

REFERENCES

1. T.J.E. Miller, 'Brushless magnet and Reluctance motor drives', Clarendon press, London, 1989.
2. R.Krishnan, ' Switched Reluctance motor drives' , CRC press, 2001.
3. T.Kenjo, ' Stepping motors and their microprocessor controls', Oxford University press, New Delhi, 2000
4. T.Kenjo and S.Nagamori, 'Permanent magnet and Brushless DC motors', Clarendon press, London, 1988
5. R.Krishnan, ' Electric motor drives' , Prentice hall of India,2002.
6. D.P.Kothari and I.J.Nagrath, ' Electric machines', Tata Mc Graw hill publishing company, New Delhi, Third Edition, 2004.
7. Irving L.Kosow, "Electric Machinery and Transformers" Pearson Education, Second Edition, 2007.

P20PE221**MODERN CONTROL THEORY**

L	T	P	C
3	0	0	3

OBJECTIVES:

- To understand the fundamentals of physical systems in terms of its linear and Non linear models.
- To educate on representing systems in state variable form
- To educate on solving linear and non-linear state equations
- To exploit the properties of linear systems such as controllability and observability
- To educate on stability analysis of systems using Lyapunov's theory
- To educate on modal concepts and design of state and output feedback controllers and estimators

UNIT I STATE VARIABLE REPRESENTATION**9**

Introduction-Concept of State-State equations for Dynamic Systems -Time invariance and linearity- Non uniqueness of state model- Physical Systems and State Assignment – free and forced responses- State Diagrams.

UNIT II SOLUTION OF STATE EQUATIONS**9**

Existence and uniqueness of solutions to Continuous-time state equations - Solution of Nonlinear and Linear Time Varying State equations - State transition matrix and its properties – Evaluation of matrix exponential- System modes- Role of Eigen values and Eigen vectors.

UNIT III STABILITY ANALYSIS OF LINEAR SYSTEMS**9**

Controllability and Observability definitions and Kalman rank conditions -Stabilizability and Detectability-Test for Continuous time Systems- Time varying and Time invariant case- Output Controllability-Reducibility- System Realizations.

UNIT IV STATE FEEDBACK CONTROL AND STATE ESTIMATOR**9**

Introduction-Controllable and Observable Companion Forms-SISO and MIMO Systems- The Effect of State Feedback on Controllability and Observability-Pole Placement by State Feedback for both SISO and MIMO Systems-Full Order and Reduced Order Observers.

UNIT V LYAPUNOV STABILTY ANALYSIS**9**

Introduction-Equilibrium Points- BIBO Stability-Stability of LTI Systems- Stability in the sense of Lyapunov - Equilibrium Stability of Nonlinear Continuous-Time Autonomous Systems-The Direct Method of Lyapunov and the Linear Continuous-Time Autonomous Systems-Finding Lyapunov Functions for Nonlinear Continuous-Time Autonomous Systems – Krasovskil’s and Variable-Gradient Method.

TOTAL : 45 PERIODS**OUTCOMES:**

- Ability to represent the time-invariant systems in state space form as well as analyze, whether the system is stabilizable, controllable, observable and detectable.
- Ability to design state feedback controller and state observers
- Ability to classify singular points and construct phase trajectory using delta and isocline methods.
- Use the techniques such as describing function, Lyapunov Stability, Popov’s Stability Criterion and Circle Criterion to assess the stability of certain class of non-linear system.
- Ability to describe non-linear behaviors such as Limit cycles, input multiplicity and output multiplicity, Bifurcation and Chaos.

REFERENCE BOOKS:

1. M. Gopal, “Modern Control System Theory”, New Age International, 2005.
2. K. Ogatta, “Modern Control Engineering”, PHI, 2002.
3. John S. Bay, “Fundamentals of Linear State Space Systems”, McGraw-Hill, 1999.
4. D. Roy Choudhury, “Modern Control Systems”, New Age International, 2005.
5. John J. D’Azzo, C. H. Houpis and S. N. Sheldon, “Linear Control System Analysis and Design with MATLAB”, Taylor Francis, 2003.
6. Z. Bubnicki, “Modern Control Theory”, Springer, 2005.
7. C.T. Chen, “Linear Systems Theory and Design” Oxford University Press, 3rd Edition, 1999.
8. M. Vidyasagar, “Nonlinear Systems Analysis”, 2nd edition, Prentice Hall, Englewood Cliffs, New Jersey.

P20PE222**DISTRIBUTED GENERATION AND MICROGRID**

L	T	P	C
3	0	3	3

OBJECTIVES

- To illustrate the concept of distributed generation
- To analyze the impact of grid integration.
- To study concept of Micro grid and its configuration
- To find optimal size, placement and control aspects of DGs

UNIT I INTODUCTION**9**

Need for distributed generation– Renewable sources in distributed generation – Current scenario in distributed generation – Planning of DGs – Siting and sizing of DGs – Optimal placement of DG sources in distribution systems.

UNIT II DISTRIBUTED GENERATIONS (DG)**9**

Grid integration of DGs– Different types of interfaces – Inverter based DGs and rotating machine based interfaces – Aggregation of multiple DG units – Energy storage elements – Batteries, ultracapacitors, flywheels.

UNIT III IMPACT OF GRID INTEGRATION 9
 Technical impacts of DGs –Transmission systems, Distribution systems, De-regulation – Impact of DGs upon protective relaying – Impact of DGs upon transient and dynamic stability of existing distribution systems.

UNIT IV ECONOMIC AND CONTROL ASPECTS OF DGS 9
 Market facts, issues and challenges – Limitations of DGs – Voltage control techniques, Reactive power control, Harmonics, Power quality issues – Reliability of DG based systems – Steady state and Dynamic analysis.

UNIT V MICROGRIDS 9
 Introduction to micro-grids –Types of micro-grids – Autonomous and non-autonomous grids – Sizing of micro-grids – Modeling & analysis – Micro-grids with multiple DGs – Micro-grids with power electronic interfacing units – Transients in micro-grids – Protection of micro-grids – Case studies.

TOTAL : 45 PERIODS

OUTCOMES

Upon the Completion of the course student will be able to

- Find the size and optimal placement DG
- Analyze the impact of grid integration and control aspects of DGs
- Model and analyze a micro grid taking into consideration the planning and operational issues of the DGs to be connected in the system
- Describe the technical impacts of DGs in power systems

TEXT BOOKS

1. H. Lee Willis, Walter G. Scott , ‘Distributed Power Generation – Planning and Evaluation’, Marcel Decker Press, 2000.
2. M.Godoy Simoes, Felix A.Farret, ‘Renewable Energy Systems – Design and Analysis with Induction Generators’, CRC press.
3. Robert Lasseter, Paolo Piagi, ‘ Micro-grid: A Conceptual Solution’, PESG 2004, June 2004.
4. F. Katiraei, M.R. Iravani, ‘Transients of a Micro-Grid System with Multiple Distributed Energy Resources’, International Conference on Power Systems Transients (IPST’05) in Montreal, Canada on June 19-23, 2005.
5. Z. Ye, R. Walling, N. Miller, P. Du, K. Nelson, ‘Facility Microgrids’, General Electric Global Research Center, Niskayuna, New York, Subcontract report, May 2005.

P20PE223 ENERGY MANAGEMENT AND AUDITING L T P C
3 0 0 3

OBJECTIVES:

- To study the concepts behind economic analysis and Load management.
- To emphasize the energy management on various electrical equipment’s and metering.
- To illustrate the concept of lighting systems and cogeneration.

UNIT I INTRODUCTION 9
 Need for energy management - energy basics- designing and starting an energy management program – energy accounting -energy monitoring, targeting and reporting energy audit process.

UNIT II ENERGY COST AND LOAD MANAGEMENT 9
 Important concepts in an economic analysis - Economic models-Time value of money-Utility rate structures- cost of electricity-Loss evaluation- Load management: Demand control techniques-Utility monitoring and control system-HVAC and energy management-Economic justification.

UNIT III ENERGY MANAGEMENT FOR MOTORS, SYSTEMS, AND ELECTRICAL EQUIPMENT 9
 Systems and equipment- Electric motors-Transformers and reactors-Capacitors and synchronous machines.

UNIT IV METERING FOR ENERGY MANAGEMENT

9

Relationships between parameters-Units of measure-Typical cost factors- Utility meters - Timing of meter disc for kilowatt measurement - Demand meters - Paralleling of current transformers - Instrument transformer burdens-Multitasking solid-state meters – Metering location vs. requirements-Metering techniques and practical examples.

UNIT V LIGHTING SYSTEMS & COGENERATION

9

Concept of lighting systems - The task and the working space -Light sources - Ballasts - Luminaries - Lighting controls-Optimizing lighting energy - Power factor and effect of harmonics on power quality - Cost analysis techniques-Lighting and energy standards Cogeneration: Forms of cogeneration - feasibility of cogeneration- Electrical interconnection.

TOTAL: 45 PERIODS

OUTCOMES:

- Students will develop the ability to learn about the need for energy management and auditing process
- Learners will learn about basic concepts of economic analysis and load management.
- Students will understand the energy management on various electrical equipment's.
- Students will have knowledge on the concepts of metering and factors influencing cost function
- Students will be able to learn about the concept of lighting systems, light sources and various forms of cogeneration

REFERENCES:

1 Barney L. Capehart, Wayne C. Turner, and William J. Kennedy, "Guide to Energy Management", Fifth Edition, The Fairmont Press, Inc., 2006
 2 Eastop T.D & Croft D.R, "Energy Efficiency for Engineers and Technologists", Logman Scientific & Technical, 1990.
 3 Reay D.A, "Industrial Energy Conservation", 1st edition, Pergamon Press, 1977.
 4 "IEEE Recommended Practice for Energy Management in Industrial and Commercial Facilities", IEEE, 1996
 5 Amit K. Tyagi, "Handbook on Energy Audits and Management", TERI, 2003.

P20PE224

SOLID STATE DC DRIVES

L	T	P	C
3	0	0	3

OBJECTIVES

- To understand steady state operation and transient dynamics of a motor load system
- To study and analyze the operation of the converter / chopper fed DC drive, both qualitatively and quantitatively.
- To analyze and design the current and speed controllers for a closed loop solid state DC motor drive.
- To understand the implementation of control algorithms using microcontrollers and phase locked loop.

UNIT I DC MOTORS FUNDAMENTALS AND MECHANICAL SYSTEMS

9

DC motor- Types, induced emf, speed-torque relations; Speed control – Armature and field speed control; Ward Leonard control – Constant torque and constant horse power operation – Introduction to high speed drives and modern drives. Characteristics of mechanical system – dynamic equations, components of torque, types of load; Requirements of drives characteristics – stability of drives – multi-quadrant operation; Drive elements, types of motor duty and selection of motor rating.

UNIT II CONVERTER CONTROL

9

Principle of phase control – Fundamental relations; Analysis of series and separately excited DC motor with single-phase and three-phase converters – waveforms, performance parameters,

performance characteristics. Continuous and discontinuous armature current operations; Current ripple and its effect on performance; Operation with freewheeling diode; Implementation of braking schemes; Drive employing dual converter.

UNIT III CHOPPER CONTROL 9

Introduction to time ratio control and frequency modulation; Class A, B, C, D and E chopper controlled DC motor – performance analysis, multi-quadrant control – Chopper based implementation of braking schemes; Multi-phase chopper; Related problems.

UNIT IV CLOSED LOOP CONTROL 9

Modeling of drive elements – Equivalent circuit, transfer function of self, separately excited DC motors; Linear Transfer function model of power converters; Sensing and feeds back elements – Closed loop speed control – current and speed loops, P, PI and PID controllers – response comparison. Simulation of converter and chopper fed d.c drive.

UNIT V DIGITAL CONTROL OF D.C DRIVE 9

Phase Locked Loop and micro-computer control of DC drives – Program flow chart for constant horse power and load disturbed operations; Speed detection and current sensing circuits.

TOTAL : 45 PERIODS

OUTCOMES:

- The learners will be exposed to design and analyze the operation of converter fed / chopper fed DC drives.
- They will be well equipped to develop the closed loop controllers for the solid state DC drives and implement it using control algorithms.

REFERENCES

1. Gopal K Dubey, “Power Semiconductor controlled Drives”, Prentice Hall Inc., New Yersy, 1989.
2. R.Krishnan, “Electric Motor Drives – Modeling, Analysis and Control”, Prentice-Hall of India Pvt. Ltd., New Delhi, 2010.
3. Gopal K.Dubey, “Fundamentals of Electrical Drives”, Narosal Publishing House, New Delhi, Second Edition ,2009
4. Vedam Subramanyam, “Electric Drives – Concepts and Applications”, Tata McGraw-Hill publishing company Ltd., New Delhi, 2002.
5. P.C Sen “Thyristor DC Drives”, John wiely and sons, New York, 1981

P20PE225	MODERN POWER ELECTRONIC CONVERTERS	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To understand the design of SMPS
- To understand the operation of hard switched and soft switched converters

UNIT I SWITCHED MODE POWER SUPPLIES (SMPS) 9

DC Power supplies and Classification; Switched mode dc power supplies - with and without isolation, single and multiple outputs; Pump circuits - developed, transformer type and super lift pumps; Luo converters - positive, negative and double output; SEPIC converter. Voltage-lift converters and Super lift converters -types and basic circuit operation. Closed loop control and regulation; Design examples on converter and closed loop performance

UNIT II AC-DC CONVERTERS 9

Switched mode ac-dc converters – synchronous rectification - single and three phase topologies – switching techniques - high input power factor – reduced input current harmonic distortion – improved efficiency – with and without input-output isolation – performance indices – closed loop control and regulation – design examples - Multi-converter systems – redundancy, reliability.

UNIT III DC-AC CONVERTERS 9

Multi-level Inversion - concept, classification of multilevel inverters, Principle of operation, main features and analysis of Diode clamped, Flying capacitor and cascaded multilevel inverters; Modulation schemes, waveforms and harmonic content; Comparison of topologies – device stress, losses, component count and dc link voltage balancing. Z - Source converters; Active filters – topologies, operation and closed loop control.

UNIT IV AC-AC CONVERTERS WITH AND WITHOUT DC LINK 9

Matrix converters – Basic topology of matrix converter; Commutation – current path; Modulation techniques - scalar modulation, indirect modulation; Matrix converter as only ac-dc converter; Vienna Rectifier – Principle of operation, main features and analysis, types and applications AC-AC converter with DC link - topologies and operation - with and without resonance link - converter with dc link converter; Performance comparison with matrix converter with DC link converters.

UNIT V SOFT-SWITCHING POWER CONVERTERS 9

Power electronic converters – analysis and determination of power losses – loss reduction techniques; Soft switching techniques – ZVS, ZCS, ZVT, quasi resonance operation; Performance comparison hard switched and soft switched converters –ac-dc converter, dc-dc converter, dc-ac converter – ac-ac converter; Resonant dc power supplies - bidirectional power supplies; Introduction to concept of integrated topologies.

TOTAL: 45 PERIODS

OUTCOMES:

- Students can able to design SMPS specific to application.
- Students can able to analyse recent AC-Dc, DC-AC, AC-DC converters

TEXT BOOKS:

1. Power Electronics Handbook, M.H.Rashid, Academic press, Newyork, 2000.
2. Advanced DC/DC Converters, Fang Lin Luo and Fang Lin Luo, CRC Press, NewYork, 2004.
3. Control in Power Electronics- Selected Problem, Marian P.Kazmierkowski,
4. R.Krishnan and Frede Blaabjerg, Academic Press (Elsevier Science), 2002.

REFERENCES:

1. Issa Batarseh, Power Electronic Circuits, John Wiley and Sons, Inc.2004.
2. Frede Blaabjerg and Zhe Chen,Power Electronics for Modern Wind Turbines, Morgan & Claypool Publishers series, United States of America, 2006.
3. Mukund R.Patel, Wind and Solar Power Systems, CRC Press, New York, 1999.
4. Jai P Agarwal, Power Electronics: Converters, Applications, and Design, 3rd edition, Prentice Hall, 2000.
5. Johann W. Kolar, Uwe Drofenik, and Franz C. Zach, “VIENNA Rectifier II—A Novel Single-Stage High- Frequency Isolated Three-Phase PWM Rectifier System”, IEEE Transactions on Industrial Electronics,vol.46, no.4, pp.674-691, August 1999.

P20PE321 POWER ELECTRONICS FOR RENEWABLE ENERGY SYSTEMS	L	T	P	C
	3	0	0	3

OBJECTIVES:

To impart knowledge on

- Different types of renewable energy systems.
- Electrical Generators used for the Wind Energy Conversion Systems.
- AC-DC, DC-DC and AC-AC power converters used in renewable energy systems.
- Standalone operation, grid connected operation and hybrid operation in renewable energy systems.

UNIT I INTRODUCTION TO RENEWABLE ENERGY SYSTEMS 9

Environmental aspects of energy: Impacts of renewable energy generation on environment - Qualitative study of renewable energy resources: Ocean energy, Biomass energy, Hydrogen energy, Fuel cells - Solar PV: Operating principles, solar cell and their characteristics, Wind Energy: Nature of wind, Types, control strategy, operating area.

UNIT II	ELECTRICAL MACHINES FOR WIND ENERGY CONVERSION SYSTEMS	9
Review of reference theory fundamentals - Principle of operation and analysis: Induction Generator: Squirrel Cage Induction Generator (SCIG), Doubly Fed Induction Generator (DFIG) - Permanent Magnet Synchronous Generator (PMSG).		
UNIT III	POWER CONVERTERS	9
Solar: Block diagram of solar photo voltaic system: Line commutated converters (inversion-mode) - Boost and buck- boost converters- selection of inverter, battery sizing, array sizing. Wind: Three phase AC voltage controllers- AC-DC-AC converters: uncontrolled rectifiers, PWM Inverters, Grid Interactive Inverters - Matrix converter.		
UNIT IV	ANALYSIS OF WIND AND PV SYSTEMS	9
Stand alone operation: Fixed and variable speed wind energy conversion systems (WECS), solar system – Grid connection Issues -Grid integrated SCIG and PMSG based WECS-Grid Integrated solar system.		
UNIT V	HYBRID RENEWABLE ENERGY SYSTEMS	9
Need for Hybrid Systems- Range and type of Hybrid systems- Case studies of Diesel-PV, Wind-PV, Microhydel-PV, Biomass-Diesel systems - Maximum Power Point Tracking (MPPT).		

TOTAL: 45 PERIODS

OUTCOMES:

At the end of the course, the students will be able to

- Demonstrate the various types of renewable energy technologies that are used to harness electrical power.
- Demonstrate the operating principle and analysis of various types of Wind generators.
- Identify a suitable converters such as AC-DC, DC-DC and AC-AC converters for renewable energy systems.
- Demonstrate and analyze the various types of wind and PV systems.
- Interpret the stand alone, grid connected and hybrid renewable energy systems

REFERENCE BOOK:

1. S.N.Bhadra, D. Kastha, & S. Banerjee “Wind Electrical Systems”, Oxford University Press, 2009
2. Rashid .M. H “power electronics Hand book”, Academic press, 2001.
3. Rai. G.D, “Non conventional energy sources”, Khanna publishes, 1993.
4. Rai. G.D, “Solar energy utilization”, Khanna publishes, 1993.
5. Gray, L. Johnson, “Wind energy system”, Prentice hall of india, 1995.
6. B.H.Khan "Non-conventional Energy sources ", Mc Graw-hill, Second Edtioin, 2009.

P20PE322	INTELLECTUAL PROPERTY RIGHTS	L	T	P	C
		3	0	0	3

OBJECTIVES:

- . To give an idea about IPR, registration and its enforcemens.

UNIT I INTRODUCTION 9

Introduction to IPRs, Basic concepts and need for Intellectual Property – Patents, Copyrights, Geographical Indications, IPR in India and Abroad – Genesis and Development – the way from WTO to WIPO –TRIPS, Nature of Intellectual Property, Industrial Property, technological Research, Inventions and Innovations – Important examples of IPR.

UNIT II REGISTRATION OF IPRs 10

Meaning and practical aspects of registration of Copy Rights, Trademarks, Patents, Geographical Indications, Trade Secrets and Industrial Design registration in India and Abroad.

UNIT III AGREEMENTS AND LEGISLATIONS 10

International Treaties and Conventions on IPRs, TRIPS Agreement, PCT Agreement, Patent Act of India, Patent Amendment Act, Design Act, Trademark Act, Geographical Indication Act.

UNIT IV DIGITAL PRODUCTS AND LAW 9
 Digital Innovations and Developments as Knowledge Assets – IP Laws, Cyber Law and Digital Content Protection – Unfair Competition – Meaning and Relationship between Unfair Competition and IP Laws – Case Studies.

UNIT V ENFORCEMENT OF IPRs 7
 Infringement of IPRs, Enforcement Measures, Emerging issues – Case Studies

TOTAL : 45 PERIODS

OUTCOMES:

- Ability to manage Intellectual Property portfolio to enhance the value of the firm

TEXT BOOKS:

1. V. Scople Vinod, Managing Intellectual Property, Prentice Hall of India pvt Ltd, 2012
2. S. V. Satakar, —Intellectual Property Rights and Copy Rights, Ess Ess Publications, New Delhi, 2002

REFERENCE BOOKS:

1. Deborah E. Bouchoux, —Intellectual Property: The Law of Trademarks, Copyrights, Patents and Trade Secrets, Cengage Learning, Third Edition, 2012.
2. Prabuddha Ganguli, Intellectual Property Rights: Unleashing the Knowledge Economy, McGraw Hill Education, 2011.
3. Edited by Derek Bosworth and Elizabeth Webster, The Management of Intellectual Property, Edward Elgar Publishing Ltd., 2013
4. <http://www.ebooks directory.com>
5. <http://Campus guides.lib.utah.edu>
6. <http://www.bookboon.com>
7. <http://www.freemagagement.com>
8. <http://www.emeraldinsight.com>

U20PE323 FLEXIBLE AC TRANSMISSION SYSTEMS

L	T	P	C
3	0	0	3

OBJECTIVES:

- To emphasis the need for FACTS controllers.
- To learn the characteristics, applications and modelling of series and shunt FACTS controllers.
- To analyze the interaction of different FACTS controller and perform control coordination

UNIT I INTRODUCTION 9

Review of basics of power transmission networks-control of power flow in AC transmission line Analysis of uncompensated AC Transmission line- Passive reactive power compensation: Effect of series and shunt compensation at the mid-point of the line on power transfer- Need for FACTS controllers- types of FACTS controllers.

UNIT II STATIC VAR COMPENSATOR (SVC) 9

Configuration of SVC- voltage regulation by SVC- Modelling of SVC for load flow Analysis Modelling of SVC for stability studies-Design of SVC to regulate the mid-point voltage of a SMIB system- Applications: transient stability enhancement and power oscillation damping of SMIB system with SVC connected at the mid-point of the line.

UNIT III THYRISTOR AND GTO THYRISTOR CONTROLLED SERIES CAPACITORS (TCSC and GCSC) 9

Concepts of Controlled Series Compensation – Operation of TCSC and GCSC- Analysis of TCSC-GCSC – Modelling of TCSC and GCSC for load flow studies- modeling TCSC and GCSC for stability studied- Applications of TCSC and GCSC.

UNIT IV VOLTAGE SOURCE CONVERTER BASED FACTS CONTROLLERS 9

Static synchronous compensator(STATCOM)- Static synchronous series compensator(SSSC)- Operation of STATCOM and SSSC-Power flow control with STATCOM and SSSC- Modelling of STATCOM and SSSC for power flow and transient stability studies –operation of Unified and Interline power flow controllers(UPFC and IPFC)- Modelling of UPFC and IPFC for load flow and transient stability studies- Applications.

UNIT V CONTROLLERS AND THEIR COORDINATION 9

FACTS Controller interactions – SVC–SVC interaction - co-ordination of multiple controllers using linear control techniques – Quantitative treatment of control coordination.

TOTAL: 45 PERIODS

OUTCOMES:

- Ability to understand the operation of the compensator and its applications in power system.
- Ability to understand the various emerging Facts controllers.
- Ability to know about the genetic algorithm used in Facts controller coordination.

REFERENCES:

1. A.T.John, “Flexible AC Transmission System”, Institution of Electrical and Electronic Engineers (IEEE), 1999.
2. NarainG.Hingorani, Laszio. Gyugyl, “Understanding FACTS Concepts and Technology of Flexible AC Transmission System”, Standard Publishers, Delhi 2001.
3. V. K.Sood, “HVDC and FACTS controllers- Applications of Static Converters in Power System”, 2004, Kluwer Academic Publishers.
4. Mohan Mathur, R., Rajiv. K. Varma, “Thyristor – Based Facts Controllers for Electrical Transmission Systems”, IEEE press and John Wiley & Sons, Inc.
5. K.R.Padiyar, “FACTS Controllers in Power Transmission and Distribution”, New Age International(P) Ltd., Publishers New Delhi, Reprint 2008.

P20PE324	FPGA BASED ARCHITECTURE DESIGN	L	T	P	C
		3	0	0	3

OBJECTIVES

- To know various programmable logic devices
- To understand the FPGA based system design
- To know the FPGA based combinational and sequential logic designs
- To know the FPGA based large scale systems

UNIT I INTRODUCTION 9

Programmable Logic Devices-Types-PLA, PAL, FPGA-architectures, SRAM-based FPGAs, Permanently Programmed FPGAs, Chip I/O. Circuit Design of FPGA Fabrics. Architecture of FPGA Fabrics.

UNIT II FPGA-BASED SYSTEMS AND VLSI TECHNOLOGY 9

Introduction, Basic Concepts, Digital Design and FPGAs. FPGA-based system design. Manufacturing Processes, Transistor Characteristics, CMOS Logic Gates, Wires, Registers and RAM, Packages and Pads.

UNIT III COMBINATIONAL LOGIC 9

The Logic Design Process. Hardware Description Languages, combinational network delay. Power and energy optimization, arithmetic logic, logic implementation for FPGAs. Physical Design for FPGAs. The Logic Design Process.

UNIT IV SEQUENTIAL MACHINES 9

The sequential machine design process. Sequential design styles. Rules for Clocking. Performance Analysis. Power Optimization.

UNIT V LARGE SCALE SYSTEMS 9

Architectures and Large Scale Systems, Behavioral Design, Design Methodologies. Design Example. Busses, Platform FPGAs, Multi-FPGA Systems, Novel Architectures.

TOTAL: 45 PERIODS

OUTCOMES

- Understands various PLDs and its uses
- Ability to design FPGA based system
- Ability to design FPGA based combinational and sequential logic systems

TEXT BOOKS:

1. Wayne Wolf, "FPGA-Based System Design", Prentice Hall, 2004.
2. Wayne Wolf, "Modern VLSI Design", Pearson Education 2002.

REFERENCE BOOKS

1. Michael D Ciletti, "Advanced Digital Design with Verilog HDL", Pearson Education 2005
2. Verilog HDL, Samir Palnitkar, Pearson Education 2005.
3. J Bhaskar, "A Verilog HDL Primer", B S Publications, 2007.
4. Kevin Skahill, "VHDL for Programmable Logic, Pearson Education, 2004.

P20PE325	MEMS TECHNOLOGY	L	T	P	C
		3	0	0	3

OBJECTIVES

- To teach the students properties of materials ,microstructure and fabrication methods.
- To teach the design and modeling of Electrostatic sensors and actuators.
- To teach the characterizing thermal sensors and actuators through design and modeling
- To teach the fundamentals of piezoelectric sensors and actuators through exposure to different MEMS and NEMS devices
- To involve Discussions/ Practice/Exercise onto revising & familiarizing the concepts acquired over the 5 Units of the subject for improved employability skills

UNIT I MICRO-FABRICATION, MATERIALS AND ELECTRO-MECHANICAL CONCEPTS 9

Overview of micro fabrication – Silicon and other material based fabrication processes – Concepts: Conductivity of semiconductors-Crystal planes and orientation-stress and strain-flexural beam bending analysis-torsional deflections-Intrinsic stress- resonant frequency and quality factor.

UNIT II ELECTROSTATIC SENSORS AND ACTUATION 9

Principle, material, design and fabrication of parallel plate capacitors as electrostatic sensors and actuators-Applications

UNIT III THERMAL SENSING AND ACTUATION 9

Principle, material, design and fabrication of thermal couples, thermal bimorph sensors, thermal resistor sensors-Applications.

UNIT V OPTOELECTRONIC INTEGRATED CIRCUITS**9**

Introduction, hybrid and Monolithic Integration, Application of Opto Electronic Integrated Circuits, Integrated transmitters and Receivers, Guided wave devices.

TOTAL: 45 PERIODS**OUTCOMES:**

Upon Completion of the course, the students will be able to

- To design display devices.
- To design optoelectronic detection devices and modulators.
- To design optoelectronic integrated circuits.

TEXTBOOKS:

1. Pallab Bhattacharya "Semiconductor Opto Electronic Devices", Prentice Hall of India Pvt., Ltd., New Delhi, 2006.
2. Jasprit Singh, "Opto Electronics – As Introduction to Materials and Devices", Mc Graw-Hill International Edition, 1998

REFERENCES:

1. S C Gupta, Opto Electronic Devices and Systems, Prentice Hal of India, 2005.
2. J. Wilson and J.Haukes, "Opto Electronics – An Introduction", Prentice Hall, 1995

P20PE432 ELECTROMAGNETIC INTERFERENCE AND COMPATIBILITY

L	T	P	C
3	0	0	3

OBJECTIVES:

- To provide fundamental knowledge on electromagnetic interference and electromagnetic compatibility.
- To study the important techniques to control EMI and EMC.
- To expose the knowledge on testing techniques as per Indian and international standards in EMI measurement.

UNIT I INTRODUCTION**9**

Definitions of EMI/EMC -Sources of EMI- Inter systems and Intra system- Conducted and radiated interference- Characteristics - Designing for electromagnetic compatibility (EMC)- EMC regulation typical noise path- EMI predictions and modeling, Cross talk - Methods of eliminating interferences.

UNIT II GROUNDING AND CABLING**9**

Cabling- types of cables, mechanism of EMI emission / coupling in cables –capacitive Coupling inductive coupling- shielding to prevent magnetic radiation- shield transfer impedance, Grounding – safety grounds – signal grounds- single point and multipoint ground systems hybrid grounds- functional ground layout –grounding of cable shields- -guard shields- isolation, neutralizing transformers, shield grounding at high frequencies, digital grounding- Earth measurement Methods

UNIT III BALANCING, FILTERING AND SHIELDING**9**

Power supply decoupling- decoupling filters-amplifier filtering –high frequency filtering- EMI filters characteristics of LPF, HPF, BPF, BEF and power line filter design -Choice of capacitors, inductors, transformers and resistors, EMC design components -shielding – near and far fields shielding effectiveness- absorption and reflection loss- magnetic materials as a shield, shield discontinuities, slots and holes, seams and joints, conductive gaskets-windows and coatings - grounding of shields

UNIT IV EMI IN ELEMENTS AND CIRCUITS**9**

Electromagnetic emissions, noise from relays and switches, non-linearity's in circuits, passive inter modulation, transients in power supply lines, EMI from power electronic equipment, EMI as combination of radiation and conduction

UNIT V SIMULATION OF HVDC SYSTEMS**9**

Introduction – DC LINK Modeling, Converter Modeling and State Space Analysis, Philosophy and tools – HVDC system simulation, Online and OFF line simulators – Dynamic interactions between DC and AC systems.

TOTAL: 45 PERIODS**OUTCOMES:**

- The learners gain an enhanced knowledge on generalized aspects of HVDC system.
- The learners gain an enhanced knowledge on the thyristor based power converters and their characteristics.
- The learners are introduced to various control methods for converters and protection techniques for HVDC lines.

REFERENCES:

- 1 P. Kundur, "Power System Stability and Control", McGraw-Hill, 1993
- 2 K.R.Padiyar, "HVDC Power Transmission Systems", New Age International (P) Ltd., New Delhi, 2002
- 3 J.Arrillaga, "High Voltage Direct Current Transmission", Peter Pregrinus, London, 1983
- 4 Erich Uhlmann, "Power Transmission by Direct Current", BS Publications, 2004.
- 5 V.K.Sood, HVDC and FACTS controllers – Applications of Static Converters in Power System, APRIL 2004, Kluwer Academic Publishers

P20PE434**PWM TECHNIQUES FOR POWER CONVERTERS**

L	T	P	C
3	0	0	3

OBJECTIVES:

- To emphasize the need for power control and to recognize the need for state of the art technique.
- To discuss about New PWM control techniques and their relative merits.
- To discuss about Implementation of PWM techniques using recent digital processors

UNIT I BASIC THREE PHASE INVERTERS**9**

Inverter leg with Inductive load operation- fundamental concept of PWM- basic three phase voltage source inverter;- operation and functions performance indices- direct calculation of harmonic spectrum- from inverter waveforms- programmed PWM for Three phase inverters-modeling a Three Phase inverter with switching functions- DC bus capacitor within an AC/DC/AC power converter.

UNIT II CARRIER BASED PULSE WIDTH MODULATION**9**

Carrier based pulse width modulation algorithms; historical importance- carrier based PWM algorithms with improved reference- PWM used within volt/Hertz- Drives- Implementation of Harmonic reduction with carrier PWM- Limits of operation

UNIT III VECTORIAL PULSE WIDTH MODULATION**9**

Review for space vector theory- vectorial analysis of the three phase inverter- SVM theory-adaptive SVM- Definition of the Switching Reference Function- Definition of the Switching sequence- Comparison between different vectorial PWM- Over Modulation for SVM- Volt- per-hertz control of PWM inverters.

UNIT IV IMPLEMENTATION OF PWM ALGORITHM**9**

Analog Pulse Width Modulation controllers- Mixed mode motor controller ICs- Digital structures with counters; FPGA Implementation- Software implementation in low cost microcontrollers- microcontrollers with Power converter interfaces- Motor control coprocessors- using the event manager within DSPs.

UNIT V PROGRAMMED MODULATION STRATEGIES 9

Optimized space vector modulation- harmonic elimination PWM- performance index for optimality – optimum PWM- Minimum Loss PWM.

Total:45 PERIODS

OUTCOMES:

- The course will enable the student to gain an enhanced knowledge on the latest control strategies and serve to design new applications.
- The learners gain an enhanced knowledge on different PWM control techniques.

REFERENCES:

1. Grahame holmes.D Thomas A.Lipo, “Pulse Width Modulation For Power Converters, Principles and Practice”, IEEE Press, 2003.
2. Dorin O.Neacsu, “Power Switching Coverters, Medium and High power”, CRC Press, 2006
3. M.H.Rashid, “Power Electronics Handbook”, Academic Press, 2001.

P20PE531	ELECTRIC VEHICLES AND POWER MANAGEMENT	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To understand the concept of electrical vehicles and its operations
- To understand the need for energy storage in hybrid vehicles
- To provide knowledge about various possible energy storage technologies that can be used in electric vehicles

UNIT I ELECTRIC VEHICLES AND VEHICLE MECHANICS 9

Electric Vehicles (EV), Hybrid Electric Vehicles (HEV), Engine ratings, Comparisons of EV with internal combustion Engine vehicles, Fundamentals of vehicle mechanics.

UNIT II ARCHITECTURE OF EV’s AND POWER TRAIN COMPONENTS 9

Architecture of EV’s and HEV’s – Plug-n Hybrid Electric Vehicles (PHEV)- Power train components and sizing, Gears, Clutches, Transmission and Brakes.

UNIT III CONTROL OF DC AND AC DRIVES 9

DC/DC chopper based four quadrant operations of DC drives – Inverter based V/f Operation (motoring and braking) of induction motor drive system – Induction motor and permanent motor based vector control operation – Switched reluctance motor (SRM) drives.

UNIT IV BATTERY ENERGY STORAGE SYSTEM 9

Battery Basics, Different types, Battery Parameters, Battery modeling, Traction Batteries.

UNIT V ALTERNATIVE ENERGY STORAGE SYSTEMS 9

Fuel cell – Characteristics- Types – hydrogen Storage Systems and Fuel cell EV – Ultra capacitors.

TOTAL : 45 PERIODS

OUTCOMES:

- Ability to determine the non-linear phenomena
- Analyze the behavior of non-linearity in DC-DC Converters
- Understand the concepts of chaos in power converters.

REFERENCES

1. George C. Vargheese, July 2001 Wiley – IEEE Press S Banerjee, Nonlinear Phenomena in Power Electronics, IEEE Press 3.
2. Steven H Strogatz, Nonlinear Dynamics and Chaos, Westview Press
3. C.K.TSE Complex Behaviour of Switching Power Converters, CRC Press, 2003

OBJECTIVES:

- To study about reactive power compensators and the different VAR compensators
- To study the Applications of converters in HVDC systems

UNIT I REACTIVE POWER REQUIREMENTS 9

Power system components – representation of single line diagram – uncompensated lines - compensators types and characteristics - conventional compensator - modern compensator - shunt compensator – series compensator- principles of reactive power control – introduction on load compensation - line compensation – P and Q control - phase angle regulation. Compensator requirements for solid state converters – determination of input power factor and harmonics for various converters – power factor improvement using Load and forced commutated converters.

UNIT II REACTIVE POWER COMPENSATION AND REGULATION 9

Load compensation- voltage regulation - power factor correction - phase balance unsymmetrical loads. Line compensations – increased power transfer capability – stability and transient limit – losses – harmonics - sub synchronous oscillations - mitigations.

UNIT III STATIC COMPENSATORS AND COMPONENTS 9

Introduction to conventional compensators - – synchronous condenser – saturable core reactor – analysis and design of static compensators - TCR – TSC – SVC – TCSC – modeling and control of static compensators.

UNIT IV DESIGN OF UPFC AND STATIC TAP CHANGERS 9

UPFC components – shunt devices - series devices – operation and control – real and reactive power – UPFC parameters and design philosophy. Conventional tap changing methods – solid state tap changer – voltage regulation -different schemes – comparison – specifications – design methods.

UNIT V HVDC AND STATIC GENERATOR EXCITATION SYSTEMS 9

HVDC components - kinds of DC links – modern HVDC converters – commutation issues - control characteristics – constant phase angle control – constant current and extinction angle control - twelve and higher pulse operation - introduction to modern converters – protections - reactive power requirements – harmonics – filter types and design of various ac and dc filters. Solid state excitation of synchronous generators – different schemes – Generator excitation systems – redundancy and reliability.

TOTAL : 45 PERIODS**OUTCOMES:**

- Ability to determine the characteristics of different types of VAR compensators
- Ability to design different types of converters models for HVDC system based on LFA

TEXT BOOKS:

1. Miller.T.J.E, Reactive power control in Electric systems, Wiley interscience, NewYork,1982.
2. R.Mohan and R.K.Varma, Thyristor-Based FACTS Controllers for Electrical Transmission Systems, IEEE Press– A John Wiley and Sons, Inc. Publications.2002.
3. K. R.Padiyar, HVDC Power Transmission Systems Technology and System Interactions, New Age International (p) Limited, New Delhi,2003.

REFERENCE BOOKS:

1. Vijay K.Sood, HVDC and FACTS Controller: Application of Static Converters in power systems, IEEE Power Electronics and Power Systems series, Kluwer Academic publishers, Boston,2004.

2. Narani.G.Hingorani and Laszlo Gyugyi, Understanding FACTS, IEEE Power Engineering society sponsor, IEEE Press.2000.
3. K.R.Padiyar, Facts Controllers in Power Transmission and Distribution, New Age International (P) Limited, Publishers, New Delhi,2007.
4. "A Static alternative to the transformer on load tap changing", IEEE Trans. on PAS, Vol.PAS-99, Jan. /Feb. 1980,
5. "Improvements in Thyristor controlled static on- load tap controllers for transformers", IEEE Trans. on PAS, Vol.PAS-101, Sept.1982,pp3091-3095.
6. "ShuntThyristorrectifiersfortheGeneratorExcitationsystems",IEEETrans.OnPAS.Vol.PAS-96, July/August, 1977,pp1219-1225.

P20MG533

RESEARCH METHODOLOGY

L	T	P	C
3	0	0	3

OBJECTIVES:

To impart knowledge on

- To impart knowledge on the basic research process.
- To provide knowledge on the different types of research.
- To educate the students on report writing.

UNIT I TYPES OF RESEARCH

9

Motivation and objectives – Research methods vs Methodology. Types of research – Descriptive vs. Analytical,Applied vs. Fundamental, Quantitative vs. Qualitative, Conceptual vs. Empirical

UNIT II RESEARCH FORMULATION

9

Defining and formulating the research problem - Selecting the problem - Necessity of defining the problem -Importance of literature review in defining a problem – Literature review – Primary and secondary sources – reviews, treatise, monographs-patents – web as a source – searching the web - Critical literature review – Identifying gap areas from literature review - Development of working hypothesis.

UNIT III RESEARCH DESIGN AND METHODS

9

Research design – Basic Principles- Need of research design – Features of good design – Important concepts relating to research design – Observation and Facts, Laws and Theories, Prediction and explanation, Induction, Deduction, Development of Models. Developing a research plan - Exploration, Description, Diagnosis and Experimentation. Determining experimental and sample designs.

UNIT IV DATA COLLECTION AND ANALYSIS

9

Execution of the research - Observation and Collection of data - Methods of data collection – Sampling Methods-Data Processing andAnalysis strategies-Data Analysis with Statistical Packages - Hypothesis-testing - Generalization and Interpretation.

UNIT V REPORTING AND THESIS WRITING

9

Structure and components of scientific reports - Types of report – Technical reports and thesis – Significance –Different steps in the preparation – Layout, structure and Language of typical reports – Illustrations and tables - Bibliography, referencing and footnotes- Plagiarism - Citation and acknowledgement - Reproducibility and accountability.

TOTAL : 45 PERIODS

OUTCOMES:

At the end of the course, the students will be able to

- Explain the basic research process.
- Identification of research problems
- Explain various design methods for formulating research problem
- Depict the methods of data collection and processing
- Write a technical report and a thesis.

TEXT BOOK:

1. Garg, B.L., Karadia, R., Agarwal, F. and Agarwal, U.K., 2002. An introduction to Research Methodology, RBSA Publishers.
2. Kothari, C.R., 1990. Research Methodology: Methods and Techniques. New Age International. 418p.
3. Sinha, S.C. and Dhiman, A.K., 2002. Research Methodology, ESS Publications. 2 volumes.

P20PE534

SOLAR PHOTOVOLTAIC SYSTEMS

L	T	P	C
3	0	0	3

OBJECTIVES:

- Providing an insight into the fundamentals of solar radiation, solar cells and describe the manufacturing processes of photovoltaic (PV).
- Concerns the basics and performance characteristics of Solar PV Module.
- Providing an insight the Modeling, Solar Tracking and MPPT techniques.
- Concerns the types and design of Stand Alone and Grid Connected PV System
- Providing knowledge to maintain quality control and safety standards on solar photovoltaic systems

UNIT I INTRODUCTION

9

Sun as Source of Energy: Nature of solar radiation, Availability of solar energy, Estimation of solar radiation, Measurement of solar radiation, Methods of using solar energy-Photovoltaic effect-Crystalline Si electrical and optical properties- Commercial solar cells - Production process of single crystalline silicon cells.

UNIT II PHOTOVOLTAIC MODULE PERFORMANCE

9

Structure and working of Solar Cells - Types, Electrical properties and Behavior of Solar Cells - Cell properties and design - PV Cell Interconnection and Module Fabrication - PV Modules and Arrays - P-V and I-V characteristics of a PV module, Maximum Power Point, Cell efficiency, Fill factor, Effect of Irradiation and Temperature.

UNIT III MODELING AND MPPT

9

Single diode and double diode modeling of PV Module- Solar Tracking: Single axis and Dual axis tracking-Maximum Power Point Tracking Techniques: P&O, INC and their comparisons-Partial Shading Effects.

UNIT IV STAND ALONE PV SYSTEMS AND GRID CONNECTED PV SYSTEMS

9

Standalone PV system Schematics, Components, Batteries, and Charge Conditioners - Balance of system components, Sizing. Grid connected PV system Schematics, Components, Charge Conditioners, Interface Components - Balance of system Components.

UNIT V PV SYSTEM MAINTENANCE

9

Minimising shading, Cleaning, Electrical and mechanical inspection, Fault finding and troubleshooting, Planning routine maintenance and inspection, Performance assessment and system monitoring.

TOTAL :45 PERIODS

OUTCOMES:

- Understand solar radiation concepts, solar physics and manufacturing technologies for Solar PV cells.
- Understand the principle of direct solar energy conversion to power using PV technology and the structure, operation and behavior of Solar Cells, PV Modules, and Arrays.
- Analyse the MPP operation of PV Module from the knowledge of Modeling, Tilting and MPPT techniques.
- Design and Analyse the concepts related to stand alone PV systems and Grid Connected PV Systems.
- Safely and correctly maintain photovoltaic systems.

REFERENCES:

1. Chetan Singh Solanki., Solar Photovoltaic: “Fundamentals, Technologies and Application”, PHI Learning Pvt., Ltd., 2009.
2. Jha A.R., “Solar Cell Technology and Applications”, CRC Press, 2010.
3. John R. Balfour, Michael L. Shaw, Sharlave Jarosek., “Introduction to Photovoltaics”, Jones & Bartlett Publishers, Burlington, 2011.
4. Partain L.D., Fraas L.M., “Solar Cells and Their Applications”, 2nd ed., Wiley, 2010.
5. Stuart R. Wenham, Martin A. Green, Muriel E. Watt, Richard Corkish (Editors), Applied Photovoltaics, Earthscan, 2008.
6. Michael Boxwell, The Solar Electricity Handbook, Code Green Publishing, UK, 2009.
7. Rik DeGunther, Solar Power Your Home for Dummies, Wiley Publishing Inc, 2008.
8. Photovoltaics: Design and Installation Manual, Published by Solar Energy International.

P20PE631 DIAGNOSIS AND PROTECTION FOR SOLID STATE SYSTEMS L T P C
3 0 0 3

OBJECTIVES:

- To understand the basics of adaptive control
- To understand the concept of model reference adaptive systems
- To know the adaptation mechanisms such as auto-tuning and gain scheduling
- To know few applications of adaptive control.

UNIT I PROTECTION AND FAULT DIAGNOSIS OF CONVERTER SYSTEMS 9

Protections to SCR based power conversion systems: devices, converters. naturally commutated converters . single and three phase converters . dual converters . cyclo-converters - higher pulse converters . forced commutated choppers/inverters. Fault diagnosis of converters: device failures - commutation failures. phase failures; Fault diagnosis of control loops: failure of controller and limiters, sensor and reference, starting and braking.

UNIT II PROTECTION AND DIAGNOSIS OF SOLID STATE DEVICES IN POWER SYSTEMS 9

Protections to solid state compensators/voltage regulator. TCR, TCS, SVC, TCSC, UPFC, solid state tap changer; Fault diagnosis through waveform/performance analysis of device failures, phase failures, sensor failures; Protection and fault diagnosis of filter. aging of passive components and detuning. auto tuning methods.

UNIT III PROTECTION AND FAULT DIAGNOSIS OF SOLID STATE DC DRIVES 9

Protections to solid state DC drives. field failures, armature failures, commutator short/open, operations with converter/chopper failures . device, input source, filter component failures. Closed loop control failures. failure of controllers and limiters, sensor and references. Diagnosis of solid state dc drive systems faults - starting and braking.

UNIT IV PROTECTION AND DIAGNOSIS OF SOLID STATE AC DRIVES 9

Protection to AC Machines - phase failures, slip-ring/brush failures, bearing failures; Effects of solid state converter/inverter systems failures of device, PWM modulators, input source, filter components - voltage/current ripple effects, closed loop failures: failure of controller . sensor - references. Diagnosis of solid state ac drive systems faults.

UNIT V PROTECTION AND DIAGNOSIS OF HVDC, UPS AND EXCITATION SYSTEMS 9

Protection and faults in HVDC, UPS, Generator excitation systems: individual systems, multiple systems operating in parallel/series. redundancy - diagnosis of faults through characterization. Analysis of simple faults in complex solid state systems.

TOTAL : 45 PERIODS

OUTCOMES:

Understands the model reference adaptive systems

- Know the auto-tuning and gain scheduling methods
- Understands the applications of adaptive control concepts to physical systems.

TEXT BOOKS:

1. Mohan, Underland and Robbins, Power Electronics, John Wiley & Sons, 1995.
2. D.Grahame Holmes, Thomas A. Lipo, Pulse Width Modulation for Power Converters: Principles and Practice, Wiley-IEEE Press, Year.
4. Jos Arrillaga, Yonghe H. Liu, Neville R. Watson, Nicholas J. Murray, Self-Commutating Converters for High Power Applications, John Wiley & Sons, 2009.
5. Bimal K. Bose, Modern Power Electronics and AC Drives, Pearson Education (Singapore) Ltd., New Delhi, 2003.
6. K.R.Padiyar, Facts Controllers in Power Transmission and Distribution, New Age International (P) Limited, New Delhi, 2007.

REFERENCES:

1. Andrzej M. Trzynadlowski, Introduction to Modern Power Electronics, John Wiley & Sons, 2010.
2. R. Mohan and R.K.Varma, Thyristor-Based FACTS Controllers for Electrical Transmission Systems, IEEE Press . A John Wiley and Sons, Inc. Publications. Year.
3. Bin Wu, High-Power Converters and AC Drives, Wiley-IEEE Press.
4. Vijay K. Sood, HVDC and FACTS Controller: Application of Static Converters in power systems, IEEE Power Electronics and Power Systems series, Kluwer Academic publishers, Boston, 2004.
5. Vector Control of Three-Phase AC Machines: System Development in the Practice, Nguyen Phung Quang, Jörg-Andreas Dittrich, Springer, 2008.

P20PE632

IOT FOR SMART GRID

L	T	P	C
3	0	0	3

OBJECTIVES:

- To Study about Smart Grid technologies, different smart meters and advanced metering infrastructure.
- To familiarize the power quality management issues in Smart Grid.
- To familiarize the high performance computing for Smart Grid applications

UNIT I INTRODUCTION TO SMART GRID

9

Introduction - Evolution of Electric Grid, Smart Grid Concept - Definitions and Need for Smart Grid – Functions – Opportunities – Benefits and challenges, Difference between conventional & Smart Grid, Technology Drivers

UNIT II ENERGY MANAGEMENT SYSTEM

9

Energy Management System (EMS) - Smart substations - Substation Automation – Feeder Automation, SCADA – Remote Terminal Unit – Intelligent Electronic Devices – Protocols, Phasor Measurement Unit – Wide area monitoring protection and control, Smart integration of energy resources – Renewable, intermittent power sources – Energy Storage.

UNIT III DISTRIBUTION MANAGEMENT SYSTEM 9
 Distribution Management System (DMS) – Volt / VAR control – Fault Detection, Isolation and Service Restoration, Network Reconfiguration, Outage management System, Customer Information System, Geographical Information System, Effect of Plug in Hybrid Electric Vehicles

UNIT IV SMART METERS 9
 Introduction to Smart Meters – Advanced Metering infrastructure (AMI), AMI protocols – Standards and initiatives, Demand side management and demand response programs, Demand pricing and Time of Use, Real Time Pricing, Peak Time Pricing.

UNIT V COMMUNICATION NETWORKS & IOT 9
 Elements of communication and networking – architectures, standards, PLC, Zigbee, GSM, BPL, Local Area Network (LAN) - House Area Network (HAN) - Wide Area Network (WAN) – Broadband over Power line (BPL) - IP based Protocols - Basics of Web Service and CLOUD Computing, Cyber Security for Smart Grid.

TOTAL : 45 PERIODS

OUTCOMES

- Get acquainted with different smart devices and smart meters
- Describe how modern power distribution system functions
- Identify suitable communication networks for Smart Grid applications

TEXT BOOKS

1. Stuart Borlase ‘Smart Grid: Infrastructure, Technology and Solutions’, CRC Press 2012.
2. JanakaEkanayake, Nick Jenkins, KithsiriLiyanage, Jianzhong Wu, Akihiko Yokoyama, ‘Smart Grid: Technology and Applications’, Wiley, 2012.

REFERENCE BOOKS

1. Mini S. Thomas, John D McDonald, ‘Power System SCADA and Smart Grids’, CRC Press, 2015
2. Kenneth C.Budka, Jayant G. Deshpande, Marina Thottan, ‘Communication Networks for Smart Grids’, Springer, 2014.

E BOOKS

1. <https://books.google.co.in/books?isbn=1119969093>
2. <https://books.google.co.in/books?isbn=135123093X>

P20PE633 ELECTRIC VEHICLE CHARGING TECHNOLOGIES L T P C
3 0 0 3

OBJECTIVES:

- To understand the concept of electrical vehicles and its operations
- To understand the need for charging methods in hybrid vehicles
- To provide knowledge about various possible charging technologies that can be used in electric vehicles

UNIT I INTRODUCTION: ELECTRIC VEHICLE 9

History, Components of Electric Vehicle, Comparison with Internal combustion Engine: Technology, EV classification and their electrification levels, EV Terminology

UNIT II TYPES OF EV CHARGERS 9

Electric Vehicle Technology and Charging Equipment’s, Basic charging Block Diagram of Charger, Difference between Slow charger and fast charger, Slow charger design rating, Fast charger design rating, AC charging and DC charging, Type of Mode of charger Mode -2 , Mode-3 and Mode-4

UNIT III SELECTION AND SIZING OF FAST AND SLOW CHARGER (AC & DC) 9

AC Pile Charger, DC Pile Charger, EVSE Power Module selection and technical specification, Selection of Electric Vehicle Supply Equipment (EVSE) Communication Protocol (PLC / Ethernet / Modbus/ CAN, Module), Communication gateway, Specification of open charge point protocol (OCCP 1.6/2.0), Bharat DC001 & AC001 Charger specification, Selection of AC charger type-1 , type -2 and type -3, Communication between AC charger and EV, IS/IEC/ARAI/ standard of Charging topology, Communication and connectors (IEC 61851-1, IEC 61851-24,62196-2)

UNIT IV PUBLIC CHARGING INFRASTRUCTURE / ELECTRICAL SYSTEM DESIGN 9

Assessment of site Location for Public charging station, Selection and Sizing of Distribution transformer, Selection and sizing of HT Equipment (VCB, CT, PT, Metering), Selection and Sizing HT Cables and LT cables, Selection and sizing of Distribution Board / feeders, Sizing calculation of LT and HT cable, Selection and of Compact Substation (CSS for EV CS)/ Power Sub station), Selection of relay and calculation

UNIT V EV CHARGER INTEGRATION WITH SOLAR POWER PLANT 9

Selection of PV module technology, Types of solar inverter, Selection of string /central / off grid inverter, Selection of power conditioning unit (PCU), Sizing of solar inverter for roof top and grid connected projects, Selection and sizing of inverter, Protection requirement of solar inverter Earthing Layout/ AC /DC cabling Layout

TOTAL : 45 PERIODS

OUTCOMES:

At the end of the course, the students will be able to

- Identify the importance of hybrid electric vehicle
- Explicate the different train topologies and power flow control in electric vehicles
- Choose a suitable drive scheme for developing an electric hybrid vehicle depending on resources
- Choose proper energy storage systems for vehicle applications
- Identify the different Energy storage for Electric Vehicle.

REFERENCE BOOKS:

1. Editors: Veneri, Ottorino “Technologies and Applications for Smart Charging of Electric and Plug-in Hybrid Vehicles: Springer, 2017
2. Ryan Collin, OrcID, Yu Miao OrcID, Alex Yokochi OrcID, Prasad Enjeti and Annette von Jouanne “Advanced Electric Vehicle Fast-Charging Technologies” , Energies 2019, 12(10), 1839; <https://doi.org/10.3390/en12101839>, (This article belongs to the Special Issue Power Processing Systems for Electric Vehicles).
- 3.Hussain Shareef, Md. MainullIslam, Azah Mohamed “A review of the stage-of-the-art charging technologies, placement methodologies, and impacts of electric vehicles”, Elsevier - Renewable and Sustainable Energy Reviews, Volume 64, October 2016, Pages 403-420.

P20PE634	WIND ENERGY CONVERSION SYSTEM	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To learn the design and control principles of Wind turbine.
- To understand the concepts of fixed speed and variable speed, wind energy conversion systems.
- To analyze the grid integration issues.

UNIT I INTRODUCTION 9

Components of WECS-WECS schemes-Power obtained from wind-simple momentum theory- Power coefficient-Sabinin’s theory-Aerodynamics of Wind turbine.

UNIT II WIND TURBINES**9**

HAWT-VAWT-Power developed-Thrust-Efficiency-Rotor selection-Rotor design considerations- Tip speed ratio-No. of Blades-Blade profile-Power Regulation-yaw control-Pitch angle control stall control-Schemes for maximum power extraction.

UNIT III FIXED SPEED SYSTEMS**9**

Generating Systems- Constant speed constant frequency systems -Choice of Generators- Deciding factors-Synchronous Generator-Squirrel Cage Induction Generator- Model of Wind Speed- Model wind turbine rotor - Drive Train model- Generator model for Steady state and Transient stability analysis.

UNIT IV VARIABLE SPEED SYSTEMS**9**

Need of variable speed systems-Power-wind speed characteristics-Variable speed constant frequency systems synchronous generator- DFIG- PMSG -Variable speed generators modeling - Variable speed variable frequency schemes.

UNIT V GRID CONNECTED SYSTEMS**9**

Wind interconnection requirements, low-voltage ride through (LVRT), ramp rate limitations, and supply of ancillary services for frequency and voltage control, current practices and industry trends wind interconnection impact on steady-state and dynamic performance of the power system including modeling issue.

TOTAL : 45 PERIODS**OUTCOMES:**

- Acquire knowledge on the basic concepts of Wind energy conversion system.
- Understand the mathematical modeling and control of the Wind turbine
- Develop more understanding on the design of Fixed speed system
- Study about the need of Variable speed system and its modeling.
- Able to learn about Grid integration issues and current practices of wind interconnections with power system.

REFERENCES:

1. L.L.Freris "Wind Energy conversion Systems", Prentice Hall, 1990
2. S.N.Bhadra, D.Kastha,S.Banerjee,"Wind Electrical Sytems",Oxford University Press,2010.
3. Ion Boldea, "Variable speed generators", Taylor & Francis group, 2006.
4. E.W.Golding "The generation of Electricity by wind power", Redwood burn Ltd.,Trowbridge,1976.
5. N. Jenkins," Wind Energy Technology" John Wiley & Sons,1997.
6. S.Heir "Grid Integration of WECS", Wiley 1998.