M.Tech. Degree

PROGRAMME

in

Power Electronics & Drives

CURRICULUM

(w. e. f. Session 2019-2020)

DEPARTMENT OF ELECTRICALENGINEERING
NATIONAL INSTITUTE OF TECHNOLOGY
KURUKSHETRA - 136119

VISION AND MISSION OF THE INSTITUTE

VISION

To be a role-model in technical education and research, responsive to global challenges.

MISSION

To impart technical education that develops innovative professionals and entrepreneurs and to undertake research that generates cutting-edge technologies and futuristic knowledge, focusing on the socio-economic needs.

VISION AND MISSION OF THE PROGRAM

Vision: To strive incessantly for excellence towards education and research in electrical technologies by nurturing and contributing to state of art perspectives useful to industry and society.

Mission: The department aims to realize the vision through the following:

- To prepare the students for fundamentals in Electrical, Electronics and computational technology.
- To prepare the foundation for undertaking the research for systems involving emerging field of electrical engineering.
- To prepare the professional skill for undertaking consultancy assignments for solving electrical engineering problems
- To prepare dynamic entrepreneurial resources, useful for the society.

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)

PEO1: Students should be competent enough to tackle problems related to their profession, be it in industry or in an academic institution in India or abroad

PEO2: Students are expected to solve Power Electronics and Drives problems and also to pursue research in the appropriate technological context

PEO3: Students should exhibit ethics, professionalism, multidisciplinary approach, entrepreneurial thinking and do effective communication in their profession

PEO4: Students should be able to work individually as well as in team and engage in life-long self-learning for a successful professional career

PROGRAM OUTCOMES (POs)

Graduates of the Programme:

PO1: An ability to independently carry out research/ investigation and development work to solve practical problems

PO2: An ability to write and present a substantial technical report/ document

PO3: Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program.

PO4: To apply the knowledge of engineering fundamentals in the area of power electronics for the upliftment of society.

PO5: To adopt the ever-changing technologies and new developments in the field of power electronics & Drives ethically.

M.Tech Program
Power Electronics and Drives
Scheme of Studies

Semester I

Course No.	Course Title	Lecture	Tutorial	Practical	Credits
MEE3C01	Modeling of electrical machines	3	-	-	3
MEE3C03	Power Conversion Techniques	3	-	-	3
MEE3C05	Electric Drives	3	-	-	3
	Elective 1	3	-	-	3
	Elective 2	3	-	-	3
MEE3L01	Power Electronics Lab	-	-	3	2
MEE3L03	Machines and Drives Lab	-	-	3	2
Total		**15**	**-**	**6**	**19**
Total contact Hours		**21**			

Semester II

Course No.	Course Name	Lecture	Tutorial	Practical	Credits
MEE3C02	Power Quality	3	-	-	3
MEE3C04	PLC and Microcontroller	3	-	-	3
MEE3C06/ MEE3O72	*Electric Vehicles	3	-	-	3
	Elective 3	3	-	-	3
	Elective 4	3	-	-	3
	Elective 5 (Open/Departmental)	3	-	-	3
MEE3L02	PLC and Microcontroller Lab	-	-	3	1
MEE3S02	Seminar			1	1
	Total	**18**	**-**	**4**	**20**
	Total contact hours	**22**			

*** Open elective**

Summer Term Academic activity

Course No.	Course name	L	T	P	Credits
MEE3I02	Case study related to Power Electronics and Drives for societal issues	-	-	-	1

Semester III

Course No.	Course Name	Lecture	Tutorial	Practical	Credits
MEE3D01	Dissertation Part-I	-	-	28	14

Semester IV

Course No.	Course Name	Lecture	Tutorial	Practical	Credits
MEE3D02	Dissertation Part-II	-	-	28	14

Annexure

List of Electives offered by department in Even and Odd semester

Odd semester	**Offered by**	**Even semester**	**Offered by**
Advanced theory of Electrical machines (MEE3E31)	PED	Intelligent control of electric drives (MEE3E32)	PED
*Switched mode power conversion (MEE3E33/MEE3O71)	PED	High power converters (MEE3E34)	PED
*Energy Efficient motors (MEE3E35/MEE3O73)	PED	*Wind energy conversion systems (MEE3E36/MEE3O74)	PED
Design and analysis of power converters (MEE3E37)	PED	Advanced electric drives (MEE3E38)	PED
Control system design (MEE1E33)	CS	*Power converters for renewable energy systems (MEE3E40/MEE3O76)	PED
Intelligent control (MEE1E31)	CS	HVDC Transmission (MEE2E44)	PS
Digital signal processing (MEE1E41)	CS	Flexible AC Transmission system (MEE2E32)	PS
Optimization theory (MEE1E43)	CS	Smart Grid Technology (MEE2C06)	PS
Solar energy in power systems (MEE2E41)	PS	Distributed generation and micro-grids (MEE2E36)	PS
Machine learning (MEE1E47)	CS	Variable structure and Sliding mode control (MEE1E32)	CS

*** Open elective**

Course Code	:	**MEE3C01**
Course Title	:	**Modelling of Electrical Machines**
Number of Credits	:	**3**
Course Type	:	**Core**

L T P Total — Duration of Exam- Three hours

3 0 0 3 — During Semester Evaluation Weight age-50%

End Semester Examination Weight age -50%

Course Learning Objectives:

- To be able to solve linear and nonlinear circuit problems of transformers and dc machines
- To be able to understand and design closed loop speed-controller for chopper-fed dc motor
- To be able to understand and design closed loop speed-controller for rectifier-fed dc motor
- To be able to develop voltage and torque equations for 3-Φ induction and synchronous machines

Course Contents:

Linear equivalent circuit of transformer, corrections for the nonlinearity in the magnetically coupled circuits including the use of computer simulation for complex problems; Electromechanical energy conversion equations; Solution of dc motor dynamic characteristics by Laplace transformation; Time-domain block diagrams and state equations for shunt-connected dc machines and permanent-magnet dc machines.

Closed loop operation of chopper-controlled dc motor drive: speed-control with inner current loop, modelling of PWM-current controller and hysteresis-current controller; Design of current controller, design of speed controller by the symmetric-optimum method; Dynamic simulation of the speed-controlled dc motor drive: Equations for motor, filter in the speed-feedback loop, speed controller, current-reference generator, current controller; flowchart for simulation.

Phase-controlled dc motor drives: Control modelling of the three-phase converter; Transfer functions of the dc motor, load, converter, current controller, speed controller, current feedback and speed feedback subsystems; Design of current controller, speed controller, solved example; Dynamic simulation of the one-quadrant phase-controlled dc motor drive: Equations for motor, filter in the speed-feedback loop, speed controller, current-reference generator, linearizing controller and bridge converter; Flowchart for simulation.

Symmetrical induction machines: Voltage and torque equation in machine variables, voltage equations and equivalent circuits in arbitrary reference-frame variables, torque equation inarbitrary reference-frame variables. Synchronous machines: Voltage and torque equation in machine variables, voltage equations and equivalent circuits in arbitrary reference-frame variables, torque equations in substitute variables.

REFERENCES:

1. R. Krishnan, Electric Motor Drives: Modeling, Analysis and Control, Prentice Hall Inc., 2001.
2. Paul C. Krause, Oleg Wasynczuk and Scott D. Sudhoff, Analysis of Electric Machinery and Drive Systems, Second Edition, Wiley India, 2004.
3. Rik De Doncker, Duco W. J. Pulle and Andre Veltman, Advanved Electric Drives: Analysis, Modeling and Control, Springer Science+Business Media B.V.2011.
4. Seung-Ki Sul, Control of Electric Machine Drive Systems, John Wiley & Sons, Inc., 2011.
5. Ion Boldea and Syed A. Nasar, Electric Drives, Third Edition, CRC Press, 2016.
6. Viktor M.Perelmuter, Electrotechnical Systems: Simulation with Simulink and SimPowerSystems, CRC Press, 2013.

Course Outcomes

At the end of the course student will be able to

CO1. Apply engineering knowledge in designing, analyzing and modeling of electrical machines for various industrial and domestic applications

CO2. Understanding of the impact of closed loop control of drives in an economic and social context.

CO3. To conduct investigation of complex problems of modeling of induction machine by using modern tools

CO4. To apply ethical principles in advance Understanding of synchronous machine modeling

Course Code	:	**MEE3C03**
Course Title	:	**Power Conversion Techniques**
Number of Credits	:	**3**
Course Type	:	**Core**

L T P Total — Duration of Exam- Three hours

3 0 0 3 — During Semester Evaluation Weight age-50%

End Semester Examination Weight age -50%

Course Learning Objectives:

- To be able to solve AC controller problems using various type of control
- To be able to understand and design cycloconverter circuits
- To be able to understand and design firing circuit for inverters
- To be able to develop rms voltage,THD and input power factor equations of AC controller.

- **Course Contents**

A.C to A.C. Converter – A.C. Controller: Single-phase and three-phase a.c. controllers. Topologies, triggering techniques for power factor and harmonic controls, Derivation of expression of output voltage, input power factor, THD using various control techniques like phase angle control, symmetrical angle control.

A.C to A.C. Converter – Cycloconverter: Concept of three-phase to single phase, single phase to single phase and single phase to three phase cyclo-converter. Constant firing angle and cosine wave crossing firing control technique. Harmonic analysis of the output voltage.Effect of source inductance.

D.C to A.C. Converter – Inverter: Series and parallel inverter, Single-phase and three-phase inverters, configuration of VSI & CSI. Concept of PWM techniques.Single Pulse, multiple pulse periodic and sinusoidal PWM technique.Multilevel inverter.Harmonic analysis of the output voltage of each type of inverter.Reduction of harmonics.

REFERENCES:

1. N. Mohan, T.M Undeland& W.P Robbin, Power Electronics, Converter Applications and design, John Wiley & Sons, 1989.

2. M.H. Rashid, Power Electronics, Prentice Hall, 1994.

3. B.K. Bose, Power Electronics and AC Drives, 1986.

4. R. Bausiere and G. Seguier, Power Electronics Converters, Springer-Verlag, 1987.

5. D.M Mitchell, DC-DC Switching Regulator Analysis, McGraw Hill, 1987

6. P. S. Bimbhra, Power Electronics, Khanna Publishers, 2012

Course Outcomes

At the end of the course student will be able to

CO1. Apply engineering knowledge in designing, analyzing and using power converters for various industrial and domestic applications

CO2. Understanding the impact of power conversion techniques in an economic and social context.

CO3. To conduct investigation of complex problems of analysis of Harmonic in the output Voltage for each type of the Inverter

CO4. To apply ethical principles in advance understanding of multilevel inverters

Course Code	:	MEE3C05
Course Title	:	**Electric Drives**
Number of Credits	:	**3**
Course Type	:	**Core**
Prerequisites		Power Electronics, basics of converter topology

L T P Total — Duration of Exam- Three hours

3 0 0 3 — During Semester Evaluation Weight age-50%

End Semester Examination Weight age -50%

Course Learning Objectives

- To learn about various electric drive systems
- To apply the control techniques to various drive systems

Course Contents

Components of Electric Drive System- electrical machines, power converters and control system. Different types of loads encountered in modern drive applications. Dynamics of drive systems, starting, braking, speed-control, steady state and dynamic operation of motors and load variations

DC Motor Drive Using Phase Controlled Rectifier – DC motor drive using half controlled and fully controlled single phase and three phase rectifiers, continuous and discontinuous conduction modes of operation, 4-quadrant operation using dual converter.

Closed Loop Control of DC Motor - Operating limits of a separately excited DC motor drive, dynamic model of DC motor, dynamic model of chopper and phase controlled rectifier, design of single loop speed controller, cascaded controller design for DC motor using inner current control loop and outer speed control loop, field weakening operation.

Voltage Source Inverter and its PWM strategies – Basic principles of voltage source inverter, 120 and 180 degree modes of operation, need for pulse width modulation, sine-triangle PWM, space-phasor based PWM, current controlled PWM.

Induction Motor Drive – Steady state equivalent circuit and phasor diagram with variable frequency supply, v/f control and constant air gap flux control of induction motor drive, field-weakening operation of induction motor drive. Introduction to vector control and direct torque control.

Synchronous Motor Drive – Synchronous motor drive with Variable Voltage Variable Frequency supply, synchronous motor drive using a voltage source inverter, synchronous motor drive using load commutated thyristor inverter, control of synchronous machine using cycloconverter.

Reference Books

1. Werner Leonhard, Control of Electrical Drives, 3rd edition, Springer 2001
2. R. Krishnan, Electric Motor Drives: Modeling, Analysis, and Control, Prentice Hall, edition 1, 2001.
3. Bimal K Bose, Modern Power Electronics and AC Drives, Prentice Hall, edition 1, 2001.

Course Outcomes

At the end of the course student will be able to

CO1. Apply engineering knowledge in designing, analyzing of Electric Drive systems
CO2. To apply ethical principles in choosing proper electric drive system to a particular application
CO3. To conduct investigation of complex problems of analysis of control techniques to the electric drive systems
CO4. Understanding of the impact of electric drives in an economic and social context.

Course Code	:	**MEE3E31**
Course Title	:	**Advanced Theory of Electrical Machines**
Number of Credits	:	**3**
Course Type	:	**Elective ODD**

L T P Total Duration of Exam- Three hours
3 0 0 3 During Semester Evaluation Weight age-50%
End Semester Examination Weight age -50%

Course Learning Objectives

- To learn about various aspects of induction machines
- To apply the modeling to induction and special machines

Course Contents

Induction Machines: Analysis with nonrated voltage, nonrated frequency & unbalanced supply, De-rating/Rerating, modelling of magnetization characteristics, capacitor self-excitation of induction machines, Applications and analysis of self-excited induction machine.

Special Machines: Energy efficient motors, Servomotors, Stepper motors, BLDC motors.

Special Topics in Induction Machines: Development and application of Power Invariant transformations, Air gap field space harmonics (parasitic torques, radial forces and noise), and slip power recovery.

Special Transformers: Concept and advantages of multi circuit transformer, its analysis, Parallel operation of dissimilar transformers, Analysis of inrush magnetizing current, Switching transients in power transformers.

REFERENCES:

1. L.F Blume, ‘Transformer Engineering’, John Wiley & Sons, Inc, New York, 1967
2. Fitzgerald & Kingsley, ‘Electric Machinery’ McGraw Hill Co. New Delhi, 2004.
3. A .Langsdorf, ‘Theory of Alternating Current Machinery’, McGraw Hill Co. New Delhi, 2004.
4. I. Boldea&S.A.Nasar, ‘Induction Machine Handbook’, CRC Press, New York, 2002.
5. C.M.Ong, ‘Dynamic Simulation of Electric Machinery using Matlab/Simulink’,Prentice Hall PTR, New Jercy, 1998.

Course Outcomes:

1. CO1: To apply engineering knowledge in understanding the working of industrial machines.
2. CO2: To conduct investigation of complex problem of analyzing the non-rated and unbalanced operation of induction machine.
3. CO3: To understand the self-excitation phenomenon in induction machine and its applications.
4. CO4: To analyze the operation of induction machine with slip power recovery schemes in an economic and social context
5. CO5: To understand switching transients in power transformers.

Course Code	:	**MEE3E33/MEE3O71**
Course Title	:	**Switched Mode Power Conversion**
Number of Credits	:	**3**
Course Type	:	**Elective ODD/ Open Elective**
Pre-requisite		**A course on Power/ Industrial Electronics**

L T P Total
3 0 0 3

Duration of Exam- Three hours
During Semester Evaluation Weight age-50%
End Semester Examination Weight age -50%

Course Learning Objectives:

- To learn steady-state analysis of SMPC
- To learn soft witching techniques in power conversion

Course contents:

Design constraints of reactive elements in Power Electronic Systems: Design of inductor, transformer and capacitors for power electronic applications, Input filter design.

Basic concepts and steady-state analysis of second and higher order Switched Mode power converters: PWM DC -DC Converters (CCM and DCM) - operating principles, constituent elements, characteristics, comparisons and selection criteria.

Dynamic Modelling and control of second and higher order switched Mode power converters: analysis of converter transfer functions, Design of feedback compensators, current programmed, frequency programmed and critical conduction mode control.

Soft-switching DC - DC Converters: zero-voltage-switching converters, zero-current- switching converters, Multi resonant converters and Load resonant converters.

Pulse Width Modulated Rectifiers: Properties of ideal rectifier, realization of near ideal rectifier, control of the current waveform, single phase and three-phase converter systems incorporating ideal rectifiers and design examples. Nonlinear phenomena in switched mode power converters: Bifurcation and Chaos.

Reference Books:

1. Robert W. Erickson and DraganMaksimovic, ‘Fundamentals of Power Electronics’, Springer, 2nd Edition, 2001.
2. Marian K. Kazimierczuk, ‘Pulse-width Modulated DC-DC Power Converters’ John Wiley & Sons Ltd., 1st Edition, 2008.

3. Philip T Krein, 'Elements of Power Electronics', Oxford University Press, 2nd Edition, 2012.
4. Batarseh, 'Power Electronic Circuits', John Wiley, 2nd Edition, 2004.
5. H. W. Whittington, B. W. Flynn, D. E. Macpherson, 'Switched Mode Power Supplies', John Wiley & Sons Inc., 2nd Edition, 1997.

Course Outcomes:

CO1. Apply engineering knowledge in Steady-State Analysis of switched-mode dc-dc power converters.

CO2. To apply ethical principles in design of Switched-Mode Converters, including selection of component values based on steady-state dc and ac ripple specifications in an economic and social context.

CO3. Dynamic Modelling Development and Analysis for switched-mode dc-dc converters using averaging techniques, including the derivation and visualization of converter small-signal transfer functions.

CO4. To conduct investigation of complex problems of analysis and Design of Control Loops around switched-mode power converters using averaging small-signal dynamic models and classical control theory.

CO5. Become proficient with computer skills for the analysis and design of switched-mode power converters.

Course Code	:	**MEE3E35/MEE3O73**
Course Title	:	**Energy Efficient Motors**
Number of Credits	:	**3**
Course Type	:	**Elective ODD**
Pre-requisite		**Course on electric motors**

L T P Total   Duration of Exam- Three hours
3 0 0 3   During Semester Evaluation Weight age-50%
End Semester Examination Weight age -50%

Course Learning Objectives

- To learn about efficient energy operation of motors
- To apply the control techniques to improve the efficiency of AC and DC motor drives

Course Contents:

Energy efficiency operation, Need for energy efficient motors.Selection and application of energy efficient motors. Technology for the development of energy efficient motors, Fundamentals of electric motor drives, Operation of motors under non sinusoidal supply system. Effect of operating power factor on efficiency.

Energy efficient induction motor under different input parameters and applications, Adjustable-speed drives their advantages and benefits from efficiency point of view,

Efficient operation of AC and DC motor drives

REFERENCES:

- Energy-Efficient Electric Motors and their Applications, **Jordan**, H.E
- **Energy Efficiency Improvements in Electric Motors and Drives, Editors:** Almeida**, Anibal de,** Bertoldi**, Paolo,** Leonhard

Course Outcomes

At the end of the course student will be able to

CO1. To apply ethical principles to select and find Application of Energy Efficient Motors

CO2. Visualize the larger picture and correlate the domain knowledge with the global industrial problems in an economic and social context

CO3. Use their Engineering Knowledge to conclude effect of Operating Power Factor on the Efficiency

CO4. To conduct investigation of complex problems of calculating Efficiency of AC and DC motor Drives

Course Code	:	MEE3E37
Course Title	:	**Design & Analysis of Power Converter Circuits**
Number of Credits	:	**3**
Course Type	:	**Elective ODD**
Prerequisites		B Tech / BE in Electrical Engineering

L T P Total Duration of Exam- Three hours
3 0 0 3 During Semester Evaluation Weight age-50%
End Semester Examination Weight age -50%

Course Learning Objectives:

- To perform Ac modelling of dc-dc converters
- To understand and apply different types of controllers
- To be able to design the input and output filters for converters
- To understand and analyse the discontinuous conduction mode with small-signal ac modelling and high-frequency dynamics of converters
- to understand the voltage-mode and current-mode controls of dc-dc converters
- To be able to perform simulation in software

Course Contents:

Ac modelling approach: Averaging the inductor currents and capacitor voltages, perturbation and linearization, construction of the small-signal equivalent circuit model; State-space averaging; Circuit averaging and averaged switch modelling; Canonical circuit model; Modelling the pulse-width modulator.

Controller design: PD, PI and PID controllers, design examples; Measurement of loop gains: Voltage injection, current injection, measurement of unstable systems; Input filter design: Effect of input filter on converter transfer functions, buck converter example, design of a damped input filter, cascading filter sections.

Ac and dc equivalent circuit modelling of the discontinuous conduction mode (DCM): Dc motor averaged switch model, small-signal ac modelling of the DCM switch network, high-frequency dynamics of converters in DCM. Voltage-mode and current-mode controls of dc-dc converters, large-signal issues in voltage-mode and current-mode control.

Simulation of power electronic circuits: Models of power devices, control blocks, simulation of Z-source converters, simulation of resonant inverters, simulation of matrix converters, Application of simulation program SEQUEL to a resistive network, an RC circuit, a circuit with two RC sections, and a buck converter.

REFERENCES:

7. Robert W. Erickson and DraganMaksimovic, Fundamentals of Power Electronics, Second Edition, Springer Science+Business Media B.V. 2001.
8. Ned Mohan, Tore M. Undeland and William P. Robbins, Power Electronics: Converters, Applications and Design, Third Edition, John Wiley & Sons, Inc., 2003.
9. Simon S. Ang, Power-Switching Converters, Marcel Dekker, Inc., 1995.
10. Philip T. Krein, Elements of Power Electronics, Oxford University Press, Inc., 1998.
11. Viktor M. Perelmuter, Electrotechnical Systems: Simulation with Simulink and SimpowerSystems, CRC Press, 2013.
12. M.B. Patil, V. Ramanarayanan and V. T. Ranganathan, Simulation of Power Electronics Circuits, Narosa Publishing House Pvt. Ltd., 2009.
13. KjeldThorborg, Power Electronics- in Theory and Practice, Overseas Press India Pvt. Ltd., 1993

Course Outcomes

At the end of the course student will be able to

CO1. To conduct investigation of complex problems of Analysing State-space averaging; Circuit averaging and averaged switch; Canonical circuit model; pulse-width modulator.

CO2. To apply engineering knowledge in design of various controllers such as PD, PI and PID controllers

CO3. To apply ethical principles in design of input filters, Damped Input filters etc.

CO4. Do modelling of the DCM switch network and learning about High frequency Dynamics converters in DCM in an economic and social context

Course Code	:	**MEE3C02**
Course Title	:	**Power Quality**
Number of Credits	:	**3**
Course Type	:	**Core**

L T P Total
3 0 0 3

Duration of Exam- Three hours
During Semester Evaluation Weight age-50%
End Semester Examination Weight age -50%

Course Learning Objectives:

- To understand poor power quality issues and its mitigation techniques

CONTENTS:

Power Quality: An Introduction

Definition of Power Quality (PQ), Classification of PQ Problems, Causes and Effect of PQ Problems, PQ standards, PQ Monitoring

Passive Shunt and Series Compensation

Passive shunt and series compensation for 1P-1W, 3P-3W and 3P-4W distribution System, Passive shunt and series compensation for power factor correction, Zero voltage regulation and load balancing

Passive Power Filters

Classification of Passive Power Filters, Principle, analysis and design of Passive Power Filters

Active Power Filter

Principle, analysis and design of shunt, series and Hybrid Active Power Filters

Custom Power Devices

Distribution Static Compensator(D-STATCOM), Dynamic Voltage Restorer (DVR) and Unified Power Quality Conditioner (UPQC)

Recommended Books:

1. Bhim Singh A. Chandra and K Al-Haddad – Power Quality, john Wiley and Sons Ltd, 2015

2. C Sankaran -Power Quality (Electric Power Engineering Series) CRC Press, Dec 2001

3. Math H. J. Bollen-Understanding Power Quality Problems: Voltage Sags and Interruption, IEEE Press 2000

4. Roger C Dugan- Electrical Power Systems Quality- McGraw Hill 2012

COURSE OUTCOMES:

CO1. Students are able to apply their Engineering Knowledge to analyze Power Quality issues

CO2. To conduct investigation of complex problems ofidentifying and formulate power quality problems

CO3. To apply ethical principles in designing active and passive filters and their analysis

CO4. Students are able to understand the consequences of power quality problems and their mitigation using custom power devices such as distribution static compensator (DSTATCOM), dynamic voltage restorer in an economic and social context

Course Code	:	**MEE3C04**
Course Title	:	**PLC & Microcontrollers**
Number of Credits	:	**3**
Course Type	:	**Core**

L T P Total Duration of Exam- Three hours

3 0 0 3 During Semester Evaluation Weight age-50%

End Semester Examination Weight age -50%

Course Learning Objectives:

- To learn PLC and PIC programming and their interfacing

CONTENTS:

PLC: Logic design, Principle of Operation, Controller, Interfacing circuits, Ladder programming examples.

PIC Microcontroller : Review of Microcontrollers, Architecture of PIC microcontroller, instruction set, timer, interrupts, I/O port, interfacing A/D converter, Programming examples, Generation of PWM waves

REFERENCES:

1. Programmable Logic controllers : Operation, interfacing and programming by Job Den Otter, PHI

2. Design with PIC Microcontrollers by John B.Peatman, Pearson

COURSE OUTCOMES:

CO1. Advanced Understanding of Logic Design using PLC

CO2. Apply Appropriate Techniques in the Field Of Automation

CO3. Able to do work for safety issues

CO4, This Course Will Train the Student for PIC Microcontroller Programing

Course Code	:	**MEE3C06/ MEE3O72**
Course Title	:	**Electric Vehicles**
Number of Credits	:	**3**
Course Type	:	**Core/ Open Elective**

L T P Total
3 0 0 3

Duration of Exam- Three hours
During Semester Evaluation Weight age-50%
End Semester Examination Weight age -50%

<u>Course Learning Objectives</u>:

1. Recognize EV/HEV technical and economic objectives.
2. Explain the mechanism of battery and motors in terms of functionality, control, and integration.
3. Identify efficient EV/HEV architectures.
4. Describe a basic co-ordinated control between different parts of EV.

<u>Course Content</u>:

1. **Electric Vehicles (EV) and Hybrid Electric Vehicles (HEV) Developments:**Historical developments, recent developments, State of art of EVs, EV configurations, EV parameters, Power flow control. Hybrid electric vehicles
2. **Electric Propulsion**:DC Regulation and Voltage Conversion,Different types of Power converter based DC motor drives, induction motor drives, permanent magnet motor drives, Switched reluctance motor drives.
3. **Energy Sources:**Basics- Parameters-Capacity, Discharge rate, State of charge, state of Discharge of Batteries, Fuel cells, Ultra-capacitors, Electric Vehicle Recharging and Refuelling Systems.
4. **EV auxiliaries:**Battery characteristics and chargers, Battery indication and management, Auxiliary power supplies, Modelling Vehicle Acceleration, Modelling Electric Vehicle Range, Regenerative Braking systems.

Reference Books:

1. C. C. Chan, K. T. Chau, “*Modern Electric Vehicle Technology*” published by Oxford University Press.
2. Rodrego Garcia-valle and J. A. P Lopes “*Electric Vehicle Integration into Modern Power Networks*” Springer.
3. Chris Mi, M. AbulMasrur and David WenzhongGao, “*Hybrid Electric Vehicles: Principles and Applications with Practical*Perspectives” John Wiley Ltd. Publication.
4. . MehrdadEhsani, YimiGao, Sebastian E. Gay, Ali Emadi, “*Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design*” CRC Press, 2004.

Course outcomes:

CO1. Learn fundamentals of advanced batteries, super-capacitors and fuel cells for electrification of vehicles.

CO2 Learn hybridization of various energy conversion devices for vehicle electrification.

CO3 Understand battery management systems and state-of-charge estimation.

CO4 Understand the overall operation of Electric vehicles.

Course Code	:	**MEE3E32**
Course Title	:	**Intelligent Control of Electric Drives**
Number of Credits	:	**3**
Course Type	:	**Elective EVEN**
Prerequisites		Power Electronics, basics of converter topology (AC-DC,AC-AC & DC-DC), basic control techniques of Electric Drives

L T P Total
3 0 0 3

Duration of Exam- Three hours
During Semester Evaluation Weight age-50%
End Semester Examination Weight age -50%

Course Learning Objectives

- To learn various artificial intelligent control techniques available
- To apply the control techniques to various drive systems

Course Contents

Fundamental concepts in control of electric drive systems.

Introduction to Neural Networks, Fuzzy logic, Evolutionary algorithms (Genetic Algorithm, Particle Swarm Optimization etc.), Kalman Filter.

Modeling of a fuzzy logic based PI controller, neural network based Park's transformation, signal measurement using Kalman filter, and a genetic algorithm optimized PID controller are discussed.

Application of Fuzzy Logic, Neural Networks, Genetic Algorithm, Hybrid Neuro-Fuzzy and Nonlinear Control of Power Converters and Drives.

Other recent topics on Intelligent Control of Drives

Reference Books

4. Tze-Fun Chan, Keli Shi, "Applied Intelligent Control of Induction Motor Drives", Wiley, 2011
5. Orowska-Kowalska, Teresa, Blaabjerg, Frede, Rodríguez, José ,"Advanced and Intelligent Control in Power Electronics and Drives", Springer, 2014.
6. Maurizio Cirrincione , Marcello Pucci , and Gianpaolo Vitale. "Power Converters and AC Electrical Drives with Linear Neural Networks",CRC Press, 2012

7. Lakhmi C. Jain, Clarence W. de Silva, "Intelligent Adaptive Control: Industrial Applications", CRC Press, 1998

Course Outcomes

At the end of the course student will be able to

CO1. Understand the need of intelligent control techniques for Electric Drive systems
CO2. Compare the intelligent techniques with the Conventional Control Techniques
CO3. Apply the intelligent control techniques to the electric drive systems
CO4. Understand how to formulate and solve Problem on Intelligent Control of Electric Drive

Course Code	:	**MEE3E34**
Course Title	:	**High Power Converters**
Number of Credits	:	**3**
Course Type	:	**Elective EVEN**

L T P Total
3 0 0 3

Duration of Exam- Three hours
During Semester Evaluation Weight age-50%
End Semester Examination Weight age -50%

Course Learning Objectives:

- Difference between low power and high power converters
- Circuit topology of High power converters and their working

Syllabus

Introduction High Power Semiconductor Devices:

Silicon Controlled Rectifier (SCR), Gate Turn-Off (GTO) Thyristor, Gate Commutated Thyristor (GCT) ,Insulated Gate Bipolar Transistor (IGBT), Other Switching Devices ,Main Causes of Voltage Unbalance and Voltage Equalization for GCTs Voltage Equalization for IGBTs.

Multi-pulse SCR Rectifiers:

Effect of Line Inductance, Power Factor and THD, 12-Pulse SCR Rectifier, Idealized 12-Pulse Rectifier, Effect of Line and Leakage Inductances, THD and PF and 24-Pulse SCR Rectifiers

Two-Level Voltage Source Inverter:

Harmonic Content, Over-Modulation, Third Harmonic Injection PWM, Space Vector Modulation, Switching States Space Vectors, Dwell Time Calculation, Modulation Index, Switching Sequence, Spectrum Analysis, Even-Order Harmonic Elimination and Discontinuous Space Vector Modulation.

Cascaded H-Bridge Multilevel Inverters:

Bipolar Pulse Width Modulation, Unipolar Pulse Width Modulation, Multilevel Inverter Topologies, CHB Inverter with Equal DC Voltage, H-Bridges with Unequal DC Voltages, Phase-Shifted Multicarrier Modulation, Level-Shifted Multicarrier Modulation, Comparison Between Phase- and Level-Shifted PWM Schemes. Staircase Modulation.

Diode Clamped Multilevel Inverters:

Three-Level Inverter, Space Vector Modulation, Neutral-Point Voltage Control, Carrier-Based PWM Scheme and Neutral-Point Voltage Control, Other Space Vector Modulation Algorithms, High-Level Diode-Clamped Inverters and NPC/H-Bridge Inverter.

Other Multilevel Voltage Source Inverters:

Multilevel Flying-Capacitor Inverter, Active Neutral-Point Clamped Inverter, Neutral-Point Piloted Inverter, Nested Neutral-Point Clamped Inverter and Modular Multilevel Converter.

PWM Current Source Inverters:

Space Vector Modulation, Parallel Current Source Inverters and Load-Commutated Inverter.

PWM Current Source Rectifiers:

Single-Bridge Current Source Rectifier, Dual-Bridge Current Source Rectifier, Active Damping Control and Power Factor Control.Introductionto Matrix Converters.

SUGGESTED BOOKS:

1. High-Power Converters and AC Drives, Second Edition Bin Wu and Mehdi Narimani
2. High-Power Converters and ac Drives. By Bin Wu © 2006 The Institute of Electrical and Electronics Engineers, Inc.
3. Abu-Rub, A. Iqbal, J. Guzinski: High Performance Control of AC Drives with Matlab/Simulink Models, John Wiley & Sons Ltd., ISBN: 978-0-470-97829-0, 2012 (500 pages).
4. Modular Multilevel Converters: Analysis, Control, and Applications (IEEE Press Series on Power Engineering) Hardcover – Import, 9 Feb 2018 by Sixing Du (Author), ApparaoDekka (Author), Bin Wu (Author), NavidZargari (Author)

Course Outcomes

CO1 Understand the operation of rectifiers

CO2 Evaluate the various performance indices of Two-Level Voltage Source Inverter

CO3 to understand about matrix converter

CO4 Compare various multilevel converters

Course Code	:	**MEE3E36/MEE3O74**
Course Title	:	**Wind Energy Conversion Systems**
Number of Credits	:	**3**
Course Type	:	**Elective EVEN / Open Elective**
Pre-requisite		**A course on induction machines**

L T P Total Duration of Exam- Three hours
3 0 0 3 During Semester Evaluation Weight age-50%
End Semester Examination Weight age -50%

Course Learning Objectives:

- Working of systems to convert wind power to electric power

Contents:

Introduction: Historical developments and current status of wind power, Wind characteristics, Wind energy conversion system, Wind Turbines: Technological developments, Aerodynamics of wind turbines.

Wind Power Generators: Construction and working of asynchronous & permanent magnet synchronous generators, modeling of magnetization curve, Steady state and transient analysis.

Static Control: Control modeling, various control schemes for cage and wound rotor induction generators, Maximum power point tracking.

Issues of Wind Power Generation: Basic integration issues, Behaviour of wind turbines during dynamic changes in grid, power quality issues of wind energy, Wind energy economics

References:

1. 'Wind power in power system', edited by Thomas Ackermann, John Wiley & Sons Ltd., 2005.
2. 'Variable Speed Generators', Ion Boldea, CRC Press, 2006.
3. 'Renewable energy – Power for Sustainable Future'.Edited by Godfrey Boyle.Oxford University Press, 2010.

Course Outcomes:

CO1: To understand and analyze of wind energy conversion.

CO2: To analyze the electrical generators used for wind energy conversion.

CO3: To understand the self-excitation phenomenon in induction machine and its applications.

CO4: To understand the control schemes for extracting maximum energy associated with wind.

CO5: To understand the power quality issues and economics of wind energy.

Course Code	:	**MEE3E38**
Course Title	:	**Advanced Electric Drives**
Number of Credits	:	**3**
Course Type	:	**Elective EVEN**
Prerequisites		Power Electronics, basics of converter topology (AC-DC,AC-AC & DC-DC), Electric Drives

L T P Total
3 0 0 3

Duration of Exam- Three hours
During Semester Evaluation Weight age-50%
End Semester Examination Weight age -50%

Course Learning Objectives

- To learn about various advanced electric drive systems
- To apply the control techniques to various drive systems

Course Contents

Review of Power Converter and Modulation Techniques: Modeling of Power Converters, Sinusoidal Pulse-Width Modulation, Space Vector Pulse-Width Modulation.

Induction Motor Drives: Field oriented control- Direct and indirect field orientation, stator-flux, rotor-flux and airgap-flux orientation. Flux-torque decoupling, Extended speed operation and Field weakening.

Direct torque control of Induction Motor, Flux and speed observers, Induction generators, Doubly Fed Induction Machines (DFIM): Different modes of operation, Equivalent circuit, Active and reactive power control, Vector control of DFIM.

Identification of Induction Motor Parameters: Linear Model, Nonlinear least square identification, Parameter error indices. Speed sensorless control: Signal injection and model based techniques, zero/low speed operation.

Synchronous Motor Drives, Vector controlled Cycloconverter fed Drive, Parameter estimation and sensorless control. Reluctance motor drive

Introduction to PM Synchronous Motor, Various rotor configurations of PMSM, Sinusoidal Back-Emf, Field oriented control, Direct torque control. Interior PM Machine: Maximum torque per ampere control, Field weakening.

Introduction to Brushless DC Motor: EMF and Torque of BLDC machine, Voltage Source Inverter fed BLDC: Half-wave and Full-wave operation, Speed control, Torque ripple minimization, Sensorless operation.

Reference Books

8. Werner Leonhard, Control of Electrical Drives, 3rd edition, Springer 2001
9. R. Krishnan, Electric Motor Drives: Modeling, Analysis, and Control, Prentice Hall, edition 1, 2001.
10. Bimal K Bose, Modern Power Electronics and AC Drives, Prentice Hall, edition 1, 2001
11. P. Vas, "Sensorless Vector and Direct Torque Control", Oxford University Press, 1998.
12. Ramu Krishnan, "Permanent Magnet and BLDC Motor Drives", CRC Press.
13. N. Mohan, "Advanced Electric Drives: Analysis, Control and Modeling using Simulink", MNPERE

Course Outcomes

At the end of the course student will be able to

CO1. Understand about various advanced electric drive systems
CO2. Choose proper electric drive system to a particular application
CO3. Apply Engineering Knowledge in various control techniques to the electric drive systems.
CO4. To study the torque dynamics of DC machine,

Course Code	:	**MEE3E40/MEE3O76**
Course Title	:	**Power converters for Renewable Energy Systems**
Number of Credits	:	**3**
Course Type	:	**Elective EVEN/ Open elective**
Prerequisites		Power Electronics course in UG with knowledge on basics of semiconductor switches, basics of converter topology (AC-DC,AC-AC & DC-DC), basic control techniques of Power Electronic equipment

L T P Total — Duration of Exam- Three hours

3 0 0 3 — During Semester Evaluation Weight age-50%

End Semester Examination Weight age -50%

Course Learning Objectives

- This give an introduction to the recent developments of power electronics from components, topology and control techniques.
- This course drives on the application requirements of power electronics.
- This is a higher level of subject that will help to work in demanding areas of power electronics in renewable energy systems

Course Contents

Advanced Converters

Drawbacks of conventional converters & Inverters, Multi-pulse converters & Inverters, Improved power quality ac-dc converters such as single-phase buck, boost, buck-boost ac/dc converters, PWM (Pulse width modulated) based single- phase, three-phase VSC (Voltage source converters), Current Source Inverters.

Multilevel Converters/ Inverters

Advance converter topologies for PEE - Interleaved converters, multilevel converters (Cascaded H-Bridge, Diode clamped, NPC, Flying capacitor) multi pulse PWM current source converters, advanced control schemes, Capacitor unbalance

PWM Schemes

Conventional PWM schemes & their performance, Multilevel PWM Schemes, Hybrid PWM schemes, Power converter topologies for solar and wind– Control of dc-dc converter, inverters and relevant.

Case Studies

Literature- MLI Applications in Drives and power quality, Hybrid converters- Inverters- Closed Loop Renewable Energy conversion systems- PV power conversion using MLIs.

Reference Books

1. N. Mohan, T. M. Undeland and W. P. Robbins, *Power Electronics Converter Application and Design*, ThirdEdition, John Willey & Sons, 2004.
2. M. H. Rashid, *Power Electronics, Circuits, Devices and Applications*, Pearson, 2002, India.
3. K. Billings, *Switch Mode Power Supply Handbook*, McGraw-Hill, 1999, Boston.
4. Bin Wu, *High-Power Converters and AC Drives*, IEEE Press, A John Wiley & Sons, Inc Publication, New York,2006.
5. Relevant literature review for case studies and course applications.

Course Outcomes

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

CO1. Understand the principles of operation of advanced PWM converters.

CO2. Appraise various advanced converter topologies and the suitable control schemes.

CO3. Recognize recent developments in design aspects of renewable power conversion systems.

CO4. Applying Engineering Knowledge in the the Field of power converters