P14PE101 MACHINE MODELLING AND ANALYSIS

Class: M.Tech. I Semester **Branch:** Power Electronics

Teaching Scheme:

L	T	P	C
4	-	-	4

Examination Scheme:

Continuous Internal Evaluation	:	40 marks
End Semester Exam	:	60 marks

Course Learning Objectives:

- *To understand the concept of 2-axis representation of an Electrical machine.*
- *To know the concepts of representing transfer function model of a DC machine.*
- *To understand the importance of 3-phase to 2-phase conversion.*
- *To know the representation of 3-phase induction motor in various reference frames*
- *To know the modeling of 3-phase synch. Motor in 2- axis representation.*

UNIT – I (12)

Basic Two-pole DC machine - primitive 2-axis machine - Voltage and Current relationship - Torque equation. Mathematical model of separately excited DC motor and DC Series motor in state variable form - Transfer function of the motor - Numerical problems. Mathematical model of D.C. shunt motor and D.C. Compound motor in state variable form - Transfer function of the motor - Numerical Problems.

UNIT – II (12)

Linear transformation - Phase transformation (a,b,c to α, β, o) - Active ransformation(α, β, o to d, q). Circuit model of a 3 phase Induction motor – Linear transformation - Phase Transformation - Transformation to a Reference frame - Two axis models for Induction motor.

UNIT – III (12)

Voltage and current Equations in stator reference frame - Equation in Rotor reference frame - Equations in a synchronously rotating frame - Torque equation-Equations in state-space form.

UNIT – IV (12)

Circuit model of a 3ph Synchronous motor - Two axis representation of Syn. Motor Voltage and current Equations in state - space variable form - Torque equation.

Text Books:

1. Vedam Subramanyam, *"Thyristor control of Electric Drives"*.
2. Paul C.Krause , Oleg wasynezuk, Scott D.Sudhoff, *"Analysis of Electric Machinery and Drive Systems"*

Course Learning Outcomes:

At the end of the course the student will be able to:

- *Develop models for linear and nonlinear magnetic circuits*
- *Determine the developed torque in an electrical machines using the concepts of filed energy and co-energy and determine the dynamic model of a DC Machine*
- *Determine the dynamic model of an induction machine based on the dq0 transformation and determine instantaneous torque developed in an induction machine-which leads to advanced control strategies such as vector control and direct torque control.*
- *Determine the torque developed in a salient pole synchronous machine using the park's transformation and identify contribution of saliency torque-damping torque and excitation torque.*

P14PE102 ANALYSES OF POWER ELECTRONIC CONVERTERS

Class: M.Tech. I Semester **Branch:** Power Electronics

Teaching Scheme:

L	T	P	C
4	-	-	4

Examination Scheme:

Continuous Internal Evaluation	:	40 marks
End Semester Exam	:	60 marks

Course Learning Objectives:

- *To analyze the performance of controlled AC-DC converters.*
- *To understand designing concepts of AC-AC voltage controllers and Cycloconverters.*
- *To learn the designing of DC-DC chopper circuits.*
- *To understand and analyze PWM techniques for Inverters.*

UNIT – I (12)

Single Phase AC Voltage Controllers: Single phase AC voltage controllers with Resistive, Resistive-inductive and Resistive-inductive-induced e.m.f. loads .

Three Phase AC Voltage Controllers: Three phase AC voltage controllers - Analysis of controllers with star and delta Connected Resistive, Resistive-inductive loads - Effects of source and load inductances - Synchronous tap changers-. ac voltage controllers with PW Control ,Applications - numerical problems.

Cycloconverters. Single phase to single phase cycloconverters - analysis of midpoint and bridge Configurations - Three phase to three phase cycloconverters - analysis of Midpoint and bridge configurations - Limitations - Advantages - Applications- numerical problems.

UNIT – II (12)

Single Phase Converters: Single phase converters - Half controlled and Fully controlled converters -Evaluation of input power factor and harmonic factor - continuous and Discontinuous load current - single phase dual converters - power factor Improvements - Extinction angle control - symmetrical angle control - PWM -single phase sinusoidal PWM - single phase series converters - Applications -Numerical problems.

Three Phase Converters. Three phase converters - Half controlled and fully controlled converters -Evaluation of input power factor and harmonic factor - continuous and Discontinuous load current - three phase dual converters - power factor Improvements - three phase PWM - twelve pulse converters - applications -Numerical problems.

UNIT – III (12)

D.C. to D.C. Converters: Analysis of step-down and step-up dc to dc converters with resistive and Resistive-inductive loads - Switched mode regulators - Analysis of Buck Regulators - Boost regulators - buck and boost regulators - Cuk regulators - Condition for continuous inductor current and capacitor voltage - comparison of regulators –Multi output boost converters - advantages - applications - Numerical problems.

UNIT – IV (12)

Pulse Width Modulated Inverters(single phase):

Principle of operation - performance parameters - single phase bridge inverter -evaluation of output voltage and current with resistive, inductive and Capacitive loads - Voltage control of single phase inverters - single PWM - Multiple PWM - sinusoidal PWM - modified PWM - phase displacement Control - Advanced modulation techniques for improved performance - Trapezoidal, staircase, stepped, harmonic injection and delta modulation - Advantage - application - numerical problems.

Pulse Width Modulated Inverters(three phase). Three phase inverters - analysis of 180 degree condition for output voltage And current with resistive, inductive loads - analysis of 120 degree Conduction - voltage control of three phase inverters - sinusoidal PWM - Third Harmonic PWM – 60 degree PWM – space vector modulation - Comparison of PWM techniques - harmonic reductions - Current Source Inverter - variable d.c. link inverter - boost inverter - buck and boost inverter - inverter circuit design - advantages -applications - numerical problems.

Multilevel inverters

Text Books:

1. Mohammed H. Rashid,"*Power Electronics*" , Pearson Education -3rd Edn - First Indian reprint 2004.
2. Ned Mohan, Tore M. Undeland and William P. Robbins, *"Power Electronics"* John Wiley and Sons, 2nd Edn.

Course Learning Outcomes:

At the end of the course the student will be able to:

- *Select an appropriate power semiconductor device and design a power converter for the required application*
- *Determine the power circuit configuration needed to fulfill the required power conversion with applicable constraints.*
- *Design the control circuit and the power circuit for a given power converter.*
- *Determine the drive circuit requirements in terms of electrical isolation and the requirement of bipolar drive and ease of control.*

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P14PE103 MODERN CONTROL THEORY

Class: M.Tech. I Semester **Branch:** Power Electronics

Teaching Scheme:

L	T	P	C
4	-	-	4

Examination Scheme:

Continuous Internal Evaluation	:	40 marks
End Semester Exam	:	60 marks

Course Learning Objectives:

- *To know the basic concepts of matrices, Eigen values and Eigen vectors.*
- *To know the modeling of systems by using state space Analysis*
- *To know the design of controllers for several classes of plants.*
- *To know the Harmonic Analysis and Stability of Non- Linear Systems*
- *To know the control problems such as dead bent control, external Disturbances and sensitivity problems in optimal linear regulators.*

UNIT – I (12)

Fields, Vectors and Vector Spaces – Linear combinations and Bases – Linear Transformations and Matrices – Scalar Product and Norms – Eigen values, Eigen Vectors and a Canonical form representation of Linear operators – The concept of state – State Equations for Dynamic systems – Time invariance and Linearity – Nonuniqueness of state model – State diagrams for Continuous-Time State models .

STATE VARIABLE ANALYSIS: Linear Continuous time models for Physical systems– Existence and Uniqueness of Solutions to Continuous-Time State Equations – Solutions of Linear Time Invariant Continuous-Time State Equations – State transition matrix and it's properties.

CONTROLLABILITY AND OBSERVABILITY

General concept of controllability – General concept of Observability – Controllability tests for Continuous-Time Invariant Systems – Observability tests for Continuous-Time Invariant Systems – Controllability and Observability of State Model in Jordan Canonical form – Controllability and Observability Canonical forms of State model.

UNIT – II (12)

NON LINEAR SYSTEMS: Introduction – Non Linear Systems - Types of Non-Linearities – Saturation – Dead-Zone - Backlash – Jump Phenomenon etc;– Singular Points – Introduction to Linearization of nonlinear systems, Properties of Non-Linear systems – Describing function–describing function analysis of nonlinear systems – Stability analysis of Non-Linear systems through describing functions. Introduction to phase-plane analysis, Method of Isoclines for Constructing Trajectories, singular points, phase-plane analysis of nonlinear control systems.

UNIT – III (12)

STABILITY ANALYSIS: Stability in the sense of Lyapunov, Lyapunov's stability and Lypanov's instability theorems - Stability Analysis of the Linear continuous time invariant systems by Lyapunov second method – Generation of Lyapunov functions – Variable gradient method – Krasooviski's method.

STATE FEEDBACK CONTROLLERS AND OBSERVERS

State feedback controller design through Pole Assignment – State observers: Full order and Reduced order

UNIT – IV (12)

Introduction to optimal control - Formulation of optimal control problems – calculus of variations – fundamental concepts, functionals, variation of functionals – fundamental theorem of theorem of Calculus of variations – boundary conditions – constrained minimization – formulation using Hamiltonian method – Linear Quadratic regulator

Text books:

1. M.Gopal, "*Modern Control System Theory*", New Age International, 1984.
2. Ogata.K, "*Modern Control Engineering*" Prentice Hall, 1997

Reference Books:

1. Kircks, "*Optimal control*"

Course Learning Outcomes:

At the end of the course the student will be able to:

- *Develop mathematical models of physical systems.*
- *Design optimal controllers for physical systems including power electronic and power systems.*
- *Analyze the issues related to the stability of automatic control systems.*
- *Design complex nonlinear systems by linearizing them*

P14PE104 POWER ELECTRONIC CONTROL OF DC DRIVES

Class: M.Tech. I Semester **Branch:** Power Electronics

Teaching Scheme:

L	T	P	C
4	-	-	4

Examination Scheme:

Continuous Internal Evaluation	:	40 marks
End Semester Exam	:	60 marks

Course Learning Objectives:

- *To Design motor starting, braking and reversing electrical circuits.*
- *To Control Speed of the DC motor by using different controllers.*
- *To Design and modeling of current and speed controllers for DC motors*
- *To Determine drive system stability by calculating different system parameters.*
- *To Calculate harmonics and their associated problems.*

UNIT – I (12)

Controlled Bridge Rectifier (1-Φ) with DC Motor Load: Separately exited DC motors with rectified single-phase supply – single phase semi converter and single phase full converter for continuous and discontinuous modes of operation – power and power factor.

Controlled Bridge Rectifier (3-Φ) with DC Motor Load: Three-phase semi converter and three phase full converter for continuous and discontinuous modes of operation – power and power factor – Addition of freewheeling diode-

Three phase naturally commutated bridge circuit as a rectifier or as an inverter: Three phase controlled bridge rectifier with passive load impedance, resistive load and ideal supply – Highly inductive load and ideal supply for load side and supply side quantities.

UNIT – II (12)

Phase controlled DC Motor drives: Three phase controlled converter, control circuit, control modeling of three phase converter – Steady state analysis of three phase converter control DC motor drive – Two quadrant, three phase converter controlled DC motor dive – DC motor and load converter.

Current and Speed Controlled DC Motor drives:

Current and speed controllers – current and speed feedback – Design of controllers – current and speed controllers – Motor equations – filter in the speed feedback loop speed controller – current reference generator – current controller and flow chart for simulation – Harmonics and associated problems – sixth harmonics torque.

UNIT – III (12)

Chopper controlled DC Motor drives

Principles of operation of the chopper – four-quadrant chopper circuit – chopper for inversion – Chopper with other power devices – model of the chopper –input to the chopper steady state analysis of chopper controlled DC motor drives – rating of the devices – Pulsating torque.

UNIT – IV (12)

Closed loop operation of DC Motor drives

Speed controlled drive system – current control loop – pulse width modulated current controller – hysteresis current controller – modeling of current controller – design of current controller.

Simulation of DC motor drives : Dynamic simulations of the speed controlled DC motor drives – Speed feedback speed controller – command current generator – current controller.

References Books:

1. Shepherd, Hulley, Liang, "*Power Electronic and Motor Control*", 2nd Edn., Cambridge University Press.
2. R. Krishnan, *"Electronic Motor Drives Modeling, Analysis and Control"*, I Edn., PHI.
3. M. H. Rashid, *"Power Electronic circuits, Drives and Applications"*, PHI – I Edn, 1995
4. G.K. Dubey, "*Fundamentals of Electric Drives*", Narosa Publications, 1995
5. S.B. Dewan and A. Straughen, *"Power Semiconductor Drives*", 1975

Course Learning Outcomes:

At the end of the course the student will be able to:

- *Design controllers for closed-loop operation of a separately excited DC motor drive.*
- *Control Speed of the DC motor by using different controllers.*
- *Design and modeling of current and speed controllers for DC motors*

P14PE105 A HIGH VOLTAGE DC TRANSMISSION
(Elective-I)

Class: M.Tech. I Semester **Branch:** Power Electronics

Teaching Scheme:

L	T	P	C
4	-	-	4

Examination Scheme:

Continuous Internal Evaluation	:	40 marks
End Semester Exam	:	60 marks

Course Learning Objectives:

1. To learn the importance of HVDC transmission.
2. To analyze HVDC converters
3. To know the faults and protections required in HVDC system
4. To get idea of Harmonics and Filters
5. To know the concepts of multi terminal DC links.

UNIT – I (12)

H.V.D.C. Transmission: General considerations, Power Handling Capabilities of HVDC Lines, Basic Conversion principles, static converter configuration. Static Power Converters: 3-pulse, 6-pu!se and 12-pulse converters, converter station and Terminal equipment, commutation process, Rectifier and inverter operation, equivalent circuit for converter -special features of converter transformers. Harmonics in HVDC Systems, Harmonic elimination, AC and DC filters.

UNIT – II (12)

Control of HVDC Converters and systems: constant current, constant extinction angle and constant Ignition angle control- Individual phase control and equidistant firing angle control, DC power flow control. Interaction between MV AC and DC systems - Voltage interaction, Harmonic instability problems and DC power modulation.

UNIT – III (12)

Multi-terminal DC links and systems; series, parallel and series parallel systems, their operation and control. Transient over voltages in HVDC systems: Over voltages due to disturbances on DC side, over voltages due to DC and AC side line faults.

UNIT – IV (12)

Converter faults and protection in HVDC Systems: Converter faults, over current protection - valve group, and DC line protection. Over voltage protection of converters, surge arresters.

Reference Books:

1. E.W. Kimbark, *"Direct current Transmission"*, Wiely Inter Science - New York.
2. J.AriMaga, *"H/V.D.C. Transmission"*, Peter Peregrinus ltd., London UK 1983
3. K_.R.Padiyar, *"High Voltage Direct current Transmission"*, Wiely Eastern Ltd,, New Delhi, 1992.
4. E.Uhlman, *"Power Transmission by Direct Current"*, Springer Verlag, Berlin Helberg, 1985

Course Learning Outcomes:

At the end of the course the student will be able to:

- *Compare the HVDC Transmission and EHVAC transmission*
- *Identify and analyze converter configurations used in HVDC and list the performance metrics.*
- *Understand controllers for controlling the power flow through a dc link.*
- *Understand the role of impedance control, phase angle control and voltage control in controlling real and reactive power in transmission systems.*

P14PE105 B DESIGN OF DIGITAL SYSTEMS
(Elective-I)

Class: M.Tech. I Semester **Branch:** Power Electronics

Teaching Scheme:

L	T	P	C
4	-	-	4

Examination Scheme:

Continuous Internal Evaluation	:	40 marks
End Semester Exam	:	60 marks

Course Learning Objectives:

- *To learn Simulation of complex digital high-and design systems and FSMs with level software tools such as VHDL*
- *To learn the synthesis of digital systems and select devices and technologies*
- *To learn fast hard-wired controllers to suit the needs of high-end power electronics applications such as Multi-Level inverter driven AC drives and FACTS devices*

UNIT – I (12)

Principles of Sequential logic design: Concept of FSM – Metastability

UNIT – II (12)

State machine structures: Moore machine - Mealy machine, Analysis of state machine with D and J-K Flip-flops

UNIT – III (12)

Design of Finite State Machines: Clocked synchronous state machine design, Designing state machine using state diagrams, State machine synthesis using transition list, Clock skew- Overview of PLDs, CPLDs and FPGAs

UNIT – IV (12)

RT level combinational circuit, Regular sequential circuit Design examples with VHDL

Reference Books:

1. J. F. Wakerly, *"Digital Design-Principles and Practices"*, 4th Edn., Pearson, 2008.
2. Pong P. Chu, *"FPGA Prototyping by VHDL Examples Xilinx Spartan-3 Version"*, 1st Edn., Wiley-Interscience, 2008.

Course Learning Outcomes:

At the end of the course the student will be able to:

1. *Simulate complex digital high-and design systems and FSMs with level software tools such as VHDL*
2. *Synthesize digital systems and select devices and technologies*
3. *Implement fast hard-wired controllers to suit the needs of high-end power electronics applications such as Multi-Level inverter driven AC drives and FACTS devices*

P14PE105 C OPTIMIZATION TECHNIQUES
(Elective-I)

Class: M.Tech. I Semester **Branch:** Power Electronics

Teaching Scheme:

L	T	P	C
4	-	-	4

Examination Scheme:

Continuous Internal Evaluation	:	40 marks
End Semester Exam	:	60 marks

Course Learning Objectives:

- *To learn the importance and value of optimization techniques in solving practical Problems in industry*
- *To learn optimization models and apply them to real life problems*
- *To learn design of new models to improve decision making and develop critical thinking and objective analysis of decision problems.*

UNIT – I (12)

Linear Programming:
Introduction and formulation of models - Convexity - simplex method - Big-M method - two-phase method - degeneracy - non-existent and unbounded solutions - duality in LPP - dual simplex method - sensitivity analysis - revised simplex method - transportation and assignment problems - traveling salesman problem.

UNIT – II (12)

Nonlinear Programming:
Classical optimization methods - equality and inequality constraints - Lagrange multipliers and Kuhn-Tucker conditions - quadratic forms - quadratic programming problem and Wolfes' method.

UNIT – III (12)

Search Methods:
One dimensional optimization - sequential search - fibonacci search - multidimensional search methods - univariate search - gradient methods - steepest descent/ascent methods - conjugate gradient method - Fletcher-Reeves method - penalty function approach.

UNIT – IV (12)

Dynamic Programming:
Principle of optimality - recursive relations - solution of LPP - simple examples.

Integer Linear Programming:
Gomory's cutting plane method - Branch and bound algorithm - Knapsack problem - linear 0-1 problem.

Reference Books:

1. J.C. Pant, *"Introduction to Optimization"*, Jain Brothers,2004
2. S.S. Rao, *"Optimization Theory and Applications"*, Wiley Eastern Ltd. 2009
3. K.V.Mittal, *"Optimization Methods"*, Wiley Eastern Ltd. 2005

Course Learning Outcomes:

At the end of the course the student will be able to:

- *Recognize the importance and value of optimization techniques in solving practical problems in industry*
- *Understand optimization models and apply them to real life problems*
- *Design new models to improve decision making and develop critical thinking and objective analysis of decision problems.*

P14PE105 D MODELING AND SIMULATION OF POWER ELECTRONIC SYSTEMS (Elective-I)

Class: M.Tech. I Semester **Branch:** Power Electronics

Teaching Scheme:

L	T	P	C
4	-	-	4

Examination Scheme:

Continuous Internal Evaluation	:	40 marks
End Semester Exam	:	60 marks

Course Learning Objectives:

- *To understand the back ground processes related to the numerical solution used.*
- *To choose the numerical solver to be used for a given type of analysis.*
- *To understand the reason for convergence problems occurring during simulation and to avoid them.*
- *To simulate the behavior of Power Converters, DC and AC drives*

UNIT-I (12)

Introduction:

Challenges in computer simulation - Simulation process - mechanics of simulation - Solution techniques for time domain analysis - Equation solvers - circuit-oriented simulators

UNIT-II (12)

Simulation Of Power Electronic Converters:

State-space representation of power electronic converters (with buck converter as a representative example) - Trapezoidal integration - M & N method for simulating power electronic converters (with buck converter as a representative example) - Introduction to MATLAB and Simulink - Simulation of rectifiers - choppers and inverter circuits along with PWM techniques

UNIT-III (12)

Simulation of Electric Drives:

Modeling of power electronic converters with transportation delay - Concept of control gain - linearization of rectifiers with inverse cosine control - State space model of 3-Ph IM - Principle of Vector control - Modeling and simulation of Vector controlled 3-Ph IM with a 3-level inverter drive

UNIT-IV (12)

Modeling - Simulation Of Switching Converters With State Space Averaging:

State Space Averaging Technique– Modeling AND linearization of converter transfer functions - Simulation and Design of power electronic converters using State-space averaged models

Reference Books:

1. M. B. Patil - V. Ramnarayanan, V. T. Ranganathan**:** *Simulation of Power Electronic Converters***,** 1st edn., Narosa Publishers, 2010
2. Ned Mohan, Undeland and Robbins**,** *"Power Electronics: Converters, Design and Control"***-** 2nd edn., John Wiley

Course Learning Outcomes:

At the end of the course the student will be able to:

- *Understand the back ground processes related to the numerical solution used.*
- *Choose the numerical solver to be used for a given type of analysis.*
- *Understand the reason for convergence problems occurring during simulation and to avoid them.*
- *Simulate the behavior of Power Converters, DC and AC drives*

P14PE106 A ALTERNATIVE SOURCES OF ELECTRICAL ENERGY
(Elective-II)

Class: M.Tech. I Semester **Branch:** Power Electronics

Teaching Scheme:

L	T	P	C
4	-	-	4

Examination Scheme:

Continuous Internal Evaluation	:	40 marks
End Semester Exam	:	60 marks

Course Learning Objectives:

- *To know the characteristics and performance of solar cells.*
- *To learn the principles of wind energy conversion*
- *To learn the concept of Distributed Generation , Demand& Supply Side Management .*
- *To learn the Energy Storage Systems*

UNIT – I (12)

Renewable Sources of Energy; Grid-Supplied Electricity; Distributed Generation; Renewable Energy Economics - Calculation of Electricity Generation Costs; Demand-Side Management Options; Supply-Side Management Options; Electricity Act 2003,Energy conservation &integrated policy

UNIT – II (12)

Wind Power Plants:

Appropriate Location; Evaluation of Wind Intensity; Topography; Purpose of the Energy Generated - General Classification of Wind Turbines; Rotor Turbines; Multiple-Blade Turbines; Drag Turbines; Lifting Turbines - Generators and Speed Control Used in Wind Power Energy; Analysis of Small Generating Systems

UNIT – III (12)

Photovoltaic Power Plants:

Solar Energy; Generation of Electricity by Photovoltaic Effect; Dependence of a PV Cell Characteristic on Temperature; Solar Cell Output Characteristics - Equivalent Models and Parameters for Photovoltaic Panels; Photovoltaic Systems - Applications of Photovoltaic Solar Energy; Economical Analysis of Solar Energy

UNIT – IV (12)

Energy Storage Systems:

Energy Storage Parameters; Lead–Acid Batteries; Ultracapacitors; Flywheels - Superconducting Magnetic Storage System; Pumped Hydroelectric Energy Storage; Compressed Air Energy Storage - Storage Heat; Energy Storage as an Economic Resource

Text Books:

1. Felix A. Farret, M. Godoy Simo` es, "*Integration of Alternative Sources of Energy*", John Wiley & Sons, 2006.
2. Remus Teodorescu, Marco Liserre, Pedro Rodríguez, "*Grid Converters for Photovoltaic and Wind Power Systems*", John Wiley & Sons, 2011.
3. Gilbert M. Masters, "*Renewable and Efficient Electric Power Systems*", John Wiley & Sons, 2004
4. B.H.Khan, *"Non conventional Energy Resources''*, Tata McGraw Hill Pvt. Ltd, New Delhi
5. G.D.Rai, *"Non conventional Sources of Energy''* Khanna publishers New delhi
6. 6.Vittal V. and Ayyanar R. (2012), "*Grid Integration and Dynamic Impact of Wind Energy*", Springer

Reference Books:

1. Rakosh das Begamudre, *"Energy Conversion Systems"* New Age International Publishers, New Delhi, 2000.
2. John Twidell and Tony Weir, *"Renewable Energy Resources"* 2nd Edn., Fspon & Co.
3. Bollen M. H. and Hassan F. "*Integration of Distributed Generation in the Power System*", Wiley-IEEE Press, 2011
4. Keyhani A. "*Design of Smart Power Grid Renewable Energy Systems*", Wiley–IEEE Press, 2011
5. Gellings C. W. "*The Smart Grid: Enabling Energy Efficiency and Demand Respons*", First Edition, CRC Press, 2009

<u>Course Learning Outcomes:</u>

At the end of the course the student will be able to:

- *Understand the characteristics and performance of solar cells.*
- *Understand the principles of wind energy conversion*
- *Understand the concept of Distributed Generation, Demand& Supply Sid Management*
- *Understand the Learn the Energy Storage Systems*

P14PE106 B DYNAMICS OF ELECTRICAL MACHINES
(Elective-II)

Class: M.Tech. I Semester **Branch:** Power Electronics

Teaching Scheme:

L	T	P	C
4	-	-	4

Examination Scheme:

Continuous Internal Evaluation	:	40 marks
End Semester Exam	:	60 marks

Course Learning Objectives:

- *To learn various design and characteristics of electrical machines.*
- *To learn the electromechanical analogy of the electrical machines*
- *To learn the dynamics characteristics of DC machine with generalized machine theory.*
- *To know and study the operation and dynamics characteristics of the induction motor.*
- *To learn the dynamic, Transient and steady state characteristics of synchronous machines.*

UNIT – I (12)

Basic Machine Theory: Electromechanical Analogy – Magnetic Saturation – Rotating field theory – Operation of Inductor motor – equivalent circuit – Steady state equations of d.c. machines – operations of synchronous motor – Power angle characteristics

UNIT – II (12)

Electro dynamical equation and their solutions: Spring and Plunger system - Rotational motion – mutually coupled coils – Lagrange's equation – Application of Lagrange's equation solution of Electro dynamical equations.

UNIT – III (12)

Dynamics of DC Machines: Separately excited d. c. generations – stead state analysis – transient analysis – Separately excited d. c. motors – stead state analysis – transient analysis – interconnection of machines – Ward Leonard system of speed control.

UNIT – IV (12)

Induction Machine Dynamics: Induction machine dynamics during starting and braking – accelerating time – induction machine dynamic during normal operation – Equation for dynamical response of the induction motor.

Synchronous Machine Dynamics: Electromechanical equation – motor operation – generator operation – small oscillations – general equations for small oscillations – representation of the oscillation equations in state variable form.

Reference Books:

1. Sen Gupta D.P. and J.W *"Electrical Machine Dynamics"*, Macmillan Press Ltd 1980.

2. Bimbhra P.S. *"Generalized Theory of Electrical Machines"*. Khanna Publishers 2002.

Course Learning Outcomes:

At the end of the course the student will be able to:

- *Understand the various design and characteristics of electrical machines.*
- *Understand the electromechanical analogy of the electrical machines*
- *Understand the dynamics characteristics of DC machine with generalized machine theory*
- *Understand the operation and dynamics characteristics of the induction motor.*
- *Understand the dynamic, Transient and steady state characteristics of synchronous machines.*

P14PE106 C ELECTRO MAGNETIC INTERFERENCE AND COMPATIBILITY (Elective-II)

Class: M.Tech. I Semester **Branch:** Power Electronics

Teaching Scheme:

L	T	P	C
4	-	-	4

Examination Scheme:

Continuous Internal Evaluation	:	40 marks
End Semester Exam	:	60 marks

Course Learning Objectives:

- *To recognize the sources of conducted and radiated EMI in Power Electronic converters and consumer appliances and suggest remedial measures to mitigate the problems*
- *To assess the insertion loss and design EMI filters to reduce the loss*
- *To design EMI filters, common-mode and RC-snubber circuits chokes measures to keep the interference within tolerable limits*

UNIT-I (12)

Introduction: EMC standardization and description, measuring instruments, conducted EMI references, EMI in power electronic equipment: EMI from power semiconductors circuits.

UNIT-II (12)

Noise suppression in relay systems: AC switching relays, shielded transformers, capacitor filters, EMI generation and reduction at source, influence of layout and control of parasites.

UNIT-III (12)

EMI filter elements: Capacitors, choke coils, resistors, EMI filter circuits.

UNIT-IV (12)

EMI filter design for insertion loss: Worst case insertion loss, design method for mismatched impedance condition and EMI filters with common mode choke-coils.

Text Books:

1. Laszlo Tihanyi, "*Electromagnetic Compatibility in Power Electronics*", IEEE Press.
2. R. F. Ficchi, "*Practical Design for Electromagnetic Compatibility*", Hayden Book Co.

Course Learning Outcomes:

At the end of the course the student will be able to:

1. *Recognize the sources of conducted and radiated EMI in Power Electronic converters and consumer appliances and suggest remedial measures to mitigate the problems*
2. *Assess the insertion loss and design EMI filters to reduce the loss*
3. *Design EMI filters, common-mode and RC-snubber circuits chokes measures to keep the interference within tolerable limits*

P14PE106 D RELIABILITY ENGINEERING
(Elective-II)

Class: M.Tech. I Semester **Branch:** Power Electronics

Teaching Scheme:

L	T	P	C
4	-	-	4

Examination Scheme:

Continuous Internal Evaluation	:	40 marks
End Semester Exam	:	60 marks

Course Learning Objectives:

- *To learn about the element's of probability theory*
- *To learn about the significance of reliability and hazard models.*
- *To learn about the reliability logic diagrams.*
- *To learn about the Discrete Markov chains and reliability evaluation of repairable systems.*

UNIT – I (12)

Elements of probability theory Probability distributions: Random variables, density and distribution functions. Mathematical expectation. Binominal distribution, Poisson distribution, normal distribution, exponential distribution, Weibull distribution.

UNIT – II (12)

Definition of Reliability. Significance of the terms appearing in the definition.
Component reliability, Hazard rate, derivation of the reliability function in terms of the hazarad rate. Hazard models.
Failures: Causes of failures, types of failures (early failures, chance failures and wear-out failures). Modes of failure. Bath tub curve. Effect of preventive maintenance. Measures of reliability: mean time to failure and mean time between failures.

UNIT – III (12)

Reliability logic diagrams (reliability block diagrams) Classification of engineering systems: series, parallel, series-parallel, parallel-series and non-series-parallel configurations. Expressions for the reliability of the basic configurations.
Reliability evaluation of Non-series-parallel configurations: minimal tie-set, minimal cut-set and decomposition methods. Deduction of the minimal cutsets from the minimal pathsets.

UNIT – IV (12)

Discrete Markov Chains: General modelling concepts, stochastic transitional probability matrix, time dependent probability evaluation and limiting state probability evaluation. Absorbing states.
Continuous Markov Processes: Modelling concepts, State space diagrams, Stochastic Transitional Probability Matrix, Evaluating limiting state Probabilities.
Reliability evaluation of repairable systems.
Series systems, parallel systems with two and more than two components, Network reduction techniques. Minimal cutset/failure mode approach.

Text Books :

1. Roy Billinton and Ronald N Allan, *" Reliability Evaluation of Engineering Systems"*, Plenum Press

Course Learning Outcomes:

At the end of the course the student will be able to:

- *Understand the element's of probability theory*
- *Understand the significance of reliability and hazard models.*
- *Understand the reliability logic diagrams.*
- *Understand the Discrete Markov chains and reliability evaluation of repairable systems.*

P14PE107 POWER ELECTRONICS LABORATORY

Class: M.Tech. I Semester **Branch:** Power Electronics

Teaching Scheme:

L	T	P	C
-	-	3	2

Examination Scheme:

Continuous Internal Evaluation	**:**	40 marks
End Semester Exam	**:**	60 marks

Course Learning Objectives:

- *To Design the control circuit and the power circuit for DC-DC converters*
- *To Verify the compliance of spectral performance of a Three-phase voltage source Inverter*
- *To Critically compare various options available for the drive circuit requirements*
- *To Recognize possible modes of failure of a circuit- troubleshoot and repair*

List of Experiments:

1. Experimental study for characteristics of DC-DC Buck converter.
2. Experimental study for characteristics of DC-DC Boost converter.
3. Experimental study for characteristics of DC-DC Buck-Boost converter.
4. Experimental study for characteristics of single phase fully controlled Full-Bridge converter.
5. Experimental study for characteristics of single phase semi controlled Full-Bridge converter.
6. Experimental study for single phase AC voltage controller using TRIAC
7. Experimental study for single phase Inverter.
8. Experimental study for three phase Inverter.
9. Experimental study for characteristics of three phase fully controlled Full-Bridge converter.
10. Experimental study for characteristics of three phase semi controlled Full-Bridge converter

Course Learning Outcomes:

The students will be able to:

- *Design the control circuit and the power circuit for DC-DC converters*
- *Verify the compliance of spectral performance of a Three-phase voltage source Inverter*
- *Understand the critically compare various options available for the drive circuit requirements*
- *Recognize possible modes of failure of a circuit- troubleshoot and repair*

P14PE108 POWER ELECTRONICS SIMULATION LABORATORY

Class: M.Tech. I Semester **Branch:** Power Electronics

Teaching Scheme:

L	T	P	C
-	-	3	2

Examination Scheme:

Continuous Internal Evaluation	**:**	40 marks
End Semester Exam	**:**	60 marks

Course Learning Objectives:

- *To perform simulations study of stability of system.*
- *To write a program for steady state and transient stability analysis of a power system*
- *To Perform simulation for load frequency control of a single-area and two area system*
- *To Perform simulation analysis of various power electronic converters with different loads.*

List of Experiments:

1. Write program and simulate dynamical system of following models:
   a) I/O Model
   b) State variable model
   Also identify time domain specifications of each.
2. Obtain frequency response of a given system by using various methods:
   (a) General method of finding the frequency domain specifications.
   (b) Polar plot
   (c) Bode plot
   Also obtain the Gain margin and Phase margin.
3. Determine stability of a given dynamical system using following methods.
   a) Root locus
   b) Bode plot
   c) Nyquist plot
4. Design a compensator for a given systems for required specifications.
5. Design a PID controller.
6. PSPICE &MATLAB Simulation of Single phase full converter using RL and E loads.
7. PSPICE &MATLAB Simulation of Three phase full converter using RL and E loads.
8. PSPICE &MATLAB Simulation of Single phase AC Voltage controller using RL load.
9. PSPICE &MATLAB Simulation of Three phase inverter with PWM controller.
10. PSPICE &MATLAB Simulation of resonant pulse commutation circuit.
11. PSPICE &MATLAB Simulation of impulse commutation circuit.

Course Learning Outcome:

The students will be able to:

- *Understand the simulations study of stability of system.*
- *Write a program for steady state and transient stability analysis of a power system*
- *Understand the simulation for load frequency control of a single-area and two area systems.*
- *Understand the simulation analysis of various power electronic converters with different loads.*

P14PE109 SEMINAR

Class: M.Tech. I Semester **Branch:** Power Electronics

Teaching Scheme:

L	T	P	C
-	-	-	2

Examination Scheme:

End Semester Exam	**:**	100 marks

The candidate should give an oral presentation before the Departmental Post-Graduate Review Committee (DPGRC) on any selected topic relevant to their specialization.

The students will submit a brief report as per specified format and present before the evaluation committee.

The seminar evaluation will be based on the day to day work report submission and presentation before the evaluation committee.

P14PE201 POWER ELECTRONIC CONTROL OF A.C. DRIVES

Class: M.Tech. II Semester **Branch:** Power Electronics

Teaching Scheme:

L	T	P	C
4	-	-	4

Examination Scheme:

Continuous Internal Evaluation	:	40 marks
End Semester Exam	:	60 marks

Course Learning Objectives:

- *To draw torque speed characteristics for different control parameters by their equivalent circuit analysis*
- *To know different slip recovery drive schemes for speed control of I.M. at rotor side.*
- *To study Victor control of Induction Motor Drive.*
- *To study and draw characteristics of synchronous motor using UPF and constant flux linkage control*
- *To speed Control of variable Reluctance motor drive and brushless DC motor drive.*

UNIT – I (12)

Introduction to AC Drives: Introduction to motor drives – Torque production – Equivalent circuit analysis – Speed – Torque Characteristics with variable voltage operation Variable frequency operation constant v/t operation – Variable stator current operation –Induction motor characteristics in constant torque and field weakening regions.

Control of Induction motor drives at Stator side Scalar control – Voltage fed inverter control – Open loop volts/Hz control – speed control slip regulation – speed control with torque and flux control – current controlled voltage fed inverter drive – current – fed inverter control – Independent current and frequency control – Speed and flux control in Current –Fed inverter drive – Volts/Hz control of Current –fed inverter drive – Efficiency optimization control by flux program.

UNIT – II (12)

Control of Induction Motor Drive at Rotor Side and Vector Control Slip power recovery drives – Static Kramer Drive – Phasor diagram – Torque expression – speed control of a Kramer Drive – Static Scherbius Drive – modes of operation. Vector control of Induction Motor Drives: Principles of Vector control – Vector control methods – Direct methods of vector control – Indirect methods of vector control – Adaptive control principles – Self tuning regulator Model referencing control.

UNIT – III (12)

Control of Synchronous motor drives: Synchronous motor and its characteristics – Control strategies – Constant torque angle control – Unity power factor control – Constant mutual flux linkage control. **Controllers:** Flux weakening operation – Maximum speed – Direct flux weakening algorithm – Constant Torque mode controller – Flux Weakening controller – indirect flux weakening – Maximum permissible torque – speed control scheme – Implementation strategy speed controller design.

UNIT – IV (12)

Variable Reluctance and Brushless DC Motor drives: Variable Reluctance motor drive – Torque production in the variable reluctance motor Drive characteristics and control principles – Current control variable reluctance motor service drive.
Brushless DC Motor drives: Three phase full wave Brushless dc motor – Sinusoidal type of Brushless dc motor- current controlled Brushless dc motor Servo drive

References Books:

1. R. Krishnan, *"Electric Motor Drives Pearson Modeling, Analysis and control"*– 1st Edn., 2002.
2. B K Bose, *"Modern Power Electronics and AC Drives"* Pearson Publications 1st Edn.,
3. MD Murthy, *"Power Electronics and Control of AC Motors"* FG Turn Bull pergman Press (For Chapters II, III, V) 1st Edn.,
4. BK Bose, *"Power Electronics and AC Drives"* Prentice Hall Eagle Wood Diffs New Jersey (for chapters I, II, IV) - 1st Edn.,
5. M H Rashid, *"Power Electronic circuits Deices and Applications"* PHI, 1995.
6. G.K. Dubey, *"Fundamentals of Electrical Drives"* Narosa Publications, 1995 (for chapter II)
7. BK Bose, *"Power Electronics and Variable frequency drives"* – IEEE Press – Standard Publications, 1st Edn., 2002.

Course Learning Outcomes:

At the end of the course the student will be able to:

- *Implement sine-triangle and Space vector PWM techniques on analog and digital platforms.*
- *Understand and simulate the behavior of high performance induction motor drives using the principles of Vector Control and DTC.*

P14PE202 DIGITAL SIGNAL PROCESSOR

Class: M.Tech. II Semester **Branch:** Power Electronics

Teaching Scheme:

L	T	P	C
4	-	-	4

Examination Scheme:

Continuous Internal Evaluation	:	40 marks
End Semester Exam	:	60 marks

Course Learning Objectives:

- *To write Assembly Language Programs for the Digital Signal Processors*
- *To configure and use digital Input/ Output lines and ADCs*
- *To configure and use Interrupts for real-time control applications*
- *To configure and use Event Managers for PWM generation*

UNIT-I (12)

Introduction to the TMS320LF2407 DSP Controller:

Basic architectural features - Physical Memory - Software Tools

C2xx DSP CPU and Instruction Set:

Introduction & code Generation - Components of the C2xx DSP core - Mapping External Devices to the C2xx core - peripheral interface - system configuration registers - Memory - Memory Addressing Modes - Assembly Programming Using the C2xx DSP Instruction set

UNIT-II (12)

General Purpose Input/Output (GPIO) Functionality:

Pin Multiplexing (MUX) and General Purpose I/O Overview - Multiplexing - General Purpose I/O control registers - Using the General Purpose I/O Ports

UNIT-III (12)

Interrupts on the TMS320LF2407:

Introduction to Interrupts - Interrupt Hierarchy - Interrupt Control Registers - Initializing and Servicing Interrupts in Software

The Analog-to-Digital Converter (ADC):

ADC Overview - Operation of the ADC and programming modes

UNIT-IV (12 Hrs)

The Event Managers (EVA - EVB):

Overview of the Event Manager - Event Manager Interrupts - General Purpose Timers - Compare Units - Capture Units and Quadrature Encoded Pulse (QEP) -General Event Manager Information - PWM signal Generation with Event Manager

Reference Books:

1. Hamid A. Tolyat, *"DSP Based Electro Mechanical Motion Control"*, CRC press, 2004.
Application Notes from the webpage of Texas Instruments

Course Learning Outcomes:

At the end of the course the student will be able to:

- *Understand the Assembly Language Programs for the Digital Signal Processors*
- *Configure and use digital Input/ Output lines and ADCs*
- *Configure and use Interrupts for real-time control applications*
- *Configure and use Event Managers for PWM generation*

P14PE203 ADVANCED POWER ELECTRONICS

Class: M.Tech. II Semester **Branch:** Power Electronics

Teaching Scheme:

L	T	P	C
4	-	-	4

Examination Scheme:

Continuous Internal Evaluation	:	40 marks
End Semester Exam	:	60 marks

Course Learning Objectives:

- *To Model existing and modified power converters under small signal and steady state condition*
- *To Develop power converters with better performance for challenging applications*
- *To Analyze and design power converters and feedback loops*
- *To Analyze power quality problems and suggest solutions*

UNIT-I (12)

Resonant Converters:

Introduction - Basic resonant circuit concepts - Classification - Load resonant converters - Resonant switch converters - Zero voltage switching clamped voltage converters - Resonant DC link inverters High frequency link integral half cycle converters - Phase modulated resonant converters.

UNIT-II (12)

Modeling of DC-DC Converters:

Basic ac modeling approach - State space averaging - Circuit averaging and averaged switch modeling - Canonical circuit modeling - Converter transfer functions for buck - boost and buck-boost topologies.

Current Mode Control:

Introduction - types - advantages and disadvantages - Slope compensation - Determination of duty cycle and transfer functions for buck - boost and buck-boost converters.

UNIT-III (12)

Design of Switching Power Converters:

Controller Design: Introduction - mechanism of loop stabilization - Shaping E/A gains vs frequency characteristics - Conditional stability in feed-back loop - Stabilizing a continuous mode forward and fly-back converter - Feed-back loop stabilization with current mode control - right plane zero.

Design of Power Converters Components: Design of magnetic components-design of transformer - Design of Inductor and current transformer - Selection of filter capacitors - Selection of ratings for devices - input filter design - Thermal design.

UNIT-IV (12)

Power Quality Issues:

Introduction - Study and design of series - shunt and hybrid compensators - Single and three phase power factor correction.

Reference Books:

1. M.H.Rashid, *"Power Electronics-Circuits, Devices & Applications"* PHI.
2. NedMohan, T.M.Undeland, William P.Robbins, *"Power Electronics: Converters, Applications & Design"* John Wiley & Sons.
3. Abraham I. Pressman, *"Switching Power Supply Design"* McGraw Hill International.
4. IEEE Publications on Power Electronics

Course Learning Outcomes:

At the end of the course the student will be able to:

- *Model existing and modified power converters under small signal and steady state condition*
- *Develop power converters with better performance for challenging applications*
- *Analyze and design power converters and feedback loops*
- *Analyze power quality problems and suggest solutions*

P14PE204 ARTIFICIAL INTELIGENCE APPLICATIONS IN ELECTRICAL ENGINEERING

Class: M.Tech. II Semester **Branch:** Power Electronics

Teaching Scheme:

L	T	P	C
4	-	-	4

Examination Scheme:

Continuous Internal Evaluation	:	40 marks
End Semester Exam	:	60 marks

Course Learning Objectives:

- *To understand properties & compositions of neural networks and learning process.*
- *To understand methods of minimization like LMS algorithm, back propagation algorithms, single & multi layer perceptions, self organized maps.*
- *To learn the use of Fuzzy logic and fuzzy system implementation*
- *To learn and understand associate memories.*

UNIT – I (12)

Introduction to Neural Networks Introduction, Humans and Computers, Organization of the Brain, Biological Neuron, Biological and Artificial Neuron Models, Hodgkin-Huxley Neuron Model, Integrate-and-Fire Neuron Model, Spiking Neuron Model, Characteristics of ANN, McCulloch-Pitts Model, Historical Developments, Potential Applications of ANN.

Essentials of Artificial Neural Networks Artificial Neuron Model, Operations of Artificial Neuron, Types of Neuron Activation Function, ANN Architectures, Classification Taxonomy of ANN – Connectivity, Neural Dynamics (Activation and Synaptic), Learning Strategy (Supervised, Unsupervised, Reinforcement), Learning Rules, Types of Application.

Feed Forward Neural Networks: Introduction, Perceptron Models: Discrete, Continuous and Multi-Category, Training Algorithms: Discrete and Continuous Perceptron Networks, Perceptron Convergence theorem, Limitations of the Perceptron Model, Applications.

UNIT – II (12)

Multilayer Feed forward Neural Networks Credit Assignment Problem, Generalized Delta Rule, Derivation of Backpropagation (BP) Training, Summary of Backpropagation Algorithm, Kolmogorov Theorem, Learning Difficulties and Improvements. **Associative Memories:** Paradigms of Associative Memory, Pattern Mathematics, Hebbian Learning, General Concepts of Associative Memory (Associative Matrix, Association Rules, Hamming Distance, The Linear Associator, Matrix Memories, Content Addressable Memory), Bidirectional Associative Memory (BAM) Architecture, BAM Training Algorithms: Storage and Recall Algorithm, BAM Energy Function, Proof of BAM Stability Theorem Architecture of Hopfield Network: Discrete and Continuous versions, Storage and Recall Algorithm, Stability Analysis, Capacity of the Hopfield Network in power and control applications

UNIT – III (12)

Self-Organizing Maps (SOM) and Adaptive Resonance Theory (ART) Introduction, Competitive Learning, Vector Quantization, Self-Organized Learning Networks, Kohonen Networks, Training Algorithms, Linear Vector Quantization, Stability-Plasticity Dilemma, Feed forward competition, Feedback Competition, Instar, Outstar, ART1, ART2, Applications. **Classical & Fuzzy Sets:** Introduction to classical sets - properties, Operations and relations; Fuzzy sets, Membership, Uncertainty, Operations, properties, fuzzy relations, cardinalities, membership functions.

UNIT – IV (12)

Fuzzy Logic System Components and Applications Fuzzification, Membership value assignment, development of rule base and decision making system, Defuzzification to crisp sets, Defuzzification methods. Applications: Neural network applications: Process identification, Function Approximation, control and Process Monitoring, fault diagnosis and load forecasting. Fuzzy logic applications: Fuzzy logic control and Fuzzy classification in power and control applications.

Text Books:

1. Rajasekharan and Pai, *"Neural Networks, Fuzzy logic, Genetic Algorithms: Synthesis and Applications"*, PHI Publication.
2. Jacek M. Zuarda, *"Introduction to Artificial Neural Systems"*, Jaico Publishing House, 1997.

Reference Books:

1. N. Yadaiah and S. Bapi Raju, *"Neural and Fuzzy Systems: Foundation, Architectures and Applications"*, Pearson Education
2. James A Freeman and Davis Skapura, *"Neural Networks"*, Pearson, 2002.
3. Simon Hykins , *"Neural Networks"* Pearson Education
4. C.Eliasmith and CH.Anderson, *"Neural Engineering"* PHI
5. Bork Kosko, *"Neural Networks and Fuzzy Logic System"*, PHI Publications

Course Learning Outcomes:

At the end of the course the student will be able to:

- *Identify the application domain, wherein the conventional controllers can be replaced with ANNs and Fuzzy Systems.*
- *Synthesize ANNs and Fuzzy systems to derive the functionality needed to implement the control strategies, relevant to power converters and drives.*
- *Evaluate and quantify the advantages offered by ANNs and Fuzzy systems over the conventional control strategies.*

P14PE205 A DIGITAL CONTROL SYSTEMS
(Elective-III)

Class: M.Tech. II Semester **Branch:** Power Electronics

Teaching Scheme:

L	T	P	C
4	-	-	4

Examination Scheme:

Continuous Internal Evaluation	:	40 marks
End Semester Exam	:	60 marks

Course Learning Objectives:

- *To learn Z-transform of a function and mapping between S-plane and Z- plane.*
- *To learn the properties and computation of state transition matrix.*
- *To understand the stability analysis of closed loop system in Z-plane.*
- *To know the designing of state feedback controller.*

UNIT – I (12)

SAMPLING AND RECONSTRUCTION Introduction sample and hold operations, Sampling theorem, Reconstruction of original sampled signal to continuous-time signal.

THE Z – TRANSFORMS Introduction, Linear difference equations, pulse response, Z – transforms, Theorems of Z – Transforms, the inverse Z – transforms, Modified Z-Transforms.

Z-PLANE ANALYSIS OF DISCRETE-TIME CONTROL SYSTEM Z-Transform method for solving difference equations; Pulse transforms function, block diagram analysis of sampled – data systems, mapping between s-plane and z-plane: Primary strips and Complementary Strips.

UNIT – II (12)

STATE SPACE ANALYSIS State Space Representation of discrete time systems, Pulse Transfer Function Matrix solving discrete time state space equations, State transition matrix and it's Properties, Methods for Computation of State Transition Matrix, Discretization of continuous time state – space equations

CONTROLLABILITY AND OBSERVABILITY Concepts of Controllability and Observability, Tests for controllability and Observability. Duality between Controllability and Observability, Controllability and Observability conditions for Pulse Transfer Function.

UNIT – III (12)

STABILITY ANALYSIS Stability Analysis of closed loop systems in the Z-Plane. Jury stability test – Stability Analysis by use of the Bilinear Transformation and Routh Stability criterion. Stability analysis using Liapunov theorems.

DESIGN OF DISCRETE TIME CONTROL SYSTEM BY CONVENTIONAL METHODS

Design of digital control based on the frequency response method – Bilinear Transformation and Design procedure in the w-plane, Lead, Lag and Lead-Lag compensators and digital PID controllers. Design digital control through deadbeat response method.

UNIT – IV (12)

STATE FEEDBACK CONTROLLERS AND OBSERVERS Design of state feedback controller through pole placement – Necessary and sufficient conditions, Ackerman's formula.

State Observers – Full order and Reduced order observers.

Linear Quadratic Regulators

Min/Max principle, Linear Quadratic Regulators, Kalman filters, State estimation through Kalman filters, introduction to adaptive controls.

Text Books:

1. K. Ogata, *"Discrete-Time Control Systems"*, Pearson Education/PHI, 2nd Edition
2. M.Gopal, *"Digital Control and State Variable Methods"* TMH

Reference Books:

1. Kuo, *"Digital Control Systems"*, Oxford University Press, 2nd Edn., 2003.
2. M.Gopal, *"Digital Control Engineering"*

Course Learning Outcomes:

At the end of the course the student will be able to:

- *Evaluate the output of a digital system for a given input.*
- *Describe the dynamics of a Linear, Time Invariant and Causal digital systems through difference equations.*
- *Analyze digital systems using the Z-transformation*
- *Design digital controllers for Power Electronics Systems*

P14PE205 B POWER QUALITY
(Elective-III)

Class: M.Tech. II Semester **Branch:** Power Electronics

Teaching Scheme:

L	T	P	C
4	-	-	4

Examination Scheme:

Continuous Internal Evaluation	:	40 marks
End Semester Exam	:	60 marks

Course Learning Objectives:

- *To understand the effect of nonlinear loads and disturbances on sensitive loads.*
- *To know the standards and classification of power quality disturbances*
- *To known the causes and effects of interruptions*
- *To understand the concepts of causes and measurement of voltage sag*
- *To get knowledge on effects and mitigation of voltage sag.*

UNIT – I (12)

Introduction : Introduction of the Power Quality (PQ) problem, Terms used in PQ: Voltage, Sag, Swell, Surges, Harmonics, over voltages, spikes, Voltage fluctuations, Transients, Interruption, overview of power quality phenomenon, Remedies to improve power quality, power quality monitoring.

UNIT – II (12)

Long Interruptions : Interruptions – Definition – Difference between failure, outage, Interruptions – causes of Long Interruptions – Origin of Interruptions – Limits for the Interruption frequency – Limits for the interruption duration – costs of Interruption – Overview of Reliability evaluation to power quality, comparison of observations and reliability evaluation.

Short Interruptions : Short interruptions – definition, origin of short interruptions, basic principle, fuse saving, voltage magnitude events due to re-closing, voltage during the interruption, monitoring of short interruptions, difference between medium and low voltage systems. Multiple events, single phase tripping – voltage and current during fault period, voltage and current at post fault period, stochastic prediction of short interruptions.

UNIT – III (12)

Voltage sag – characterization – Single phase: Voltage sag – definition, causes of voltage sag, voltage sag magnitude, monitoring, theoretical calculation of voltage sag magnitude, voltage sag calculation in non-radial systems, meshed systems, voltage sag duration.

Voltage sag – characterization – Three phase: Three phase faults, phase angle jumps, magnitude and phase angle jumps for three phase unbalanced sags, load influence on voltage sags.

PQ considerations in Industrial Power Systems: Voltage sag – equipment behaviour of Power electronic loads, induction motors, synchronous motors, computers, consumer electronics, adjustable speed AC drives and its operation. Mitigation of AC Drives, adjustable speed DC drives and its operation, mitigation methods of DC drives.

UNIT – IV (12 Hrs)

Mitigation of Interruptions and Voltage Sags: Overview of mitigation methods – from fault to trip, reducing the number of faults, reducing the fault clearing time changing the power system, installing mitigation equipment, improving equipment immunity, different events and mitigation methods. System equipment interface – voltage source converter, series voltage controller, shunt controller, combined shunt and series controller.

Power Quality and EMC Standards: Introduction to standardization, IEC Electromagnetic compatibility standards, European voltage characteristics standards, PQ surveys.

Reference Book:

1. Math H J Bollen. "*Understanding Power Quality Problems*" IEEE Press.

Course Learning Outcomes:

At the end of the course the student will be able to:

- *Implement compensating techniques for a given power quality problem.*
- *Suggest protection techniques under different fault conditions.*
- *Develop control techniques for compensating devices.*

P14PE205 C MICROPROCESSOR & MICROCONTROLLERS
(Elective-III)

Class: M.Tech. II Semester **Branch:** Power Electronics

Teaching Scheme:

L	T	P	C
4	-	-	4

Examination Scheme:

Continuous Internal Evaluation	:	40 marks
End Semester Exam	:	60 marks

Course Learning Objectives:

- *To learn importance of microprocessors and microcontrollers.*
- *To learn and understand architecture and programming of 8086 processor*
- *To learn and understand interfacing techniques like memory and I/O interfacing*
- *To learn the various data transfer techniques like programmed I/O, interrupt I/O and direct memory access.*
- *To learn and understand architecture of advanced processors.*

UNIT – I (12)

8086/8088 processors: Introduction to 8086 Microprocessors, Architecture, Addressing modes, Instruction set, Register Organization, Assembler directives.
Hard ware description: Pin diagram signal description of min & max modes, bus timing, ready & wait states, 8086 based micro computing system. Special features & Related Programming: Stack structure of 8086, Memory segmentation, Interrupts, ISR, NMI, MI and interrupt Programming, Macros.

UNIT – II (12)

Advanced Microprocessors: Intel 80386 programming model, memory paging, Introduction to 80486, Introduction to Pentium Microprocessors and special Pentium pro features. Basic peripherals & Their Interfacing:-Memory Interfacing (DRAM) PPI-Modes of operation of 8255, interfacing to ADC & DAC.

UNIT – III (12)

Special Purpose of Programmable Peripheral Devices and Their interfacing:- Programmable interval timer, 8253, PIC 8259A, display controller Programmable communication Interface 8251, USART and Exercises.

UNIT – IV (12)

Microcontrollers: Introduction to Intel 8-bit &16-bit Microcontrollers, 8051-Architecture, Memory organization, Addressing Modes and exercises. Hardware description of 8051: Instruction formats Instruction sets, interrupt Structure & interrupt priorities, Port structures &Operation linear counter Functions different Modes of Operation and Programming examples.

Text Books:
1. Barry B Brey, *“The Intel Microprocessors, Architecture Programming & Interfacing”*
2. Kenrith J Ayala, *“Advanced Microprocessors”* Thomson publishers
3. Kentrith J Ayala, *“Microcontrollers”* Thomson publishers

Reference Books:
1. Douglas V. Hall, *“Microprocessors & Interfacing Programming & Hardware”*
2. Prof. C.R. Sarma, *“Microprocessors & Microcontrollers”*

Course Learning Outcomes:

At the end of the course the student will be able to:

- *Understand the architecture of a 8086 microprocessor.*
- *Write the program by using 8086-assembly language by understanding the instruction set and addressing modes.*
- *Configure the interrupt structures and to use interrupt sub routines to implement real-time control.*
- *Interface the microprocessor with memory and I/O subsystems.*

P14PE205 D APPLICATIONS OF POWER CONVERTERS
(Elective-III)

Class: M.Tech. II Semester **Branch:** Power Electronics

Teaching Scheme:

L	T	P	C
4	-	-	4

Examination Scheme:

Continuous Internal Evaluation	:	40 marks
End Semester Exam	:	60 marks

Course Learning Objectives:

- *To analyze the Power Electronic Application requirements.*
- *To identify suitable power converter from the available configurations.*
- *To develop improved power converters for any stringent application requirements.*
- *To improvise the existing control techniques to suit the application*

UNIT-I (12)

Overview of the course- Power converter topologies for Induction heating- Welding- Lighting

UNIT-II (12)

High voltage power supplies - power supplies for X-ray applications - power supplies for radar applications - power supplies for space applications - Low voltage high current power supplies

UNIT-III (12)

Power Conditioners – UPS - Active Power Filters - Shunt active power filters - Series active power filters - Hybrid active power filters – UPQC

UNIT-IV (12)

Electric Vehicle – batteries, chargers, inverters, bi-directional DC-DC converters, motors, Automotive Electronics

Reference Books:

1. Ali Emadi, A. Nasiri, and S. B. Bekiarov, *"Uninterruptible Power Supplies and Active Filters"*, CRC Press, 2005.
2. M. Ehsani, Y. Gao, E. G. Sebastien and A. Emadi, *"Modern Electric, Hybrid Electric and Fuel Cell Vehicles"*, 1st Edn., CRC Press, 2004.
3. William Ribbens, *"Understanding Automotive Electronics"*, Newnes, 2003.

Course Learning Outcomes:

At the end of the course the student will be able to:

- *Analyze the Power Electronic Application requirements.*
- *Identify suitable power converter from the available configurations.*
- *Develop improved power converters for any stringent application requirements.*
- *Improvise the existing control techniques to suit the application*

P14PE206 A ELECTRICAL MACHINE DESIGN
(Elective-IV)

Class: M.Tech. II Semester **Branch:** Power Electronics

Teaching Scheme:

L	T	P	C
4	-	-	4

Examination Scheme:

Continuous Internal Evaluation	:	40 marks
End Semester Exam	:	60 marks

Course Learning Objectives:

- *To carryout optimal design of electrical machinery with due considerations for magnetic and electric circuits.*
- *To evaluate and judge the options available for the thermal management of electrical machines.*
- *To convert the generic design procedures into computer aided methodologies*

UNIT-I (12)

Thermal circuit: Enclosures-types, ventilation and cooling methods in electrical machines and transformers

UNIT-II (12)

Magnetic circuit: Basic principles, flux density calculations. Electric circuit: Types AC windings, fractional Pitch.

UNIT-III (12)

DC machines: Output equation and coefficient, design of pole. Transformer: Output coefficient and equation, window dimensions.

UNIT-IV (12)

Induction motor: Output equation, main dimensions calculation.
Alternators: Output coefficient and calculation of main dimensions, short circuit ratio.

Text Books:

1. A.K. Sawhney, *"A Course in Electrical Machine Design"*, New Age International Co., 1990.
2. R.K. Agarwal, *"Principles of Electrical Machine Design"*, 4th Edn., S.K. Kataria & Sons, 2002.

Course Learning Outcomes:

At the end of the course the student will be able to:

- *Carryout optimal design of electrical machinery with due considerations for magnetic and electric circuits.*
- *Evaluate and judge the options available for the thermal management of electrical machines.*
- *Convert the generic design procedures into computer aided methodologies*

P14PE206 B ELECTRIC SMART GRID
(Elective-IV)

Class: M.Tech. II Semester **Branch:** Power Electronics

Teaching Scheme:

L	T	P	C
4	-	-	4

Examination Scheme:

Continuous Internal Evaluation	:	40 marks
End Semester Exam	:	60 marks

Course Learning Objectives:

- *To learn the concept of smart grid- Electricity network.*
- *To know the dc distribution & smart grid.*
- *To know the understand of Energy system concept.*
- *To learn the efficient electric end-use technology alternatives.*

UNIT–I (12)

INTRODUCTION

Introduction to -Local energy networks- Electric transportation- Low carbon central generation-Attributes of the smart grid- Alternate views of a smart grid.

SMART GRID TO EVOLVE A PERFECT POWER SYSTEM: Introduction- Overview of the perfect power system configurations- Device level power system- Building integrated power systems- Distributed power systems- Fully integrated power system-Nodes of innovation.

DC DISTRIBUTION AND SMART GRID

AC vs DC sources-Benefits of and drives of DC power delivery systems-Powering equipment and appliances with DC-Data centers and information technology loads-Future neighborhood Potential future work and research.

INTELLIGRID ARCHITECTURE FOR THE SMARTGRID: Introduction- Launching intelligrid today- Smart grid vision based on the intelligrid architecture-Barriers and enabling technologies.

UNIT–II (12)

ENERGY SYSTEMS CONCEPT

Smart energy efficient end use devices-Smart distributed energy resources-Advanced whole building control systems- Integrated communications architecture-Energy management-Role of technology in demand response- Current limitations to dynamic energy management-Distributed energy resources-Overview of a dynamic energy management-Key characteristics of smart devices- Key characteristics of advanced whole building control systems-Key characteristics of dynamic energy management system.

UNIT–III (12)

ENERGY PORT AS PART OF THE SMART GRID:

Concept of energy -Port, generic features of the energy port.

POLICIES AND PROGRAMS TO ENCOURAGE END – USE ENERGY EFFICIENCY: Policies and programs in action -multinational - national-state-city and corporate levels.

MARKET IMPLEMENTATION: Framework-factors influencing customer acceptance and response - program planning-monitoring and evaluation.

UNIT–IV (12)

EFFICIENT ELECTRIC END – USE TECHNOLOGY ALTERNATIVES

Existing technologies – lighting - Space conditioning - Indoor air quality - Domestic water heating- hyper efficient appliances - Ductless residential heat pumps and air conditioners – Variable refrigerant flow air conditioning-Heat pump water heating - Hyper efficient residential appliances -Data center energy efficiency- LED street and area lighting - Industrial motors and drives -Equipment retrofit and replacement - Process heating - Cogeneration, Thermal energy storage -Industrial energy management programs - Manufacturing process-Electro-technologies, Residential, Commercial and industrial sectors.

Text Books:

1. Clark W Gellings, *"The Smart Grid, Enabling Energy Efficiency and Demand Side Response",* CRC Press, 2009
2. Janaka Ekanayake, Kithsiri Liyanage,Jianzhong.Wu, Akihiko, Yokoyama, Nick Jenkins, *"Smart Grid: Technology and Applications"* Wiley, 2012.
3. James Momoh, *"Smart Grid :Fundamentals of Design and Analysis"*, Wiley IEEE Press, 2012

Course Learning Outcomes:

At the end of the course the student will be able to:

- *Understand the concept of smart grid- Electricity network.*
- *Understand the dc distribution & smart grid.*
- *Understand the Energy system concept.*
- *Understand the efficient electric end-use technology alternatives.*

P14PE206 C DIGITAL SIGNAL PROCESSOR CONTROLLED DRIVES (Elective-IV)

Class: M.Tech. II Semester **Branch:** Power Electronics

Teaching Scheme:

L	T	P	C
4	-	-	4

Examination Scheme:

Continuous Internal Evaluation	:	40 marks
End Semester Exam	:	60 marks

Course Learning Objectives:

- *To Interface the DSP platform with sensors such as hall-effect voltage sensors, hall-effect current sensors, shaft encoder for data acquisition for motor drive applications.*
- *To Scale and normalize the data to suit the requirements of the drive system.*
- *To Exploit the architectural features of the DSP platform to design and implement algorithms for the realization of controllers, Pulse Width Modulators and observers*

UNIT-I (12)

Overview of TMSLF2407 DSP controller: Instruction Set, Interrupts. Clarke's and park's transformations:

UNIT-II (12)

Implementation of Clarke's and Park's transformation.

UNIT-III (12)

SVPWM, BLDC Motor Control System, permanent magnet synchronous machines control system,

UNIT-IV (12)

Vector control of IM, field oriented control, Induction Motor Speed Control using LF2407 DSP.

Text Books:

1. Hamid A. Toliyat, *"DSP Based Electromechanical Motion Control"*, 1st Edn., CRC Press, 2004.
2. Ned Mohan, T.M. Undeland and William P. Robbins, *"Power Electronics: Converters, Applications"*, 3rd Edn., John Wiley & Sons, 2009.

Course Learning Outcomes:

At the end of the course the student will be able to:

- *Interface the DSP platform with sensors such as hall-effect voltage sensors, hall-effect current sensors, shaft encoder for data acquisition for motor drive applications.*
- *Scale and normalize the data to suit the requirements of the drive system.*
- *Exploit the architectural features of the DSP platform to design and implement algorithms for the realization of controllers, Pulse Width Modulators and observers*

P14PE206 D FLEXIBLE A.C. TRANSMISSION SYSTEMS

Class: M.Tech. II Semester **Branch:** Power Electronics

Teaching Scheme:

L	T	P	C
4	-	-	4

Examination Scheme:

Continuous Internal Evaluation	:	40 marks
End Semester Exam	:	60 marks

Course Learning Objectives:

- *To learn the power flow in transmission system concepts.*
- *To learn the operations of application voltage source converters*
- *To learn the Objectives of shunt & Series compensation*
- *To learn the behavior of various FACTS devices*

UNIT – I (12)

FACTS Concepts: Transmission interconnections power flow in an AC system, loading capability limits, Dynamic stability considerations, importance of controllable parameters basic types of FACTS controllers, benefits from FACTS controllers.

UNIT – II (12)

Voltage Source Converters: Single phase three phase full wave bridge converters transformer connections for 12 pulse 24 and 48 pulse operation. Three level voltage source converter, pulse width modulation converter, basic concept of current source Converters, comparison of current source converters with voltage source converters.

UNIT – III (12)

Static Shunt Compensation: Objectives of shunt compensation, mid point voltage regulation, voltage instability prevention, improvement of transient stability, Power oscillation damping, Methods of controllable var generation, variable impedance type static var generators switching converter type var generators hybrid var generators.

SVC and STATCOM: Regulation and slope transfer function and dynamic performance, transient stability enhancement and power oscillation damping operating point control and summary of compensator control.

UNIT – IV (12)

Static Series Compensators: Concept of series capacitive compensation, improvement of transient stability, power oscillation damping Functional requirements. GTO thyristor controlled series capacitor (GSC), thyristor switched series capacitor (TSSC), and thyristor controlled series capacitor (TCSC) control schemes for GSC TSSC and TCSC.

Text Book:

1. N.G. Hingorani and L. Gyugi, *"Understanding FACTS Devices"*, IEEE Press Publications 2000.

Course Learning Outcomes:

At the end of the course the student will be able to:

- *Understand the role of impedance control, phase angle control and voltage control in controlling real and reactive power in transmission systems.*
- *Identify configuration of FACTS controller required for a given application.*

P14PE207 ELECTRIC DRIVES LABORATORY

Class: M.Tech. II Semester **Branch:** Power Electronics

Teaching Scheme:

L	T	P	C
-	-	3	2

Examination Scheme:

Continuous Internal Evaluation	:	40 marks
End Semester Exam	:	60 marks

Course Learning Objectives:

- *To learn the advantages of closed loop control of electrical machines.*
- *To learn the control techniques for two and four quadrant operations of DC drives.*
- *3 To learn the speed control methods of induction motor.*
- *To learn the application of power electronic converters voltage control.*

List of Experiments:

1. Speed Measurement and closed loop control using PMDC motor
2. Thyristorised drive for PMDC Motor with speed measurement and closed loop control.
3. IGBT used single 4 quadrant chopper drive for PMDC motor with speed measurement and closed loop control.
4. Thyristorised drive for 1Hp DC motor with closed loop control.
5. 3 Phase input, thyristorised drive, 3 Hp DC motor with closed loop
6. 3 Phase input IGBT, 4 quadrant chopper drive for DC motor with closed loop control equipment.
7. Cycloconverter based AC Induction motor control equipment.
8. Speed control of 3 phase wound rotor Induction motor.
9. Single phase fully controlled converter with inductive load
10. Single phase half wave controlled converter with inductive load.

Course Learning Outcomes:

At the end of the course the student will be able to:

- To understand the advantages of closed loop control of electrical machines.
- To understand the control techniques for two and four quadrant operations of DC drives.
- To understand the speed control methods of induction motor.
- To understand the application of power electronic converters voltage control.

P14PE208 DIGITAL SIGNAL PROCESSORS LABORATORY

Class: M.Tech. II Semester **Branch:** Power Electronics

Teaching Scheme:

L	T	P	C
-	-	3	2

Examination Scheme:

Continuous Internal Evaluation	:	40 marks
End Semester Exam	:	60 marks

Course Learning Objectives:

- *To learn understand the architecture and addressing modes of the DSP TMS320LF2407A*
- *To learn use the instruction set of the DSP TMS320LF2407A for writing programs*
- *To learn use the event manager of DSP TMS320LF2407A for PWM generation*
- *To learn configure the interrupts and use the digital I/Os-ADC and DAC*

List of Experiments:

1) General programming examples such as:
   a) Arithmetic and logical operations
   b) Direct & Indirect Data Transfer
   c) Generation of Ramp-up and Ramp-down wave
   d) Sorting of Data in Ascending order and descending order
   e) Square root of positive integer
   f) Maximum and minimum of given set of numbers
2) Study of aliasing phenomenon.
3) Study of the On-Chip Analog to Digital conversion of TMS320LF2407 processor.
4) Study of the GPIO registers
5) Producing a saw tooth wave from the DAC
6) PWM signal generation using event manager
7) Space Vector Modulation of a 3-Phase VSI
8) Implementation of the difference equation
9) Study of the interrupts of TMS320LF2407 processor
10) Dead time generation to avoid shoot-through fault

Course Learning Outcomes:

At the end of the course the student will be able to:

- *To understand the architecture and addressing modes of the DSP TMS320LF2407A*
- *To use the instruction set of the DSP TMS320LF2407A for writing programs*
- *To use the event manager of DSP TMS320LF2407A for PWM generation*
- *To configure the interrupts and use the digital I/Os-ADC and DAC*

P14PE209 COMPREHENSIVE VIVA

Class: M.Tech. II Semester **Branch:** Power Electronics

Teaching Scheme:

L	T	P	C
-	-	-	2

Examination Scheme:

End Semester Exam	**:**	100 marks

Course Learning Objectives:

- *To learn comprehend and correlate the understanding of various courses in design and operation of modern power electronic & drive systems.*

The Viva includes question from all the subjects of first and second semesters with more emphasis on Power Electronics Concepts.

Course Learning Outcomes:

At the end of the course the student will be able to:

- *Comprehend and correlate the understanding of various courses in design and operation of modern power electronic & drive systems.*

P14PE301 INDUSTRIAL TRAINING

Class: M.Tech. III Semester **Branch:** Power Electronics

Teaching Scheme:

L	T	P	C
-	-	-	4

Examination Scheme:

End Semester Exam	**:**	100 marks

Course Learning Objectives:

- *To learn advanced topics in power electronics & drives.*
- *To Improve language and communication skills*
- *To Enrich employability & entrepreneurial skills by providing necessary inputs in line*
- *with global vision through Industry-Institute Interaction.*

The candidate should submit the report and present talk on the training undergone highlighting the contents of the Report before the Departmental Post-Graduate Review Committee (DPGRC).

Course Learning Outcomes:

At the end of the course the student will be able to:

- *Understand advanced topics in power electronics & drives.*
- *Improve language and communication skills*
- *Enrich employability & entrepreneurial skills by providing necessary inputs in line*
- *with global vision through Industry-Institute Interaction.*

P14PE302 DISSERTATION

Class: M.Tech. III Semester **Branch:** Power Electronics

Teaching Scheme:

L	T	P	C
-	-	-	8

Examination Scheme:

Continuous Internal Evaluation	:	40 marks
End Semester Exam	:	60 marks

Course Learning Objectives:

- *To learn Recognize and formulate a problem to analyze, synthesize, evaluate, simulate and create a power electronic converter and / or a drive system.*
- *To learn carryout modeling and simulation studies pertaining to the system and prepare a presentation.*

The candidate will chose the topic of the Project Work in consultation with the Guide allotted. A report in the prescribed format is to be submitted that includes extensive survey of literature on the topic, highlighting the scope of the work. It should also state the methodology to be adopted and work involved in different modules of the Project Work. The report should clearly specify the expected outcome.

The candidate should submit the report and present talk on the work done, highlighting the contents of the Report before the Departmental Post-Graduate Review Committee (DPGRC).

Course Learning Outcomes:

At the end of the course the student will be able to:

- *Recognize and formulate a problem to analyze, synthesize, evaluate, simulate and create a power electronic converter and / or a drive system.*
- *Carryout modeling and simulation studies pertaining to the system and prepare a presentation.*

P14PE401 DISSERTATION & VIVA-VOCE

Class: M.Tech. IV Semester **Branch:** Power Electronics

Teaching Scheme:

L	T	P	C
12	-	-	12

Examination Scheme:

Continuous Internal Evaluation	:	40 marks
End Semester Exam	:	60 marks

Course Learning Objectives:

- *To learn build the hardware to demonstrate the principle of working.*
- *To learn correlate the analytical, simulation and experimental results.*
- *To learn deduce conclusions and draw inferences worthy of publication.*

The candidate should submit the report and present talk on the work done, highlighting the conclusions drawn and outcome of the work before the Departmental Post-Graduate Review Committee (DPGRC).

Course Learning Outcomes:

At the end of the course the student will be able to:

- *Build the hardware to demonstrate the principle of working.*
- *Correlate the analytical, simulation and experimental results.*
- *Deduce conclusions and draw inferences worthy of publication.*