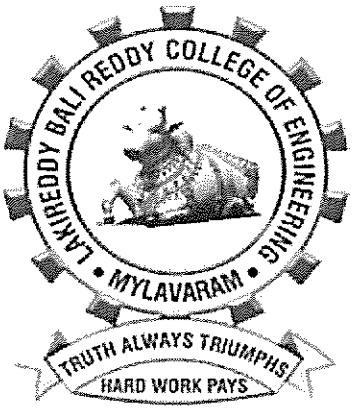
# LAKIREDDY BALIREDDY COLLEGE OF ENGINEERING (AUTONOMOUS)

**(Approved by AICTE, Accredited by NBA, Affiliated to JNTUK, Kakinada and ISO 9001: 2008 Certified)**

# ACADEMIC REGULATIONS, COURSE STRUCTURE AND DETAILED SYLLABUS




## 2011 - 2012

## M.TECH – POWER ELECTRONICS AND DRIVES

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

**L.B.Reddy Nagar, MYLAVARAM – 521 230**
**Krishna District, Andhra Pradesh State**

## COURSE STRUCTURE

### I-SEMESTER

| Code No. | Name of the Course | Scheme of Instruction | | | Scheme of Examination | | Total | credits |
|---|---|---|---|---|---|---|---|---|
| | | Periods per Week | | | Maximum Marks | | | |
| | | Lecture | Tutorial | Lab. | Internal | External | | |
| MEE101 | Machine Modeling and Analysis | 4 | 1 | - | 40 | 60 | 100 | 4 |
| MEE102 | Power Converters | 4 | 1 | - | 40 | 60 | 100 | 4 |
| MEE103 | Control of Motor Drives-I | 4 | 1 | - | 40 | 60 | 100 | 4 |
| MEE104 | Special machines | 4 | 1 | - | 40 | 60 | 100 | 4 |
| MEE1051<br>MEE1052 | **Elective - I**<br>Modern Control Theory<br>Intelligent Control | 4 | 1 | - | 40 | 60 | 100 | 4 |
| MEE1061<br><br>MEE1062 | **Elective - II**<br>Digital controllers for Power Electronic systems<br><br>Reliability Systems Engineering | 4 | 1 | - | 40 | 60 | 100 | 4 |
| MEE151 | Simulation of Power Electronic Systems Lab | - | - | 3 | 40 | 60 | 100 | 2 |
| MEE152 | Mini Project | - | - | - | 50 | - | 50 | 2 |
| | **TOTAL** | **24** | **6** | **3** | **330** | **420** | **750** | **28** |

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## II-SEMESTER

| Code No. | Name of the Course | Scheme of Instruction | | | Scheme of Examination | | Total | credits |
|---|---|---|---|---|---|---|---|---|
| | | Periods per Week | | | Maximum Marks | | | |
| | | Lecture | Tutorial | Lab | Internal | External | | |
| MEE201 | Switched Mode Power Conversion | 4 | 1 | - | 40 | 60 | 100 | 4 |
| MEE202 | Control of Motor Drives-II | 4 | 1 | - | 40 | 60 | 100 | 4 |
| MEE203 | Flexible AC Transmission Systems | 4 | 1 | - | 40 | 60 | 100 | 4 |
| MEE204 | Power Quality | 4 | - | - | 40 | 60 | 100 | 4 |
| MEE2051<br>MEE2052 | **Elective - III**<br>Optimization techniques<br>Industrial Electronics | 4 | 1 | - | 40 | 60 | 100 | 4 |
| MEE2061<br>MEE2062 | **Elective - IV**<br>Power Electronics for renewable energy systems<br>Energy Auditing, Conservation and Management | 4 | 1 | - | 40 | 60 | 100 | 4 |
| MEE251 | Power Converters and Drives Lab | - | - | 3 | 40 | 60 | 100 | 2 |
| MEE252 | Term Paper | - | - | - | 50 | - | 50 | 2 |
| | | **24** | **5** | **3** | **330** | **420** | **750** | **28** |

## III & IV SEMESTERS

| Code No. | Name of the Course | Scheme of Instruction | | | Scheme of Examination | | Total | credits |
|---|---|---|---|---|---|---|---|---|
| | | Periods per Week | | | Maximum Marks | | | |
| | | Lecture | Tutorial | Lab. | Internal | External | | |
| MEE351 | Technical Seminar | -- | -- | 6 | 50 | | 50 | 8 |
| | | | | | | | | |
| MEE451 | Dissertation | -- | -- | 15 | 50 | 150 | 200 | 24 |
| | **TOTAL** | **--** | **--** | **21** | **100** | **150** | **250** | **32** |

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# I SEMESTER

## MEE101 - MACHINE MODELING AND ANALYSIS

| | | | |
|---|---|---|---|
| **Lecture** | **: 4 Periods/week** | **Internal Marks** | **: 40** |
| **Tutorial** | **: 1** | **External Marks** | **: 60** |
| **Credits** | **: 4** | **External Examination** | **: 3 Hrs** |

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**UNIT – I**

**Basic concepts of Modeling**
Basic Two-pole Machine representation of Commutator machines, 3-phase synchronous machine with and without damper bars and 3-phase induction machine, Kron's primitive Machine-voltage, current and Torque equations.

**UNIT - II**

**DC Machine Modeling**
Mathematical model of separately excited D.C motor – Steady State analysis-Transient State analysis-Sudden application of Inertia Load-Transfer function of Separately excited D.C Motor- Mathematical model of D.C Series motor, Shunt motor-Linearization Techniques for small perturbations

**UNIT - III**

**Reference frame theory**
Linear transformation-Phase transformation - three phase to two phase transformation (abc to $\alpha\beta0$) and two phase to three phase transformation $\alpha\beta0$ to abc - -Power equivalence.

**UNIT - IV**

**Modeling of three phase Induction Machine**
Generalized model in arbitrary reference frame-Electromagnetic torque-Derivation of commonly used Induction machine models- Stator reference frame model-Rotor reference frame model-Synchronously rotating reference frame model-state space model with flux linkages as variables

**UNIT - V**

**Modeling of Synchronous Machine**
Synchronous machine inductances – Mathematical model-transformation to the rotor's dq0 reference frame- Flux linkages in terms of winding currents-refering rotor quantities to the stator- voltage equations in the rotor's dq0 reference frame-electromagnetic torque-currents in terms of flux linkages-steady state operation- modeling of PM Synchronous motor, modeling of BLDC motor, modeling of Switched Reluctance motor

**TEXT BOOKS**

1. Electric Motor Drives - Modeling, Analysis& control -R.Krishnan- Pearson Publications-1st edition -2002
2. Analysis of Electrical Machinery and Drive systems – P.C.Krause, Oleg Wasynczuk, Scott D.Sudhoff – Second Edition-IEEE Press



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## REFERENCE BOOKS

1. Generalized Theory of Electrical Machines – P.S.Bimbra-Khanna publications-5th edition-1995
2. Dynamic simulation of Electric machinery using Matlab / Simulink –Chee Mun Ong-Prentice Hall

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## MEE102 - POWER CONVERTERS

| | | | |
|---|---|---|---|
| **Lecture** | **: 4 Periods/week** | **Internal Marks** | **: 40** |
| **Tutorial** | **: 1** | **External Marks** | **: 60** |
| **Credits** | **: 4** | **External Examination** | **: 3 Hrs** |

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**UNIT - I**

### AC VOLTAGE CONTROLLERS

Single Phase AC Voltage Controllers with PWM control-Effects of source and load inductances –synchronous tap changers, Three Phase AC Voltage controllers-Analysis of Controllers with star and delta connected R and RL load -Effects of source and load inductances numerical problems.

**UNIT - II**

### AC-DC CONVERTERS

Single phase controlled Converters– Evaluation of input power factor and harmonic factor-Continuous and Discontinuous load current-Power factor improvements-Extinction angle control-symmetrical angle control-PWM control- Three Phase ac-dc Converters- Half controlled and fully controlled Converters with RL load, three phase dual converters-Power factor improvements-three phase PWM control-twelve pulse converters- numerical problems

**UNIT - III**

### POWER FACTOR CORRECTION CONVERTERS

Single-phase single stage boost power factor corrected rectifier, power circuit principle of operation, and steady state- analysis, three phase boost PFC converter

**UNIT - IV**

### PWM INVERTERS

PWM control strategies of inverters - sinusoidal PWM – modified PWM – phase displacement Control – Trapezoidal, staircase, stepped, harmonic injection and delta modulation – numerical problems ,Voltage Control of Three-Phase Inverters- Sinusoidal PWM- $60^0$ PWM- Third Harmonic PWM- Space Vector Modulation- Comparison of PWM Techniques-current source inverters-Variable dc link inverter - numerical problems.

**UNIT - V**

### MULTI LEVEL INVERTERS

Introduction, Multilevel Concept, Types of Multilevel Inverters- Diode-Clamped Multilevel Inverter, Principle of Operation, Features of Diode-Clamped Inverter, Improved Diode-Clamped Inverter- Flying-Capacitors Multilevel Inverter, Cascaded Multilevel Inverter, Switching Device Currents-DC-Link Capacitor Voltage Balancing- Features of Multilevel Inverters

**TEXTBOOKS**

1. Power Electronics-Md.H.Rashid –Pearson Education Third Edition- First Indian Reprint- 2008
2. Power Electronics- Ned Mohan, Tore M.Undelan and William P.Robbins –John Wiley & Sons -2nd Edition.

## MEE103 – CONTROL OF MOTOR DRIVES - I

| | | | |
|---|---|---|---|
| **Lecture** | **: 4 Periods/week** | **Internal Marks** | **: 40** |
| **Tutorial** | **: 1** | **External Marks** | **: 60** |
| **Credits** | **: 4** | **External Examination** | **: 3 Hrs** |

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**UNIT - I**

**CONVERTER CONTROLLED DC MOTOR DRIVES**

Steady state analysis of the single and three phase fully controlled converter fed series and separately excited D.C motor drives: Continuous and discontinuous conduction mode, control of output voltage by sequence and sector control, reduction of harmonic using multiple-pulse control.

**UNIT - II**

**CHOPPER CONTROLLED DC MOTOR DRIVES**

Principle 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.

**UNIT - III**

**VOLTAGE SOURCE INVERTER FED INDUCTION MOTOR DRIVES**

Scalar control- Voltage fed Inverter control-Open loop volts/Hz control-Speed control with slip regulation-Speed control with torque and Flux control-Current controlled voltage fed Inverter Drive

**UNIT - IV**

**CURRENT SOURCE INVERTER FED INDUCTION MOTOR DRIVES**

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 - V**

**ROTOR SIDE CONTROL OF INDUCTION MOTOR**

Rotor resistance control- fixed resistance control, variable resistance control-converter controlled rotor resistance control, Slip power recovery schemes- Static Kramer drive-Phasor diagram-Torque expression-Speed control of a Kramer drive-Static scherbius drive-Modes of operation

**TEXT BOOKS**

1. Fundamentals of Electric Drives – G. K. Dubey – Narosa Publications – 1995.
2. Power Electronics and Motor Control – Shepherd, Hulley, Liang – II Edition, Cambridge University Press

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## REFERENCES


1. Power Electronic Circuits, Devices and Applications – M. H. Rashid – PHI.
2. Control of Induction Motors - Andrzej M. Trzynadlowski
3. Dynamics and control of electrical drives - Piotr Wach
4. Electric Motor Drives Modeling, Analysis and Control – R. Krishnan, Prentice Hall India.
5. Fundamentals of Electric Drives – G. K. Dubey – Narosa Publications – 1995.
6. Power Semiconductor drives – G. K. Dubey.


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## MEE104 - SPECIAL MACHINES

| | | | |
|---|---|---|---|
| **Lecture** | **: 4 Periods/week** | **Internal Marks** | **: 40** |
| **Tutorial** | **: 1** | **External Marks** | **: 60** |
| **Credits** | **: 4** | **External Examination** | **: 3 Hrs** |

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**UNIT- I**

### STEPPER AND SWITCHED RELUCTANCE MOTORS

Types of stepper motors-hybrid stepping motor-construction-principle- -different configurations for switching the phase windings. Control circuits. Variable reluctance stepping motors-single stack vr motor-multi stacks vr motor. Closed loop control of step motor.

SRM-principle of operation, torque equation, torque-speed characteristics, Design aspects of stator and rotor pole arcs

**UNIT-II**

### PERMANENT MAGNET AND BRUSHLESS D.C MOTORS

Minor hysteresis loops and recoil line, stator frames of Conventional PM dc Motors, Equivalent circuit of a PM , Brushless D.C motor-principle of operation, Types of construction, d-q analysis of BLDC motor.

**UNIT-III**

### LINEAR INDUCTION MOTOR

Types of linear motors, construction details-Flat LIMs, Tubular LIMs, LIM equivalent circuit, Design considerations, Realistic Considerations, selection and applications of LIM.

**UNIT-IV**

### LINEAR SYNCHRONOUS MOTORS

Principle of operation-type of LSM-iron core LSM-permanent magnet LSM-air core LSM-linear homopolar synchronous motor-LSM control.

**UNIT-V**

### SERVO MOTORS

Servomotors: General principle of operation, Types of Servomotors

D.C Servomotors: Armature controlled D.C Servomotor-Field controlled D.C Servomotor.

A.C Servomotors: Principle of Operation, Construction and working, Speed-Torque Characteristics, Transfer function of an A.C servo motor.

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## TEXT BOOKS

1. Special Electric machines-K.Venkataratnam, Universities press.
2. Linear Electric Motors: Theory, Design, and Practical Applications /Syed A.Nasar & I.Boldea.
3.

## REFERENCE BOOKS

1. Brushless Permanent-Magnet and Reluctance Motor Drives-T.J.E.Miller, Clarendon Press, oxford.
2. Sensorless Vector Direct Torque control –Peter Vas, Oxford University Press

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## MEE1051 – MODERN CONTROL THEORY

| | | | |
|---|---|---|---|
| **Lecture** | **: 4 Periods/week** | **Internal Marks** | **: 40** |
| **Tutorial** | **: 1** | **External Marks** | **: 60** |
| **Credits** | **: 4** | **External Examination** | **: 3 Hrs** |

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**UNIT - I**

**DESCRIBING FUNCTION ANALYSIS**

Introduction to Non Linear Systems , behavior of nonlinear systems, properties of Nonlinear Systems, Types of Nonlinearities – Saturation – Dead Zone – Hysteresis-Relay-Backlash etc, Introduction to Linearization of nonlinear systems, Describing function (DF)– Derivation of general DF, DF for different nonlinearities -saturation, Dead-Zone-Dead-Zone and Saturation, Hysteresis-Backlash .Stability analysis of Non – Linear systems through describing functions

**UNIT - II**

**PHASE PLANE ANALYSIS**

Introduction to phase plane analysis, singular points , and their classification, limit cycle and behavior of limit cycle. Analytical method ,Isocline method, and delta method for constructing Trajectories, phase plane analysis of nonlinear control systems.

**UNIT - III**

**STABILITY ANALYSIS**

Stability of equilibrium state,asymptotic stability, graphical representation, Lyapunov stability theorems, stability analysis of linear systems,nonlinear systems, construction of Lyapunov functions using– Krasovskii method, variable gradient method

**UNIT–IV**

**MODAL CONTROL**

Introduction to controllability and observability. Effect of state feedback on controllability and observability, Design of State Feedback Control through Pole placement. Full order observer and reduced order observer.

**UNIT –V**

**OPTIMAL CONTROL**

Introduction, Formulation of optimal control problems. Minimum time, Minimum energy, minimum fuel problems. State regulator problem. Output regulator problem. Tracking problem, calculus of variations – fundamental concepts, minimization of functionals, Linear quadratic regulator.

**Text Book**

1. Modern Control System Theory by M. Gopal – New Age International – 1984

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## REFERENCES


1. Modern Control Engineering by Ogata. K – Prentice Hall – 1997
2. Control systems by R.C.Sukla-Dhanpat Rai and Co (Pvt) Ltd
3. Advanced Control Theory by A.Nagoor Kani-RBA
4. Optimal control by Kirck, PHI


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## MEE1052 – INTELLIGENT CONTROL

| | | | |
|---|---|---|---|
| **Lecture** | **: 4 Periods/week** | **Internal Marks** | **: 40** |
| **Tutorial** | **: 1** | **External Marks** | **: 60** |
| **Credits** | **: 4** | **External Examination** | **: 3 Hrs** |

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**UNIT I**

**INTRODUCTION**

Introduction and motivation. Approaches to intelligent control. Architecture for intelligent control. Symbolic reasoning system, rule-based systems, the AI approach. Knowledge representation.

**UNIT II**

**ANN**

Concept of Artificial Neural Networks and its basic mathematical model, McCulloch-Pitts neuron model, simple perceptron, Adaline and Madaline, Feed-forward Multilayer Perceptron. Learning and Training the neural network.Networks: Hopfield network, Self-organizing network and Recurrent network.

**UNIT III**

**GENETIC ALGORITHM**

Genetic Algorithm: Basic concept of Genetic algorithm: Mutation,Reproduction and cross over and detail algorithmic steps, adjustment of free parameters. Solution of typical control problems using genetic algorithm, genetic algorithm as classifier and engineering applications.

**UNIT IV**

**FUZZY SYSTEMS**

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

**UNIT-V**

**FUZZY LOGIC & NEURAL NETWORK APPLICATIONS TO DRIVES**

**Fuzzy logic applications:** Design of Fuzzy PI controller for speed control of DC motor- Flux programming efficiency improvement of three phase induction motor-Induction motor speed control

**Neural network applications:-**PWM Controller-Selected harmonic elimination PWM-Space vector PWM

**TEXT BOOKS**

1. Neural Networks: A comprehensive Foundation – Simon Haykins, Pearson Edition, 2003.
2. Fuzzy logic with Fuzzy Applications – T.J.Ross – Mc Graw Hill Inc, 1997.
3. Genetic Algorithms- David E Goldberg.

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4. Modern Power Electronics and AC Drives –B.K.Bose-Pearson Publications
5. Artificial Intelligent based Electrical Machines and Drives- Peter Vas, Oxford University Press
6. Intelligent Control Systems with Lab VIEW - Pedro Ponce-Cruz, Fernando D. Ramírez-Figueroa.

## REFERENCES

1. Neural Network Design-M.T.Hagan, H. B. Demuth and M. Beale, Indian reprint, 2008.
2. Principles of Neurocomputing for science and Engineering,- Fredric M.Ham and Ivica Kostanic, McGraw Hill, 2001.
3. Neural Network Fundamentals with Graphs, Algorithms and Applications, N.K. Bose and P.Liang, Mc-Graw Hill, Inc. 1996.
4. Intelligent System- Modeling, Optimization and Control- Yung C. Shin and Chengying Xu,CRC Press, 2009.
5. Soft computing & Intelligent Systems- Theory & Applications – N.K.Sinha and Modan M Gupta. Indian Edition, Elsevier, 2007.
6. Fuzzy logic Intelligence, Control, and Information- John Yen and Reza Langari, Pearson Education, Indian Edition, 2003.
7. Fuzzy Control and Fuzzy Systms, Witold Pedrycz, Overseas Press, Indian Edition, 2008.

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## MEE1061 – DIGITAL CONTROLLERS FOR POWER ELECTRONIC SYSTEMS

| | | | |
|---|---|---|---|
| **Lecture** | **: 4 Periods/week** | **Internal Marks** | **: 40** |
| **Tutorial** | **: 1** | **External Marks** | **: 60** |
| **Credits** | **: 4** | **External Examination** | **: 3 Hrs** |

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**UNIT- I**

**PIC MICROCONTROLLERS**

PIC Microcontrollers: Overview and Features, PIC 16C6X/7X, FSR(File Selection Register) [Indirect Data Memory Address Pointer], PIC Reset Actions, PIC Oscillator Connections, PIC Memory Organizations, PIC PIC 16C6X/7X Instructions, Addressing Modes, I/O Ports, Interrupts in PIC 16C61/71, PIC 16C61/71 Timers, PIC 16C71 Analog-to-Digital Converter (ADC)

**UNIT - II**

**INTRODUCTION TO DSP**

Introduction to the C2xx DSP core and code generation, The components of the C2xx DSP core, Mapping external devices to the C2xx core , peripherals and Peripheral Interface , System configuration registers , Memory , Types of Physical Memory , memory Addressing Modes , Assembly Programming using C2xx DSP, Instruction Set, Software Tools.

**UNIT - III**

**I/O & CONTROL REGISTERS**

Pin Multiplexing (MUX) and General Purpose I/O Overview, Multiplexing and General Purpose I/O Control Registers .Introduction to Interrupts, Interrupt Hierarchy, Interrupt Control Registers, Initializing and Servicing Interrupts in Software.

**UNIT - IV**

**ADC & EVENT MANAGER**

ADC Overview , Operation of the ADC in the DSP , Overview of the Event manager (EV) , Event Manager Interrupts , General Purpose (GP) Timers , Compare UNITs, Capture UNITs And Quadrature Enclosed Pulse (QEP) Circuitry , General Event Manager Information

**UNIT - V**

**FPGA**

Introduction to Field Programmable Gate Arrays – CPLD Vs FPGA – Types of FPGA , Xilinx XC3000 series , Configurable logic Blocks (CLB), Input/Output Block (IOB) – Programmable Interconnect Point (PIP) – Xilinx 4000 series – HDL programming – overview of Spartan 3E and Virtex II pro FPGA boards- case study.

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## REFERENCES


1. Microcontrollers-Theory and Applications by Ajay V Deshmukh, McGraw Hills
2. Microcontrollers by Kennith J ayala, Thomson publishers
3. Microprocessor and Microcontrollers by Prof C.R.Sarma
4. Hamid.A.Toliyat and Steven G.Campbell " DSP Based Electro Mechanical Motion Control " CRC Press New York , 2004
5. XC 3000 series datasheets ( version 3.1). Xilinx,Inc.,USA, 1998
6. Wayne Wolf," FPGA based system design ", Prentice hall, 2004


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## MEE1062 – RELIABILITY SYSTEMS ENGINEERING

| | | | |
|---|---|---|---|
| **Lecture** | **: 4 Periods/week** | **Internal Marks** | **: 40** |
| **Tutorial** | **: 1** | **External Marks** | **: 60** |
| **Credits** | **: 4** | **External Examination** | **: 3 Hrs** |

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**UNIT – I**

**BASICS OF PROBABILITY THEORY & DISTRIBUTION**

Basic probability theory – rules for combining probabilities of events – Bernoulli's trials – probabilities density and distribution functions – binomial distribution – expected value and standard deviation of binomial distribution.

Network Modelling and Reliability Analysis-Analysis of Series, Parallel, Series-Parallel networks – complex networks – decomposition method.

**UNIT – II**

**RELIABILITY FUNCTIONS**

Reliability functions f(t), F(t), R(t), h(t) and their relationships – exponential distribution – Expected value and standard deviation of exponential distribution – Bath tub curve – reliability analysis of series parallel networks using exponential distribution – reliability measures MTTF, MTTR, MTBF.

**UNIT – III**

**MARKOV MODELLING**

Markov chains – concept of stochastic transitional probability Matrix, Evaluation of limiting state Probabilities. – Markov processes one component repairable system – time dependent probability evaluation using Laplace transform approach – evaluation of limiting state probabilities using STPM – two component repairable models.

**UNIT –IV**

**FREQUENCY & DURATION TECHNIQUES**

Frequency and duration concept – Evaluation of frequency of encountering state, mean cycletime, for one , two component repairable models – evaluation of cumulative probability and cumulative frequency of encountering of merged states.

**UNIT – V**

**GENERATION SYSTEM RELIABILITY ANALYSIS**

Reliability model of a generation system– recursive relation for unit addition and removal – load modeling - Merging of generation load model – evaluation of transition rates for merged state model – cumulative Probability, cumulative frequency of failure evaluation – LOLP, LOLE.

**TEXT BOOKS**

1. Reliability Evaluation of Engg. System – R. Billinton, R.N.Allan, Plenum Press, New York, reprinted in India by B.S.Publications, 2007.

2. Reliability Evaluation of Power systems – R. Billinton, R.N.Allan, Pitman Advance Publishing Program, New York, reprinted in India by B.S.Publications, 2007.

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## MEE151 – SIMULATION OF POWER ELECTRONIC SYSTEMS LAB.

| | | | |
|---|---|---|---|
| **Lab.** | **: 3 Periods/week** | **Internal Marks** | **: 40** |
| | | **External Marks** | **: 60** |
| **Credits** | **: 2** | **External Examination** | **: 3 Hrs** |

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**PSPICE**

1. Switching characteristics of power MOSFET & IGBT
2. Three phase IGBT based AC Voltage controller using RL load.

**MATLAB/SIMULINK**

3. Single phase current source inverter with RL Load.
4. Cascade speed control of a dc motor drive.
5. Capacitor start & run single phase Induction motor.
6. Characteristics of induction machines under balanced and symmetrical conditions for the following
   a. dq model in synchronous reference frame
   b. dq model in stator reference frame
   c. dq model in rotor reference frame
7. Sinusoidal PWM excitation of an Induction motor.
8. Speed control of PM synchronous motor.

**PSCAD**

9. Single phase full converter using RL load without and with LC Filter.
10. Three phase fully controlled converter with RL &RLE Loads.
11. Single phase AC Voltage controller with PWM control for RL load.
12. Chopper fed dc motor drive.
13. Three phase bridge inverter with SPWM control.

**ADDITIONAL EXPERIMENTS:**

14. 3-phase IM drive using v/f control using MATLAB/simulink
15. Speed control of single-phase induction motor using PSCAD.

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# II SEMESTER

## MEE201 – SWITCHED MODE POWER CONVERSION

| | | | |
|---|---|---|---|
| **Lecture** | **: 4 Periods/week** | **Internal Marks** | **: 40** |
| **Tutorial** | **: 1** | **External Marks** | **: 60** |
| **Credits** | **: 4** | **External Examination** | **: 3 Hrs** |

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**UNIT - I**

**SINGLE-SWITCH ISOLATED CONVERTERS**

Requirement for isolation in the switch-mode converters, transformer connection, Forward and flyback converters, power circuit and steady-state analysis. Push-Pull Converters-Power circuit and steady-state analysis, utilization of magnetic circuits in single switch and push-pull topologies.

**UNIT - II**

**ISOLATED BRIDGE CONVERTERS**

Half bridge and full-bridge converters, Power circuit and steady-state analysis, utilization of magnetic circuits and comparison with previous topologies.

**UNIT - III**

**DYNAMIC ANALYSIS OF DC-DC CONVERTERS**

Formulation of dynamic equation of buck and boost converters, averaged circuit models, linearization technique, small-signal model and converter transfer functions.

**UNIT - IV**

**CONTROLLER DESIGN**

Review of frequency-domain analysis of linear time-invariant systems, concept of bode plot, phase and gain margins, bandwidth, controller specifications, proportional (P), proportional plus integral (PI), proportional plus integral plus integral controller (PID), selection of controller parameters.

**UNIT - V**

**RESONANT CONVERTERS**

Classification of Resonant converters-Basic resonant circuits- Series resonant circuit-parallel resonant circuits- Resonant switches. Concept of Zero voltage switching, principle of operation, analysis of M-type and L-type Buck or boost Converters. Concept of Zero current switching, principle of operation, analysis of M-type and L-type Buck or boost Converters.

**TEXT BOOKS**

1. Fundamentals of Power Electronics – Robert Erickson and Dragon Maksivimovic, Springer Publications.
2. Power Electronics–Issa Batarseh- John Wiely

**REFERENCES**

1. Elements of Power Electronics - Philip T.Krein – Oxford University Press
2. Power Electronics, L. Umanand, Tata Mc-Graw Hill



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## MEE202 – CONTROL OF MOTOR DRIVES - II

| | | | |
|---|---|---|---|
| **Lecture** | **: 4 Periods/week** | **Internal Marks** | **: 40** |
| **Tutorial** | **: 1** | **External Marks** | **: 60** |
| **Credits** | **: 4** | **External Examination** | **: 3 Hrs** |

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**UNIT - I**

**VECTOR CONTROL OF INDUCTION MOTOR**

Principles of vector control, Direct vector control, derivation of indirect vector control, implementation – block diagram; estimation of flux, flux weakening operation.

**UNIT - II**

**SENSORLESS VECTOR CONTROL OF INDUCTION MOTOR**

Slip and Speed Estimation at Low performance, Rotor Angle and Flux-linkage Estimation at high performance -rotor Speed Estimation Scheme- estimators using rotor slot harmonics, Model Reference adaptive systems, Extended Kalman Filter, injection of auxiliary signal on salient rotor.

**UNIT – III**

**CONTROL OF SYNCHRONOUS MOTOR DRIVES**

Synchronous motor and its characteristics- Control strategies-Constant torque angle control-power factor control, constant flux control, flux weakening operation, Load commutated inverter fed synchronous motor drive, motoring and regeneration, phasor diagrams

**UNIT - IV**

**CONTROL OF SWITCHED RELUCTANCE MOTOR DRIVES**

SRM Structure-Stator Excitation-techniques of sensor less operation-convertor topologies-SRM Waveforms-SRM drive design factors-Torque controlled SRM-Torque Ripple-Instantaneous Torque control -using current controllers-flux controllers.

**UNIT – V**

**CONTROL OF BLDC MOTOR DRIVES**

principle of operation of BLDC Machine, Sensing and logic switching scheme, BLDM as Variable Speed Synchronous motor-methods of reducing Torque pulsations -Three-phase full wave Brushless dc motor -Sinusoidal type of Brushless dc motor - current controlled Brushless dc motor Servo drive.

**TEXT BOOKS**

1. Electric Motor Drives Modeling, Analysis & control -R. Krishnan- Pearson Education
2. Modern Power Electronics and AC Drives –B. K. Bose-Pearson Publications
3. Sensorless Vector Direct Torque control –Peter Vas, Oxford University Press

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## REFERENCES


1. Modern Power Electronics and AC Drives –B. K. Bose-Pearson Publications-
2. Power Electronics control of AC motors – MD Murphy & FG Turn Bull Pergman Press -1st edition-1998
3. Fundamentals of Electrical Drives – G.K. Dubey – Narosa Publications -1995
4. Power Semiconductor drives- G.K. Dubey-Prentice hall


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## MEE203 – FLEXIBLE AC TRANSMISSION SYSTEMS

| | | | |
|---|---|---|---|
| **Lecture** | **: 4 Periods/week** | **Internal Marks** | **: 40** |
| **Tutorial** | **: 1** | **External Marks** | **: 60** |
| **Credits** | **: 4** | **External Examination** | **: 3 Hrs** |

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**UNIT - I**

**INTRODUCTION**

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**

**SHUNT COMPENSATION**

Principles of shunt compensation – Variable Impedance type & switching converter type-Static Synchronous Compensator (STATCOM) configuration, characteristics and control.

**UNIT - III**

**SERIES COMPENSATION**

Principles of static series compensation using GCSC, TCSC and TSSC, applications, Static Synchronous Series Compensator (SSSC).

**UNIT - IV**

**VOLTAGE REGULATORS**

Principles of operation-Steady state model and characteristics of a static voltage regulators and phase shifters- power circuit configurations.

**UNIT - V**

**UNIFIED POWER FLOW CONTROLLER (UPFC)**

Introduction: The Unified Power Flow Controller-Basic Operating Principles, Conventional Transmission Control Capabilities, Independent Real and Reactive Power Flow Control, Control Structure, Basic Control system for P and Q Control.

**REFERENCES**

1. N.G.Hingorani & L.Gyugyi, *Understanding FACTS*: *Concepts and Technology of Flexible AC Transmission Systems*, IEEE Press, 1999.
2. X.P. Zang, C. Rehtanz and B. Pal, *Flexible AC Transmission Systems: Modeling and Control*, Birkhauser, 2006.
3. Y. H. Song and A. T. Johns, *Flexible AC Transmission Systems*, IET, 1999.

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## MEE204 – POWER QUALITY

| | | | |
|---|---|---|---|
| **Lecture** | **: 4 Periods/week** | **Internal Marks** | **: 40** |
| **Tutorial** | **: 1** | **External Marks** | **: 60** |
| **Credits** | **: 4** | **External Examination** | **: 3 Hrs** |

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**OBJECTIVE**

This subject deals with the Basic Concepts of Power Quality issues. In addition to the basic Concepts, Voltage Sags and Interruptions, Fundamentals of Harmonics, and Power Quality Monitoring are also discussed.

**UNIT - I**

**INTRODUCTION TO POWER QUALITY**

What is Power Quality?, Voltage Quality, Why are we concerned about power quality?, The power quality evaluation procedure-Need for a consistent-Vocabulary, General classes of power quality problems, Transients, Long-Duration voltage variations, Short-Duration voltage variations, Voltage Imbalance, waveform distortion, voltage fluctuation, Power frequency variations, Power quality terms

**UNIT- II**

**VOLTAGE SAGS AND INTERRUPTIONS**

Sources of sags and interruptions-Estimating Voltage sag performance-Fundamental principles of protection-Solutions at the End-User level-Evaluating the economics of different ride_ through alternatives-Motor_ starting sags-Utility system fault_ clearing issues

**UNIT - III**

**FUNDAMENTALS OF HARMONICS**

Harmonic Distortion-Voltage versus current distortion-Harmonic versus Transients-Power system Quantities under non sinusoidal conditions-Harmonic indices-Harmonic sources from commercial loads-Harmonic sources from industrial loads-Locating harmonic sources-System response characteristics-Effects of harmonic distortion- Inter harmonics

**UNIT - IV**

**APPLIED HARMONICS**

Harmonic Distortion Evaluation-Principles of Controlling Harmonics-Where to control Harmonics? - Harmonic studies-Devices for controlling Harmonic Design- Harmonic filter Design.

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## UNIT - V

### POWER QUALITY MONITORING

Monitoring considerations-Historical perspective of power quality measuring instruments-Power quality measurement equipment-Assessment of power quality measurement data-Application of intelligent systems-Power quality monitoring standards

## TEXT BOOKS

1. Electrical power systems quality-Roger C.Dugan- McGraw- Hills
2. Power quality- C.Sankaran, CRC Press

## REFERENCES

1. Electrical power systems quality-Roger C.Dugan- McGraw- Hills
2. Power quality- C.Sankaran, CRC Press

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## MEE2051 – OPTIMIZATION TECHNIQUES

| | | | |
|---|---|---|---|
| **Lecture** | **: 4 Periods/week** | **Internal Marks** | **: 40** |
| **Tutorial** | **: 1** | **External Marks** | **: 60** |
| **Credits** | **: 4** | **External Examination** | **: 3 Hrs** |

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**OBJECTIVES**

This course is a basic mathematical tool in solution of number of system operational methods and design of components and systems. The course also contains non-traditional optimization techniques like Genetic Algorithms and Particle Swarm methods. The contents of this course are also widely used in operations research in systems planning and management.

**UNIT - I**

**LINEAR PROGRAMMING (LP)**

Introduction through engineering applications, standard form of LP problem (LPP), Geometrical interpretation, simplex method and algorithm, two phases of simplex method, Numerical problems, Revised simples method, Duality in LP, Dual simplex method, sensitivity analysis.

**UNIT - II**

**APPLICATIONS AND EXTENSIONS OF LP:**

Transportation problem, Assignment problem, Karmarkar's method, Quadratic programming and Electrical Engineering Applications.

**UNIT - III**

**NON-LINEAR PROGRAMMING – UNCONSTRAINED MINIMIZATION:**

Interpolation methods, quadratic and cubic interpolation methods, Newton's method.Gradient Methods – Steepest descent, conjugate gradient, Newton's and quasi Newton methods, Davidon-Flecher-Powell method, numerical problems.

**UNIT - IV**

**NON-LINEAR PROGRAMMING – CONSTRAINED MINIMIZATION:**

Legrangian multipliers, Kuhn-Tucker conditions, sequential LP method, methods of feasible directions, Rosen's gradient projection method, Generalized reduced gradient method, Interior and exterior penalty function methods.

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## UNIT - V

**DYNAMIC PROGRAMMING & NON-TRADITIONAL OPTIMIZATION:**

Principle of optimality, computational procedure, applications from electrical engineering. Evolutionary Programming Techniques – Genetic Algorithm (GA ), the three parameters of GA, computational procedure for both binary and analogue coded inputs. Introduction to Particle swarm Optimization. Numerical examples.

## TEXT BOOKS

1. Engineering Optimization – Theory and Practice, S.S. Rao, III Edition, John Woley & Sons 1996 and New Age International Pvt Ltd., New Delhi, 2002.
2. Optimization Methods in Operations Research and Systems Analysis, K V Mittal and C Mohan, II edition 1983, New Age International Publishers, New Delhi

## REFERENCES

1. Optimization for Engineering Design - Algorithms and Examples, Kalyanmoy Deb, PHI Learning Private Ltd, New Delhi, 1995
2. Combinatorial Optimization – Algorithms and Complexity, Christos H Papadimitriou and Kenneth Steiglitz, Prentice Hall of India 1997.
3. Introduction to Optimization & Operations Research, J C Pant, IV Edition, Jain Brothers, New Delhi.


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## MEE2052 – INDUSTRIAL ELECTRONICS

| | | | |
|---|---|---|---|
| **Lecture** | **: 4 Periods/week** | **Internal Marks** | **: 40** |
| **Tutorial** | **: 1** | **External Marks** | **: 60** |
| **Credits** | **: 4** | **External Examination** | **: 3 Hrs** |

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**UNIT - I**

### STABILIZED POWER SUPPLIES

Uninterrupted power supplies, online UPS, offline UPS, high frequency online UPS, programmable logic controllers, Voltage stabilizers-servo mechanism, single phase & three phase servo voltage stabilizers.

**UNIT – II**

### AMPLIFIERS IN INDUSTRIAL ELECTRONIC CIRCUITS & INDUSTRIAL TIMING CIRCUITS

Introduction, Direct coupled amplifiers (DCA)-basic & special, differential amplifier as DCA, chopper stabilized DCA, differential DCA using Op-Amp, Timers-classification, thermal, electro-mechanical, electronic timers, transistor coltrol with relay load control, SCR delay timer, IC electronic timer.

**UNIT - III**

### OPTOELECTRONICS & OPTICAL FIBRE

Introduction, photoemitters, lasers, liquid crystal displays, photoconductive sensors, photodiodes, phototransistors, LASCRs/photo SCRs, optocouplers, solid state relays (light operated relays), optical fibre.

**UNIT - IV**

### STORAGE SYSTEMS

Introduction, Energy Storage Parameters, Lead–Acid Batteries-Constructional Features, Battery Charge–Discharge Cycles, Ultracapacitors-Double-Layer Ultracapacitors, High-Energy Ultracapacitors, Applications of Ultracapacitors, Flywheels-Advanced Performance of Flywheels, Applications of Flywheels.

**UNIT - V**

### HEATING & WELDING CONTROL

Induction heating, Effects of supply frequency & source voltage on induction heating, Dielectric heating, Effect of variation of supply voltage & frequency on dielectric heating, Welding, Resistance welding-theory & classification, scheme of AC resistance welding, Ignitron-heat control by change of firing angles in Ignitrons, complete control in resistance welding by a sequence timer.

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## TEXT BOOKS

1. Industrial and Power Electronics /G.K.Mithal and Dr.Maneesha Gupta
2. Industrial Electronics and control /Biswanath Paul.

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## MEE2061 – POWER ELECTRONICS FOR RENEWABLE ENERGY SYSTEMS

| | | | |
|---|---|---|---|
| **Lecture** | **: 4 Periods/week** | **Internal Marks** | **: 40** |
| **Tutorial** | **: 1** | **External Marks** | **: 60** |
| **Credits** | **: 4** | **External Examination** | **: 3 Hrs** |

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**UNIT-I**

### INTRODUCTION TO RENEWABLE ENERGY SYSTEMS

Wind power, Hydropower, Solar energy-Biomass, Bio-fuel, Geothermal Heat energy, Solar-thermal plants, Applications.

**UNIT-II**

### SOLAR ENERGY

Introduction to PV-Cells, Array, Solar power extraction using PV-Cells, I-V Characteristics, PV-Inverters without D.C. to D.C. converters, Grid interfacing-with isolation, without isolation, Maximum power point tracking-Methods, PV-Inverters with D.C. to D.C. converters-on low frequency side and high frequency side with isolation, without isolation.

**UNIT-III**

### WIND ENERGY

Sources and potentials, Evaluation of Wind Intensity, Topography, General Classification of Wind Turbines-Rotor Turbines, Multiple-Blade Turbines, Drag Turbines, Lifting Turbines, System TARP–WARP, Generators and speed control used in wind power energy

**UNIT-IV**

### WIND POWER CONTROL

Fixed speed with capacitor bank, Rotor resistance control, DFIG, Synchronous Generator-external magnetized, Synchronous Generator-permanent magnets.

**UNIT-V**

### FUEL CELLS

Fuel cells, Commercial Technologies for Generation of Electricity, Constructional Features of Solid Oxide Fuel Cells, Constructional Features of Proton Exchange Membrane Fuel Cells, Load Curve Peak Sharing with Fuel Cells, Advantages and Disadvantages of Fuel Cells, voltage step-up using D.C.-D.C. converter- with and without battery storage, Voltage controller for Fuel cell using D.C. – D.C. converter, Inverter interaction with fuel cell for A.C. loads, A.C. Voltage build-up and controller for fuel cells- using power converters and transformers (isolation).

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## TEXT BOOKS

1. Non-Conventional Energy Sources /G.D. Rai
2. Renewable Energy Technologies /Ramesh & Kumar /Narosa
3. Integration of alternative sources of energy /Felix A. Farret, M. Godoy simoes

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## MEE2062 – ENERGY AUDITING, CONSERVATION AND MANAGEMENT

| | | | |
|---|---|---|---|
| **Lecture** | **: 4 Periods/week** | **Internal Marks** | **: 40** |
| **Tutorial** | **: 1** | **External Marks** | **: 60** |
| **Credits** | **: 4** | **External Examination** | **: 3 Hrs** |

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### UNIT - I

**BASIC PRINCIPLES OF ENERGY AUDIT**

Energy audit- definitions, concept , types of audit, energy index, cost index ,pie charts, Sankey diagrams, load profiles, Energy conservation schemes- Energy audit of industries- energy saving potential, energy audit of process industry, thermal power station, building energy audit

### UNIT - II

**ENERGY MANAGEMENT**

Principles of energy management, organizing energy management program, initiating, planning, controlling, promoting, monitoring, reporting, Energy manger, Qualities and functions, language, Questionnaire - check list for top management

### UNIT - III

**ENERGY EFFICIENT MOTORS**

Energy efficient motors , factors affecting efficiency, loss distribution , constructional details , characteristics - variable speed , variable duty cycle systems, RMS hp- voltage variation- voltage unbalance- over motoring- motor energy audit

### UNIT - IV

**POWER FACTOR IMPROVEMENT, LIGHTING & ENERGY INSTRUMENTS**

Power factor – methods of improvement, location of capacitors, Pf with non linear loads, effect of harmonics on p.f. , p.f motor controllers - Good lighting system design and practice, lighting control ,lighting energy audit, Energy Instruments- watt meter, data loggers, thermocouples, pyrometers,lux meters, tongue testers ,application of PLC's

### UNIT - V

**ECONOMIC ASPECTS AND ANALYSIS & ITS COMPUTATION**

Economics Analysis-Depreciation Methods, time value of money, rate of return, present worth method , replacement analysis, life cycle costing analysis - Energy efficient motors, Calculation of simple payback method, net present worth method- Power factor correction, lighting - Applications of life cycle costing analysis, return on investment.

### TEXT BOOKS

1. Energy management by W.R. Murphy & G. Mckay Butter worth, Heinemann publications.
2. Energy efficient electric motors by John .C. Andreas, Marcel Dekker Inc Ltd-2nd edition, 1995-



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## REFERENCES

1. Energy management by Paul o' Callaghan, Mc-graw Hill Book company-1st edition, 1998
2. Energy management hand book by W.C.Turner, John wiley and sons
3. Energy management and good lighting practice : fuel efficiency- booklet12-EEO

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## MEE251 – POWER CONVERTERS AND DRIVES LABORATORY

| | | | |
|---|---|---|---|
| **Lab.** | **: 3 Periods/week** | **Internal Marks** | **: 40** |
| | | **External Marks** | **: 60** |
| **Credits** | **: 2** | **External Examination** | **: 3 Hrs** |

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### LIST OF EXPERIMENTS

1. Operation of 3-phase Fully controlled Converter with R & R-L load.
2. Performance & Operation of a four quadrant Chopper fed D.C. Drive
3. Performance & Operation of a 3-phase A.C. Voltage controller on motor load.
4. Operation of 3-phase IGBT based PWM Inverter on R & R-L load.
5. Operation of 3-phase multilevel Inverter
6. Performance & speed control of 3 phase slip ring Induction motor by Static Rotor Resistance Controller.
7. PIC Microcontroller based Power factor correction with Boost converter
8. Speed control of BLDC motor with spring-balance.
9. Speed control of Switched Reluctance motor with eddy current load.
10. DSP based V/F Control of 3 phase Induction motor.

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