SREE VIDYANIKETHAN ENGINEERING COLLEGE

(AUTONOMOUS)

Sree Sainath Nagar, Tirupati

Department of Electrical and Electronics Engineering

Supporting Document for 1.1.3

Courses having focus on

Employability/ Entrepreneurship/ skill Development

Program: M.Tech.- Power Electronics and Drives

Regulations : SVEC-19

The Courses (with course outcomes) under SVEC-19 Regulations which focus on ***employability/ entrepreneurship/ skill development*** are highlighted with the following colours.

Skill

Employability

Entrepreneurship

M. Tech.– I Semester
(19MT18301) DYNAMICS OF ELECTRICAL MACHINES

Int. Marks	Ext. Marks	Total Marks	L	T	P	C
40	60	100	3	-	-	3

PRE-REQUISITES: Courses on DC Machines, Transformers, Induction Machines & Synchronous Machines at UG level.

COURSE DESCRIPTION: Modelling and analysis of DC, induction and synchronous machines in stationary and rotating reference frames.

COURSEOUTCOMES: On successful completion of the course, students will be able to

CO1. Demonstrate the potential knowledge of magnetically coupled circuits, model and analyze the performance of AC machines.
CO2. Apply the knowledge of two pole DC machines and use appropriate technique to model different types DC Machines mathematically.
CO3. Apply appropriate transformation technique to obtain reference frame variables, analyze and design induction machine and synchronous machine.

DETAILED SYLLABUS:

Unit - I: Basic Principles of Electrical Machine Analysis (10 hours)

Magnetically coupled circuits: Review of basic concepts, magnetizing inductance, modeling linear and non-linear magnetic circuits. Numerical Problems.
Electromechanical energy conversion: Principles of energy flow, concept of field energy and co-energy. Derivation of torque expression for various machines using the principles of energy flow and the principle of co-energy. Inductance matrices of induction and synchronous machines.

Unit - II: Theory of DC Machines (08 hours)

Basic Two-pole DC machine - Primitive 2-axis machine – Voltage and Current relationship – Torque equation. Mathematical model of separately excited DC motor, DC Series motor and DC shunt motor in state variable form – Transfer function of DC motors.

Unit - III: Reference Frame Theory (09 hours)

Concept of space vector, types of transformation, condition for power invariance, zero-sequence component, expression for power with various types of transformation. Transformations between reference frames: Clarke and Park’s Transformations, variables observed from various frames.

Unit - IV: Theory of Symmetrical Induction Machines (09 hours)

Voltage and torque equation in machine variables, derivation of dq0 model for a symmetrical induction machine, voltage and torque equation in arbitrary reference frame variables, analysis of steady state operation.

State-space model of induction machine in 'd-q' variables. Numerical problems.

Unit - V: Theory of Synchronous Machines (09hours)

Equations in arbitrary reference frame. Park's transformation, derivation of dq0 model for a salient pole synchronous machine with damper windings, torque expression of a salient pole synchronous machine with damper windings and identification of various components. Numerical problems.

Total hours: 45

TEXT BOOKS:

1. Paul C. Krause, Oleg Wasynczuk, Scott D. Sudhoff, *Analysis of Electric Machinery &Drive systems,* IEEE Press, 2002.
2. R. Krishnan, *Electric motor drives, Modeling, Analysis and Control,* Prentice Hall, 2001.

REFERENCE BOOKS:

1. P.S. Bimbhra, *Generalized Theory of Electrical Machines*, Khanna Publishers, 2008.
2. A.E. Fitzgerald*,* Charles Kingsley, Stephen D. Umans, *Electric Machinery*,5th edition, Tata McGraw – Hill Publishing Company, 2003.

M. Tech. – I Semester
(19MT18302) POWER ELECTRONIC CONVERTERS

Int. Marks	Ext. Marks	Total Marks	L	T	P	C
40	60	100	3	-	-	3

PRE-REQUISITES: Courses on Engineering Mathematics, Electrical circuits, Power Electronics at UG Level.

COURSE DESCRIPTION: Single phase and three phase converters - Types, operation of controlled and uncontrolled converters; Inverters – Types, operation of Single and Three Phase Voltage Source Inverters; Current Source Inverters; DC-DC Converters andAC Voltage Controllers.

COURSE OUTCOMES: On successful completion of the course, students will be able to

CO1. Demonstrate the knowledge of AC–DC Converters of various configurations to model and apply appropriate control technique to analyze their performance subjected to various loads.

CO2. Apply the knowledge of various types of inverter topology and analyze the performance parameters subjected to various control techniques to provide feasible solutions.

CO3. Apply the knowledge of DC-DC converters & AC voltage Controllers and analyze their performance subjected to different load conditions.

DETAILED SYLLABUS:

Unit - I:Single Phase Rectifiers (09 hours)

Classification of converters, analysis of semi controlled and fully controlled converters with R, R-L, freewheeling diodes, continuous & discontinuous modes of operation and evaluation of various performance parameters. Total Harmonic Distortion (THD), power factor, effect of source impedance, extinction angle control, symmetrical angle control and SPWM control.

Unit - II:Multi Pulse Converters (09 hours)

Analysis of semi converter and fully controlled converters with R, R-L loads, freewheeling diodes, continuous and discontinuous modes of operation. Total Harmonic Distortion (THD), power factor improvements and effect of source impedance.

Unit - III: Single and Three Phase Voltage Source Inverters

(11 hours)

Single Phase Voltage Source Inverter: Classification of inverters, single phase half bridge and full bridge voltage source inverters and performance parameters of inverter. Voltage control of single phase inverters – single PWM, multiple PWM, sinusoidal PWM, modified sinusoidal PWM and phase displacement control. Three Phase Voltage Source Inverter: 180° and 120° conduction modes with R load.

Unit - IV: Current Source Inverters (08 hours)

Operation of six-step thyristor inverter, commutated Inverters, Auto Sequential Current source Inverter (ASCI), current pulsations, comparison of current source inverter and voltage source inverters, PWM techniques for current source inverters.

Unit - V:DC-DC Converters andAC Voltage Controllers(08 hours)

DC-DC Converters: Principles of step down and step up converters. Choppers: Types – Class A, B, C, D & E operation and characteristics. Concept of duty ratio and current limit control.
Principle of phase control: Single phase and three phase controllers - Analysis with R and R-L loads.

Total hours: 45

TEXT BOOKS:

1. Muhammad H. Rashid, *Power Electronics: Circuits, Devices and Applications*, 4th Edition, Pearson Education, 2014.
2. Ned Mohan, T. M. Undeland, W.P. Robbins, *Power Electronics: Converters, Applications and Design*, 3rd Edition, Wiley, 2007.

REFERENCE BOOKS:

1. M. D. Singh & K. B. Kanchandhani, *Power Electronics*, 3rd Edition, Tata McGraw – Hill Publishing Company, 2008.
2. Dr. P. S. Bimbhra, *PowerElectronics*, 4th Edition, Khanna Publishers, New Delhi, 2012.
3. P C Sen, *Modern Power Electronics*, 1st Edition, Wheeler publishing Co, New Delhi, 1998.

M. Tech. – I Semester

(19MT18303) POWER SEMICONDUCTOR DEVICES AND MODELING

Int. Marks	Ext. Marks	Total Marks	L	T	P	C
40	60	100	3	-	-	3

PRE-REQUISITES: Courses on Electronic Devices and Power Electronics at UG Level.

COURSE DESCRIPTION: Construction, types, switching, operating characteristics and applications of power semiconductor devices; Design of firing, protective circuits and heat sinks for various power semiconductor devices.

COURSE OUTCOMES: On successful completion of the course, students will be able to

CO1. Apply the knowledge of various power switching devices to model and analyze their performance parameters & characteristics when used for various power converters.

CO2. Demonstrate the operation, analyze the performance characteristics and there by suggest suitable special power devices for power converters.

CO3. Apply the knowledge of firing and protection circuits to model and design power converters.

DETAILED SYLLABUS:

Unit - I:Introduction To Power Switching Devices (08 hours)

Power semiconductor devices: Introduction, classifications of various power switching devices – circuit symbols and ratings. Characteristics of an ideal switch, characteristics of practical devices, switch specifications, device selection strategy and Electro Magnetic Interference (EMI).

Power diodes: Construction, steady state characteristics, switching characteristics, electrical rating, Types – schottky diodes, fast recovery diodes, silicon carbide diodes, series and parallel connected diodes.

Unit - II:Thyristor (09 hours)

Construction, steady state characteristics and switching characteristics. Thyristor protection – di/dt protection, dv/dt protection, design of snubber circuits, over voltage protection, over current protection and gate protection. Heat sink – Thermal resistance and specifications. Improvements of thyristor ratings and thyristor mounting techniques. SPICE Thyristor Model.

Unit - III: Power Transistors (10 hours)

Power Bipolar Junction Transistor: Construction, steady state characteristics, switching characteristics and Safe Operating Area (SOA).

Power MOSFETs: Types - Depletion & Enhancement, construction,

steady state characteristics and switching characteristics.
IGBTs: Construction, steady state characteristics, switching characteristics, series & parallel operation, comparison of BJT, MOSFET & IGBT and design of snubber circuit. BJT, MOSFET and IGBT SPICE Model.

Unit - IV: Special Power Devices (09 hours)

Thyristors: GTOs – Construction, operation, steady state characteristics and switching characteristics. Construction and operation: BCTs, TRIAC, FET – CTHs, ETOs, IGCTs, MCTs, SITHs, ASCR, RCT, SCS and light activated thyristor. Comparison of various thyristors.
Transistors: Construction and operation – COOLMOS and SITs. GTO, MCT and SITH SPICE Model.

Unit - V:Gate Drive Circuits (09 hours)

MOSFET and BJT gate drive circuits. Isolation of gate and base drives – Pulse transformer and opto-couplers. Thyristor firing circuits – R, RC firing circuits, photo – SCR isolator, pulse transformer isolation, 1:6 isolation transformer for inverter gate bias circuits, thyristor converter gating circuits and UJT firing circuits. Gate drive ICs – MOSFETs and IGBTs. Drive ICs for converters – MOS Gated Driver.

Total hours: 45

TEXT BOOKS:

1. Muhammad H. Rashid, *Power Electronics: Circuits, Devices and Applications*, 4th Edition, Pearson Education, 2014.
2. Dr. P. S. Bimbhra, *PowerElectronics*, 4th Edition, Khanna Publishers, New Delhi, 2012.

REFERENCE BOOKS:

1. M. D. Singh & K. B. Kanchandhani, *Power Electronics*, 3rd Edition, Tata McGraw – Hill Publishing Company, 2008.
2. Ned Mohan, T. M. Undeland, W.P. Robbins, *PowerElectronics: Converters, Applications and Design*, 3rd Edition, Wiley, 2007.

M. Tech. – I Semester
(19MT10704) HIGH VOLTAGE DC TRANSMISSION
(Program Elective-1)
(Common to EPS and PED)

Int. Marks	Ext. Marks	Total Marks	L	T	P	C
40	60	100	3	-	-	3

PRE-REQUISITES: Power Electronics and Power Systems at UG level

COURSE DESCRIPTION: HVDC Transmission: Capabilities, Applications and planning; Analysis and control of power converter; Harmonics and Filters; Types of Multi-Terminal DC Systems and control; Faults and Protection.

COURSE OUTCOMES: On successful completion of the course, student will be able to

CO1. Demonstrate the knowledge on HVDC transmission systems, MTDC systems and to analyze and control static power converters.
CO2. Analyze harmonics, filters, faults and protection schemes in HVDC Transmission system.
CO3. Design and develop various types of filters to suppress harmonics in HVDC systems.

DETAILED SYLLABUS:

Unit - I: Introduction To HVDC Transmission (10 hours)

HVDC Transmission – Comparison of HVAC and HVDC transmission, types of DC Links, power handling capabilities of HVDC lines, applications of HVDC Transmission, planning for HVDC transmission, modern trends in DC Transmission, basic conversion principles.

Unit - II: Static Power Convertor Analysis and Control (10 hours)

Static Power Converters: Static converter configuration- 6 pulse & 12 pulse converters, converter station and terminal equipment, rectifier and inverter operation, converter bridge characteristics, equivalent circuit for converter.
Control of HVDC converter: Principle of DC link control – constant current, constant extinction angle and constant ignition angle control. Individual phase control and equidistant firing angle control.

Unit - III: Harmonics and Filters (09 hours)

Generation of harmonics in HVDC systems, methods of harmonics elimination, harmonic instability problems, Causes for instability, remedies for instability problems. Design of AC filters, single frequency tuned filter, Double frequency tuned filter, high pass filter, cost consideration of AC harmonic filter, DC filters.

Unit - IV: Multi-Terminal DC Links and Systems (08 hours)

Introduction – Potential applications of MTDC systems – Types of MTDC systems – series, parallel and series-parallel systems, their principle of operation and control - Protection of MTDC systems.

Unit - V: Faults and Protection (08 hours)

Over voltages due to disturbance on DC side, over voltages due to DC and AC side line faults – Converter faults, over current protection– Valve group and DC line protection. Over voltage protection of converters – Surge arresters.

Total hours: 45

TEXT BOOKS:

1. K.R.Padiyar, *High Voltage Direct current Transmission*, New Age International (P) Ltd, Publishers, 2004.
2. S. Rao, *EHV-AC, HVDC Transmission & Distribution Engineering*, Khanna Publishers, 2006.

REFERENCE BOOKS:

1. E. Uhlman, *Power Transmission by Direct Current*, Springer Verlag, Berlin, 2000.
2. E. W. Kimbark, *Direct current Transmission*, John Wiely& sons, New York, 1971.
3. J. Arillaga, *HVDCTranmission*, peter peregrilnus Ltd., London UK, 1983.

M.Tech. - I Semester

(19MT18304) CONTROL SYSTEM DESIGN

(Program Elective - 1)

(Common to EPS and PED)

Int. Marks	Ext. Marks	Total Marks	L	T	P	C
40	60	100	3	-	-	3

PRE-REQUISITES: Course on Control systems in UG Level.

COURSE DESCRIPTION: Design of compensators and controllers; Controllability and observability of a system; Control systems design using state space; Nonlinear systems.

COURSEOUTCOMES: On successful completion of the course, students will be able to

CO1. Apply the knowledge of Lag, Lead and Lead-Lag compensators to analyze and design the systems in frequency and time domains for the given specifications.

CO2. Demonstrate the knowledge of PD, PI &PID Controllers to develop a suitable controller based on the required time and frequency domain specifications and analyze their performance.

CO3. Apply appropriate methods to solve linear and non-linear systems using state space approach.

CO4. Identify the attributes for analyzing the given non-linear systems.

DETAILED SYLLABUS:

Unit - I: Introduction toDesign (09 hours)

The Design Problem, Preliminary considerations of classical design, Realization of Basic Compensators, Design of Lead, Lag and Lag-Lead compensators using root locus technique. Lead, Lag and Lag-Lead compensators design using Bode plot.

Unit - II: Controllers Design (09 hours)

Introduction to controllers, Types of controllers, Effect of P, PI and PID controllers. Design of PI, PD and PID controllers using bode plot and root locus technique.

Unit - III: Controllability and Observability (09hours)

Review of state variable techniques – Concept of controllability and observability for Continuous Time Systems. Principles of Duality. Controllability and Observability of state models in Jordan canonical form and other canonical forms – effect of state feedback on controllability and observability.

Unit - IV: Design of Control Systems in State Space (09hours)

Necessity of pole placement, design by pole placement, necessary and sufficient conditions for arbitrary pole placement. Determination of feedback gain matrix using direct substitution method and Ackermann's formula. Full order observer and reduced order observer.

Unit - V: Introduction To Non Linear System (09 hours)

Introduction to non-linear systems, behavior of non linear systems, common physical nonlinearities, describing function method, concept derivation of describing function method, phase plane method, singular points, stability of non linear system, construction of phase trajectories by isocline method.

Total hours: 45

TEXT BOOKS:

1. M. Gopal, *Modern Control System Theory*, 2nd edition, New Age International (P) Ltd., New Delhi, 2005.
2. K. Ogata, *Modern Control Engineering,*4th edition, Prentice Hall of India, 2006.
3. Hasan A. Khalil,*Nonlinear Systems*,3rd edition, Prentice Hall of India, 2002.

REFERENCE BOOKS:

1. Nagoorkani, *Advanced control theory*,2nd edition, RBA publications, Chennai, 2009.
2. I.J. Nagrath and M.Gopal, *Control Systems Engineering*, New Age International (P) Ltd., New Delhi, 2007.

M. Tech. – I Semester

(19MT18305) INTELLIGENT CONTROLLERS

(Program Elective – 1)

(Common to EPS and PED)

Int. Marks	Ext. Marks	Total Marks	L	T	P	C
40	60	100	3	-	-	3

PRE-REQUISITES: Engineering Mathematics, Electrical Machines, Power Systems at UG level.

COURSE DESCRIPTION: Neural Networks; Fuzzy Logic Systems; Genetic Algorithms; Differential Evaluation; Hybrid Intelligent Systems; Swarm intelligence; Applications.

COURSE OUTCOMES: On successful completion of the course, student will be able to

CO1. Apply the conceptual knowledge of neural networks and fuzzy logic controllers, evolutionary algorithms in hybrid intelligent controllers to analyze and develop the suitable controller for solving engineering problems.

CO2. Analyze the conceptual knowledge of neural networks and fuzzy logic controllers and various evolutionary algorithms to provide optimal solutions.

DETAILED SYLLABUS:

Unit - I:Neural Networks (10 hours)

Neural network architectures, perceptron model, learning strategies: supervised learning, radial basis function network, back propagation network. Unsupervised learning: Kohonen's SOM, reinforced learning, load forecasting using neural networks.

Unit - II: Fuzzy Logic Systems (9 hours)

Fuzzy sets: relations & operations, membership functions, Fuzzification, rule base, Inference mechanism, defuzzification and design of fuzzy control system, speed control of separately excited DC motor using fuzzy logic.

Unit - III: Genetic Algorithms and Differential Evaluation(10 hours)

Genetic algorithms: Introduction to evolutionary computation, Genetic algorithms (GA): biological background, traditional optimization and search techniques, basic terminologies, simple GA, Flow chart, operators in GA, encoding, selection, crossover, mutation, constraints in GA, fitness function, advantages and limitations of GA, optimal allocation of DG using GA. Differential Evaluation: Overview, initialization, base vector selection, Differential mutation, recombination, selection and Termination criteria.

Unit - IV: Swarm Intelligence **(9 hours)**

Introduction to swarm intelligence, Swarm intelligence algorithms-Ant colony optimization: Biological and artificial ant colony systems, applications of ant colony intelligence: Static & dynamic combinatorial optimization problems, Algorithm of Ant colony system, Particle swarm optimization: The basic PSO method, characteristic features of PSO, PSO algorithm, Optimum parameter setting for the best performance of PSO, Comparison with other Evolutionary computing techniques, MPPT of PV system by using PSO and Ant-colony.

Unit - V: Hybrid Intelligent Systems **(7 hours)**

Introduction to hybrid intelligent systems: Adaptive neuro-fuzzy Inference Systems, Architecture and learning. Fuzzy GA systems: rules generation. ANN Learning Using GA: Optimization of weights, Load forecasting problem using Neuro-fuzzy approach.

Total hours: 45

TEXT BOOKS:

1. S. N. Sivanandam, S.N. Deepa, *Principles of Soft Computing*, *Wiley–India Edition*, 2008.
2. N.P. Padhy, *Artificial Intelligence and Intelligent Systems*, *Oxford University press*, 10th reprint, 2011.

REFERENCE BOOKS:

1. Saroj Kaushik, *Artificial Intelligence*, Cengage Learning India Private Limited, Fifth Indian reprint, 2013.
2. J.S.R. Jang, C.T. Sun, E. Mizutani, *Neuro-fuzzy and Soft Computing: A Computational Approach to Learning and Machine Intelligence*, Pearson EducationTaiwan Limited, 2004.
3. Fakhreddine O. karray, Clarence De Silva, *Soft computing and Intelligent systems Design, Theory, tools and applications*, *Pearson Education Limited*, 2009.
4. Kenneth V. Price · Rainer M. StornJouni A. Lampinen, *Differential Evolution, A Practical Approach to Global Optimization*, Springer, 2005.

M.Tech. – I Semester
(19MT18306) MICROCONTROLLER AND APPLICATIONS
(Program Elective - 1)
(Common to EPS and PED)

Int. Marks	Ext. Marks	Total Marks	L	T	P	C
40	60	100	3	-	-	3

PRE-REQUISITES: Digital logic design, Microprocessors and Microcontrollers at UG level.

COURSE DESCRIPTION:PIC Microcontroller: Architecture, Peripherals, Programming, Interfacing and Applications.

COURSEOUTCOMES: On successful completion of the course, students will be able to

CO1. Demonstrate the knowledge of PIC Microcontroller and its internals and use appropriate tools to program it for the control of systems.
CO2. Interface the peripherals and control them by programing the PIC microcontroller through MPLAB, PIC 'C' Compiler etc.,

DETAILED SYLLABUS:

Unit - I: PIC Microcontrollers (9 hours)

Microcontrollers and Embedded processors, Overview of PIC18 family, CISC vs RISC. Harvard vs Von Neumann architectures. PIC18architecture and features. PIC18 Memory organization – program memory, data memory. PIC18 Register file – General purpose registers and SFRs.

Unit - II: PIC 18 Basic Programming and Tools (9 hours)

Introduction to PIC18 Assembly Programming, PIC18 Data Format and Directives. PIC18 programming tools. Instruction set – data transfer, arithmetic, logical, bit manipulation, branch Instructions. Addressing modes – Immediate, Direct, Register Indirect Addressing Modes. Macros and Modules. PIC18 programming using MPLAB and PIC 'C' Compiler.

Unit - III: Timers, Serial Port and I/O Ports programming (9 hours)

Timer –Programming Timers 0 and 1 in Assembly language, Programming Timers 2 and 3 in Assembly language, Serial Port – Basics of Serial Communication and PIC Serial Port programming in Assembly language. I/O Ports – Port A TRISA, Port B TRISB, Port C TRISC, Port D and Port E.

Unit - IV:Interrupts, CCP and ECCP Programming (9 hours)

PIC18 Interrupts, Programming Timer Interrupts, Programming the Serial Communication Interrupts, Port-B - Change Interrupt, Interrupt Priority in the PIC18. Standard and Enhanced CCP Modules, Compare Mode programming, Capture Mode programming, PWM Programming, ECCP Programming.

Unit - V: PIC Interfacing (9 hours)

ADC Characteristics, ADC Programming in the PIC18, DAC Interfacing, Sensor Interfacing and Signal Conditioning, Relays and Opto-isolators, Stepper Motor Interfacing, DC Motor Interfacing and PWM, PWM Motor Control with CCP, DC Motor Control with ECCP.

Total hours: 45

TEXT BOOKS:

1. Muhammad Ali Mazidi, Rolin D. McKinlay, Danny Causey, *PIC Microcontroller and Embedded Systems: Using assembly and C for PIC 18*, Pearson Education, India, 2008.
2. John B. Peatman, *Design with PIC Microcontrollers*, Pearson Education, India, 2007.

REFERENCE BOOKS:

1. PIC18C MCU Family Reference Manual, Microchip.
2. John B. Peatman, *Embedded design with the PIC18F452 Microcontroller*, Prentice Hall, 2003.

M. Tech. - I Semester

(19MT10705) DIGITAL SIGNAL PROCESSING

(Program Elective – 2)

(Common to EPS and PED)

Int. Marks	Ext. Marks	Total Marks	L	T	P	C
40	60	100	3	-	-	3

PRE-REQUISITES: Laplace transforms, Z-transforms, Fourier Transforms, Signal and Systems.

COURSE DESCRIPTION: Discrete-time signals and systems; Discrete Fourier series, Discrete Fourier Transforms (DFT) and Fast Fourier Transform (FFT) algorithms for the analysis of discrete time sequences; design and realization of Digital IIR and FIR filters; implementation of Park's and Clark's transformation using LF240X processor; DSP based implementation of DC-DC buck-boost converters.

COURSE OUTCOMES: On successful completion of the course, students will be able to

CO1. Demonstrate knowledge of digital signals and systems to analyze DFT and FFT techniques.

CO2. Apply the knowledge of analog and digital filters to design and realize IIR and FIR filters using different techniques.

CO3. Apply DSP controllers for buck-boost converter, control of motors and further extend to real time application.

DETAILED SYLLABUS:

Unit - I: Discrete Time Signals and Systems (8 hours)

Review of discrete time signals and systems; Review of Z-transforms, Solutions for difference equation of discrete time systems; frequency response of discrete time signals; A/D and D/A conversion; Introduction to DSP system with block diagram.

Unit - II: Frequency Transformations (9 hours)

Introduction to DFT – Properties of DFT, relation between DFT and Z-transforms, linear convolution, Circular Convolution. FFT Algorithms – Decimation in time Algorithms, Decimation in frequency Algorithms, inverse DFT.

Unit - III: IIRFilter Design (10 hours)

Digital Vs Analog filters, Analog low pass filter design: Butterworth and chebyshev low pass filters. Design of IIR filter from analog filters using Impulse Invariance and Bilinear transformation techniques. Frequency transformation in digital domain. Realization of Digital filters - Direct form–I and Direct form–II structures.

Unit - IV:FIR Filter Design (8 hours)

Linear phase FIR filters and its frequency response; location of zeros in linear phase FIR filters; Fourier series method of design of FIR filters. Design of FIR filters using windows - Rectangular, Triangular, Hamming, Hanning and Blackmann windows.

Unit - V: DSP Applications (10 hours)

Introduction to peripherals-types of physical memory-software used (Preliminary approach). DSP based implementation of DC-DC buck boost converters – introduction, converter structure, continuous and discontinuous conduction modes, connecting DSP to buck-boost converter, controlling the buck-boost converter. Field Oriented Control (FOC) transformations, implementing Clarke's and Park's Transformations on the LF240X

Total hours: 45

TEXT BOOKS:

1. Anand kumar, *Digital signal processing*, PHI Learning Private limited, New Delhi, 2013.
2. Hamid A. Toliyat, Steven G. Campbell, *DSP based electromechanical motion control*, CRC Press Special Indian edition, 2012.

REFERENCE BOOKS:

1. Nagoorkani, *Digital signal processing*, 2nd Edition, TMH Education Pvt., Ltd., 2012.
2. Alan.V. Oppenheim, Ronald.W. Schafer, John R Buck, *Discrete Time Signal Processing*, Prentice Hall, 2nd edition, 2006.

M.Tech. – I Semester
(19MT10706) POWER QUALITY
(Program Elective – 2)
(Common to EPS and PED)

Int. Marks	Ext. Marks	Total Marks	L	T	P	C
40	60	100	3	-	-	3

PRE-REQUISITES: Power electronics, Electric Machines, Electronic Devices and Circuits at UG level and high power converters at PG level.

COURSE DESCRIPTION: Power Quality concepts; harmonics and power quality standards and monitoring; power quality enhancement using custom power devices; power quality issues in distributed generation.

COURSE OUTCOMES: On successful completion of the course, students will be able to

CO1. Apply the conceptual knowledge of power quality and it's standards to analyze, monitor and mitigate various power quality issues.

CO2. Apply the knowledge of filters to mitigate harmonic distortion due to industrial and commercial loads.

CO3. Apply the conceptual knowledge of various custom power devices to enhance power quality for specific applications.

CO4. Demonstrate the conceptual knowledge of distributed generation to analyze the power quality issues in power systems.

DETAILED SYLLABUS:

Unit - I: Fundamentals Of Power Quality (10 hours)

Definition of Power Quality, Classification of Power Quality Issues, Power Quality Standards, Categories and Characteristics of Electromagnetic Phenomena in Power Systems: Impulsive and Oscillatory Transients, Interruption, Sag, Swell, Sustained Interruption, Under Voltage, Over Voltage, Outage. Sources and causes of different Power Quality Disturbances.

Unit - II: Harmonics & Applied Harmonics (10 hours)

Harmonic Distortion, Voltage Vs Current Distortion, Harmonics Vs Transients, Power System Qualities under Non Sinusoidal Conditions, Harmonic Indices, Harmonic Sources from Commercial Loads, Harmonic Sources from Industrial Loads. Applied Harmonics: Effects of Harmonics, Harmonic Distortion Evaluations, Principles of controlling harmonics, devices for Controlling Harmonic Distortion.

Unit - III: Power Quality Monitoring (08 hours)

Power quality benchmarking, monitoring considerations, choosing monitoring locations, permanent power quality monitoring equipment, historical perspective of power quality measuring instruments, power quality measurement equipment-types of instruments, assessment of power quality measurement data, power quality monitoring standards.

Unit - IV: Power Quality Enhancement Using Custom Power Devices (09 hours)

Introduction to Custom Power Devices-Network Reconfiguring Type: Solid State Current Limiter (SSCL) -Solid State Breaker (SSB) -Solid State Transfer Switch (SSTS). Compensating Type: Dynamic Voltage Restorer, Distribution STATCOM and Unified Power Quality Conditioner –operation, realization and control of DVR, DSTATCOM and UPQC – load compensation.

Unit - V: Power Quality Issues in Distributed Generation (08 hours)

DG Technologies, Perspectives on DG benefits- Interface to the Utility System - power quality issues affected by DG - Operating Conflicts: Utility fault-clearing, Reclosing, Interference with relaying, Voltage regulation issues, Islanding - siting DG.

Total hours: 45

TEXT BOOKS:

1. Roger C. Dugan, Mark E. Mc. Granaghan, Surya Santosoh and H. Wayne Beaty, Electrical Power Systems Quality, 2nd edition, TATA McGraw Hill, 2010.
2. ArindamGhosh, Gerard Ledwich, Power Quality Enhancement Using Custom Power Devices, Springer, 2002.

REFERENCE BOOKS:

1. Math H J Bollen, Understanding Power Quality Problems, IEEE Press, 1998.
2. C. Sankaran,Power quality, CRC Press, 2002.

M.Tech. - I Semester
(19MT10707) SMART GRIDS
(Program Elective - 2)
(Common to EPS and PED)

Int. Marks	Ext. Marks	Total Marks	L	T	P	C
40	60	100	3	-	-	3

PRE-REQUISITES: Power Systems at UG level.

COURSE DESCRIPTION: Concept of smart grid; various information and communication technologies for smart Grid; Smart metering; Demand side integration; Energy management systems.

COURSE OUTCOMES: On successful completion of the course, students will be able to

CO1. Apply the conceptual knowledge of smart grid and communication technologies to analyze fault levels and to estimate the state of the system.

CO2.Apply
- modern techniques to integrate renewable energy sources to power system.
- information security tools for secured operation of smart grid.

DETAILED SYLLABUS:

Unit - I: Smart Grid (05 hours)

smart grid introduction, ageing assets and lack of circuit capacity, thermal constraints, operational constraints, security of supply, national initiatives, early smart grid initiatives, active distribution networks, virtual power plant, other initiatives and demonstrations, overview of the technologies required for the smart grid.

Unit - II: Transmission and Distribution Management System (09 hours)

Data Sources, Energy Management System, Wide Area Applications, Visualization Techniques, Data Sources and Associated External Systems, SCADA, Customer Information System, Modeling and Analysis Tools, Distribution System Modeling, Topology Analysis, Load Forecasting, Power Flow Analysis, Fault Calculations, State Estimation, Applications, System Monitoring, Operation, Management, Outage Management System, Overview of energy storage technologies.

Unit - III: Smart Metering and Demand Side Integration (11 hours)

Introduction, smart metering – evolution of electricity metering, key components of smart metering, smart meters: an overview of the hardware used – signal acquisition, signal conditioning, analogue to digital conversion, computation, input/output and communication. Communication infrastructure and protocols for smart metering - Home area network, Neighborhood Area Network, Data Concentrator, meter data management system, Protocols for communication. Demand Side Integration- Services Provided by DSI, Implementation of DSI, Hardware Support, Flexibility Delivered by Prosumers from the Demand Side, System Support from DSI.

Unit - IV: Communication Technologies for the Smart Grid (11 hours)

Data Communications: Dedicated and Shared Communication Channels, Switching Techniques, Circuit Switching, Message Switching, Packet Switching, Communication Channels, Introduction to TCP/IP
Communication Technologies: IEEE 802 Series, Mobile Communications, Multi-Protocol Label Switching, Power line Communication.

Unit - V: Information Security for the Smart Grid(09 hours)

Introduction, Encryption and Decryption, Symmetric Key Encryption, Public Key Encryption, Authentication, Authentication Based on Shared Secret Key, Authentication Based on Key Distribution Center, Digital Signatures, Secret Key Signature, Public Key Signature, Message Digest.

Total hours: 45

TEXT BOOKS:

1. JanakaEkanayake, KithsiriLiyanage, Jianzhong Wu, Akihiko Yokoyama, Nick Jenkins, *Smart Grid Technology and Applications*, Wiley Publications, 2012.
2. James Momoh, *Smart Grid: Fundamentals of Design and Analysis*, Wiley, IEEE Press, 2012.
3. Bharat Modi, Anuprakash, Yogesh Kumar, *Fundamentals of Smart Grid Technology*, S.K Kataria& Sons, 2015.

REFERENCE BOOKS:

1. Eric D. Knapp, Raj Samani, *Applied Cyber Security and the Smart Grid-Implementing Security Controls into the Modern Power Infrastructure*, Syngress Publishers, 2013.
2. Nouredine Hadjsaid, Jean Claude Sabonnadiere, *Smart Grids*, Wiley Blackwell Publications.
3. Peter-Fox Penner, *Smart Power: Climate Changes, the Smart Grid, and the future of electric utilities,* Island Press, 1stedition, 2010.

M. Tech. –I Semester

(19MT18307) ELECTROMAGNETIC FIELD COMPUTATION AND MODELING

(Program Elective-2)

(Common to EPS and PED)

Int. Marks	Ext. Marks	Total Marks	L	T	P	C
40	60	100	3	-	-	3

PRE-REQUISITES: Electromagnetic fields, Electrical Machines at UG level.

COURSE DESCRIPTION: Review of basic field theory; Basic solution methods for field equations; Formulation of finite element method; Computation of basic quantities using FEM packages; Design applications.

COURSE OUTCOMES: On successful completion of the course, students will be able to

CO1. Apply the knowledge of Electromagnetic fields to analyze various electrical field problems using analytical and numerical methods.

CO2. Demonstrate the knowledge in Computation of electrical parameters using Finite Element Method.

CO3. Provide solutions to design electrical equipment.

DETAILED SYLLABUS:

Unit - I: Introduction (9 hours)

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

Unit - II: Basic Solution Methods for Field Equations (9 hours)

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

Unit - III: Formulation of Finite Element Method (9 hours)

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

Unit - IV: Computation of Basic Quantities Using FEM Packages (6 hours)

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

Unit - V: Design Applications (12 hours)

Electromagnetic field analysis of Magnetic actuators, transformers, switched reluctance motors, three phase induction motors.

TEXT BOOKS:

1. Matthew. N.O. Sadiku, *Elements of Electromagnetics*, Fourth Edition, Oxford University Press, First Indian Edition 2007.
2. Nicola Biyanchi , *Electrical Machine analysis using Finite Elements*, Taylor and Francis Group, CRC Publishers, 2005.

REFERENCE BOOKS:

1. Nathan Ida, Joao P.A.Bastos, *Electromagnetics and calculation of fields*, SpringerVerlage, 1992.
2. S.J Salon, *Finite Element Analysis of Electrical Machines,* Kluwer Academic Publishers, London, 1995, distributed by TBH Publishers & Distributors, Chennai, India.
3. User manuals of MAGNET, MAXWELL & ANSYS software.

M. Tech.-I Semester

(19MT10708) RESEARCH METHODOLOGY and IPR

(Common to all M. Tech. Programs)

Int. Marks	Ext. Marks	Total Marks	L	T	P	C
40	60	100	2	-	-	2

PRE REQUISITES: Engineering Mathematics at UG level.

COURSE DESCRIPTION: Overview of research; research problem and design; various research designs; Data collection methods; Statistical methods for research; Interpretation& drafting reports and Intellectual property rights.

COURSE OUTCOMES: On successful completion of the course, student will be able to:

CO1. Apply the conceptual knowledge of research methodology to formulate the hypothesis, data collection and processing, analyzing the data using statistical methods, interpret the observations and communicating the novel findings through a research report.

CO2. Practice ethics and have responsibility towards society throughout the research process and indulge in continuous learning process.

CO3. Apply the conceptual knowledge of intellectual property rights for filing patents and trade mark registration process.

DETAILED SYLLABUS:

Unit - I: Introduction to Research Methodology (07 hours)

Objectives and Motivation of Research, Types of Research, Defining and Formulating the Research Problem; Features of research design, Different Research Designs; Different Methods of Data Collection, Data preparation and Processing.

Unit - II: Data Analysis and Hypothesis Testing (09 hours)

ANOVA; Principles of least squares-Regression and correlation; Normal Distribution- Properties of Normal Distribution; Testing of Hypothesis – Hypothesis Testing Procedure, Types of errors, t-Distribution, Chi-Square Test as a Test of Goodness of Fit.

Unit - III: Interpretation and Report Writing (04 hours)

Interpretation – Need, Techniques and Precautions; Report Writing – Significance, Different Steps, Layout, Types of reports,Mechanics of Writing a Research Report, Precautions in Writing Reports; Research ethics.

Unit - IV: Introduction to Intellectual Property and Trade Marks

(07 hours)

Importance of intellectual property rights; types of intellectual property, international organizations; Purpose and function of trademarks, acquisition of trade mark rights, protectable matter, selecting and evaluating trade mark, trade mark registration processes.

Unit - V: Law of Copyrights (08 Hours)

Fundamental of copy right law, originality of material, rights of reproduction, rights to perform the work publicly, copy right ownership issues, copy right registration, notice of copy right, international copy right law.

Law of patents: Foundation of patent law, patent searching process, ownership rights and transfer

New Developments in IPR: Administration of Patent System.

Total hours: 35

TEXT BOOKS:

1. C.R. Kothari, *Research Methodology: Methods and Techniques*, 2nd revised edition, New Age International Publishers, New Delhi, 2004.
2. Deborah, E. Bouchoux, *Intellectual Property: The Law of Trademarks, Copyrights, Patents and Trade Secrets*, 5th edition, Cengage learning, 2017.

REFERENCE BOOKS:

1. R. Panneerselvam, *Research Methodology*, PHI learning Pvt. Ltd., 2009.
2. Prabuddha Ganguli, *Intellectual property right - Unleashing the knowledge economy*, Tata McGraw Hill Publishing Company Ltd, 2001.

M. Tech. – I Semester

(19MT18331)POWER ELECTRONICS DESIGN LAB

Int. Marks	Ext. Marks	Total Marks	L	T	P	C
50	50	100	-	-	4	2

PRE-REQUISITES: Courses on Electronic Devices, Power Electronics at UG Level

COURSE DESCRIPTION: Design and development of various power converters.

COURSE OUTCOMES: On successful completion of the course, students will be able to

CO1. Identify appropriate devices, domain specific tools and techniques to develop and control power electronic converters.

CO2. Analyze and evaluate the performance of Power converters by practicing professional code of ethics.

CO3. Prepare laboratory reports that clearly communicate experimental information.

CO4. Function effectively as an individual to solve various problems.

PRACTICAL EXERCISES/LIST OF EXPERIMENTS: Conduct any **Two Experiments** from the following:

1. Design, develop and analyze DC to DC converter using IGBTs.
2. Design, develop and analyze DC to DC converter using Power MOSFETs.
3. Design, develop and analyze DC to AC converter using IGBTs.
4. Design, develop and analyze DC to AC converter using Power MOSFETs.
5. Design, develop and analyze AC to AC converters using SCRs.
6. Design, develop and analyze AC to AC converters using TRIACs.
7. Design, develop and analyze AC to AC converters using IGBTs.
8. Design, develop and analyze AC to DC converters using SCRs and Diodes.
9. Analysis of Three Level Neutral Point Clamped Multilevel Inverter.
10. Design, develop and analyze a five level cascaded multilevel inverter.

M. Tech. – I Semester

(19MT18332)POWER ELECTRONICS SIMULATION LAB

Int. Marks	Ext. Marks	Total Marks	L	T	P	C
50	50	100	-	-	4	2

PRE-REQUISITES: Courses on Electronic Devices, Power Electronics at UG Level.

COURSE DESCRIPTION: Design and simulation of various power converters.

COURSEOUTCOMES: On successful completion of the course, students will be able to

CO1. Identify appropriate devices, domain specific tools and techniques to develop and control power electronic converters.

CO2. Analyze and evaluate the performance of Power converters by practicing professional code of ethics.

CO3. Prepare laboratory reports that clearly communicate experimental information.

CO4. Function effectively as an individual to solve various problems.

LIST OF EXPERIMENTS: Conduct any **TEN** Experiments from the following using **MATLAB/PSPICE**

1. Simulation of single phase semi converter.
2. Simulation of single phase fully controlled converter.
3. Simulation of three phase semi converter.
4. Simulation of three phase fully controlled converter.
5. Simulation of single phase full bridge inverter.
6. Simulation of three phase full bridge inverter.
7. Simulation of sinusoidal PWM inverter.
8. Simulation of single phase and three phase AC voltage controllers.
9. Simulation of DC–DC Buck–Boost Converter.
10. Simulation of Three Level Neutral Point Clamped Multilevel Inverter.
11. Simulation of Five Level Flying Capacitor Multilevel Inverter.
12. Simulation of Five Level H–Bridge Cascaded Multilevel Inverter.

M. Tech. - I Semester

(19MT1AC01) TECHNICAL REPORT WRITING

(Audit Course)

Int. Marks	Ext. Marks	Total Marks	L	T	P	C
-	-	-	2	-	-	-

PRE-REQUISITES: -

COURSE DESCRIPTION: Introduction; Process of writing; Style of writing; Referencing; Presentation.

COURSE OUTCOMES: On successful completion of the course, students will be able to

CO1. Demonstrate knowledge of Technical Report Writing by examining kinds of reports and structure with scientific attitude.

CO2. Apply the techniques in preparing effective reports by examining Techniques of Description, Describing Machines and Mechanisms and Describing Processes.

CO3. Communicate effectively through writing technical reports by demonstrating the knowledge of Industry Reports, Survey Reports, Interpretive Report and Letter Report.

DETAILED SYLLABUS:

Unit - I:Introduction (6 hours)

Introduction to Technical Report - Types of Reports - Planning Technical Report Writing - Components of a Technical Report - Report Writing in Science and Technology - Selecting and Preparing a 'Title' - Language Use in Report Writing.

Unit - II:Process of Writing (5 hours)

Writing the 'Introduction' - Writing the 'Materials and Methods' - Writing the Findings/Results' - Writing the 'Discussion' - Preparing and using 'Tables'.

Unit - III:Style of Writing (6 hours)

Preparing and using Effective 'Graphs' - Citing and Arranging References—I - Citing and Arranging References —II - Writing for Publication in a Scientific Journal.

Unit - IV:Referencing(9 hours)

Literature citations - Introductory remarks on literature citations - Reasons for literature citations – Bibliographical data according to ISO - Citations in the text - Copyright and copyright laws - The text of the Technical Report - Using word processing and desktop publishing (DTP) systems - Document or page layout and hints on editing - Typographic details - Cross-references.

Unit - V:Presentation (4 hours)

Giving the presentation - Appropriate pointing - Dealing with intermediate questions - Review and analysis of the presentation - Rhetoric tips from A to Z.

Total hours: 30

TEXT BOOKS:

1. R C Sharma – Krishna Mohan, *Business Correspondence and Report Writing,* Tata McGraw-Hill Publishing Company Limited, New Delhi, Third Edition, 2005 (reprint).
2. Patrick Forsyth*, How to Write Reports and Proposals,*THE SUNDAY TIMES (Kogan Page), New Delhi, Revised Second Edition, 2010.

REFERENCE BOOKS:

1. John Seely, *The Oxford Writing & Speaking*, Oxford University Press, Indian Edition.
2. Anne Eisenberg, *A Beginner's Guide to Technical Communication*, McGraw Hill Education (India) Private Limited, New Delhi, 2013.

M. Tech. – II Semester

(19MT28301)DIGITAL CONTROL OF POWER ELECTRONICS AND DRIVE SYSTEMS

Int. Marks	Ext. Marks	Total Marks	L	T	P	C
40	60	100	3	-	-	3

PRE-REQUISITES: Courses on Power Electronics, Power Semiconductor Drives at UG Level.

COURSE DESCREPTION: Peripherals; Memory addressing modes; DSP based control of dc-dc converters; DSP based control of matrix converters; DSP based control of PMBLDC and SRM drives.

COURSE OUTCOMES: On successful completion of the course, students will be able to

CO1. Apply the knowledge of various addressing modes of LF2407 processor and its instruction set to develop simple and complex programs to control power electronic circuits.

CO2. Apply the knowledge of Space vector modulation technique to control inverter fed AC drives and to implement them in real time using LF2407.

CO3. Design and develop controller for PMBLDC and SRM drives using LF2407.

DETAILED SYLLABUS:

Unit - I: Motor Control Signal Processors (09 hours)

Introduction- Brief Introduction to Peripherals -Types of Physical Memory - The Components of the C2xx DSP Core -System configuration registers- Memory Addressing modes - Instruction set – Programming techniques – simple programs.

Unit - II: Peripherals of Signal Processors (09 hours)

General purpose Input/output (GPIO) Functionality- Interrupts - A/D converter-Event Managers (EVA, EVB)- PWM signal generation.

Unit - III: DSP-Based Control of DC-DC Converters (09 hours)

Introduction- Converter Structure-Continuous Conduction Mode, Discontinuous Conduction Mode- Connecting the DSP to the Buck-Boost Converter- Controlling the Buck-Boost Converter-Main Assembly Section Code Description Interrupt Service Routine. The regulation Code Sequences.

Unit - IV: DSP-Based Control of Matrix Converters (09 hours)

Space Vector Pulse Width Modulation- Principle of Constant V/Hz Control for Induction Motors- Space Vector PWM Technique- DSP Implementation-Introduction to matrix converter-Topology and Characteristics- Control Algorithms- Bidirectional Switch-Current Commutation - Overall Structure of Three-Phase Matrix Converter-Implementation of the Venturini Algorithm using the LF2407.

Unit - V: DSP-Based Control of PMBLDC and SRM Drives (09 hours)

Control of PMBLDC motor drives: Introduction-Principles of the BLDC Motor-Torque Generation -BLDC Motor Control System Implementation of the BLDC Motor Control System Using LF2407.Control of SRM drives: Introduction-Fundamentals of Operation-Fundamentals of Control in SRM Drives- Open Loop Control Strategy for Torque- Closed Loop Torque Control of the SRM Drive.

Total hours: 45

TEXT BOOKS:

1. Hamid A.Toliyat, Steven Campbell, *DSP based electromechanical motion control*, CRC Press, Special Indian Edition.

REFERENCE BOOKS:

1. R.Krishnan*, Electric Motor Drives – Modeling, Analysis and Control,* Prentice-Hall of India Pvt. Ltd., New Delhi, 2010
2. T.Kenjo and S.Nagamori*, Permanent magnet and Brushless DC motors,* Clarendon press, London, 1988.

M. Tech. – II Semester

(19MT28302) ELECTRICAL DRIVES

Int. Marks	Ext. Marks	Total Marks	L	T	P	C
40	60	100	3	-	-	3

PRE-REQUISITES: Courses on Power Electronic Converters, Modelling & Analysis of Electrical Machines.

COURSE DESCRIPTION: Performance characteristics and parameters of single phase, three phase converters fed DC motor; Chopper control of DC drives; Open loop and closed loop speed control of induction motor; Induction motor drive, torque control, field oriented control; Synchronous motor drive; synchronous motor control.

COURSE OUTCOMES: On successful completion of the course, students will be able to

CO1. Demonstrate knowledge on various electrical drives.

CO2. Use the knowledge of converter/chopper fed DC drives of various configurations to analyze and select appropriate power circuit configuration for obtaining the better torque-speed characteristics.

CO3. Apply the knowledge of various types of induction motor drives and analyze their performance characteristics with the effects of various control strategies

CO4. Apply the knowledge of synchronous motor drive and analyze the performance parameters subjected to various control techniques.

CO5. Design and develop electrical drives to solve engineering problems pertaining to drives in real time applications.

DETAILED SYLLABUS:

Unit - I: Rectifier Control of DC Drives (09 hours)

Principle of phase control–Fundamental relations; Analysis of separately excited DC motor with single-phase and three-phase converters–waveforms, performance parameters, performance characteristics. Continuous and discontinuous armature current operations; Current ripple and its effect on performance; Operation with freewheeling diode; Implementation of braking schemes; Drive employing dual converter.

Unit - II: Chopper Control of DC Drives (09 hours)

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

Unit - III: Control of Induction Motor Drives-Stator Side and Rotor Side (09 hours)

AC voltage controller circuit, six step inverter voltage control, closed loop variable frequency PWM inverter with dynamic braking, CSI fed variable frequency drives- comparison. Static rotor resistance control, injection of voltage in the rotor circuit, static scherbius drives, power factor considerations, modified Kramer drives.

Unit - IV: Field Oriented Control of Induction Motor Drives (09 hours)

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

Unit - V: Synchronous Motor Drives (09 hours)

Wound field cylindrical rotor motor–Equivalent circuits, performance equations for operation from a voltage source, starting and braking, V curves. Self-control, margin angle control, torque control, power factor control. Brushless excitation systems

Total hours: 45

TEXT BOOKS:

1. P.C Sen, *Thyristor DC Drives,* John wiely and sons, New York, 1981
2. Gopal K Dubey, *Power Semiconductor controlled Drives*, Prentice Hall Inc., NewJersy, 1989
3. Gopal K.Dubey, *Fundamentals of Electrical Drives*,2ndEdition,Narosa Publishing House, New Delhi, 2009
4. Bimal K Bose, *Modern Power Electronics and AC Drives,* PearsonEducation Asia, 2002.

REFERENCE BOOKS:

1. R.Krishnan, *Electric Motor Drives–Modeling, Analysis and Control*,Prentice-Hall of India Pvt. Ltd., New Delhi, 2010.
2. VedamSubramanyam, *Electric Drives–Concepts and Applications,* TataMcGraw-Hill publishing company Ltd., New Delhi, 2002
3. W.Leonhard, *Control of Electrical Drives*, Narosa Publishing House, 1992
4. Murphy J.M.D and Turnbull, *Thyristor Control of AC Motors*, PergamonPress, Oxford, 1988.

M. Tech. – II Semester

(19MT28303) ADVANCED POWER ELECTRONIC CIRCUITS

(Program Elective – 3)

Int. Marks	Ext. Marks	Total Marks	L	T	P	C
40	60	100	3	-	-	3

PRE-REQUISITES: Courses on Power Electronic Converters, Power Semiconductor Devices.

COURSE DESCRIPTION: Improved DC-DC Converters – Types and operation; Voltage-Lift DC-DC Converters;Super-Lift Converters; Ultra-Lift DC-DC Converter; Multilevel and Soft-Switching DC-AC Inverters – Types, operation and applications; Improved AC-AC Converters Inverters.

COURSE OUTCOMES: On successful completion of the course, students will be able to

CO1. Apply the knowledge of various types of improved AC-DC Converters and use appropriate control technique to model and analyze with different configurations subjected to various loads.

CO2. Describe the operation of voltage-lift, super-lift & ultra-lift DC-DC converter and analyze their performance factors with the effects of various control techniques.

CO3. Demonstrate the knowledge of various types of multilevel and soft-switching DC-AC inverter topology and analyze the performance parameters with various control techniques.

CO4. Understand the knowledge of different types of improved AC-AC converters and use appropriate control techniques to model and analyze with different configurations.

DETAILED SYLLABUS:

Unit - I:Improved AC-DC Converters (09 hours)

DC/DC Converterized Rectifiers, PWM Boost-Type Rectifiers - DC-Side PWM Boost-Type Rectifier - Constant-Frequency Control, Constant-Tolerance-Band (Hysteresis) Control and Source-Side PWM Boost-Type Rectifiers. Tapped-Transformer Converters, Single-Stage PFC AC/DC Converters - Operating Principles, Mathematical Model Derivation - Averaged Model over One Switching Period T_s and Averaged Model over One Half Line Period T_L. VIENNA Rectifiers - Circuit Analysis and Principle of Operation, Proposed Control Arithmetic, Block Diagram of the Proposed Controller for the VIENNA Rectifier and Converter Design and Waveform Analysis.

Unit - II:Voltage-Lift DC-DC Converters (09 hours)

Self-Lift Cuk-Converter – Continuous and Discontinuous mode operation. P/O Luo-Converters - Relift Circuit, Triple-Lift Circuit and Quadruple-Lift Circuit. N/O Luo-Converters - Relift Circuit, N/O Triple-Lift Circuit and N/O Quadruple-Lift Circuit. Voltage Lift SEPICs - Self-Lift SEPIC, Relift SEPIC and Multiple-Lift SEPICs.

Unit - III: Super-Lift Converters and Ultra-Lift DC-DC Converter

(09 hours)

P/O SL Luo-Converters: Elementary Circuit, Relift Circuit, Triple-Lift Circuit and Higher Order Lift Circuit. N/O Cascaded Boost Converters: Main series - N/O Elementary Boost Circuit, N/O Two-Stage Boost Circuit, N/O Three-Stage Boost Circuit and N/O Higher Stage Boost Circuit. UL Luo-Converter – Operation of Continuous and Discontinues Conduction Mode.

Unit - IV: Multilevel and Soft-Switching DC-AC Inverters (09 hours)

Multilevel Inverters: Types - Diode-Clamped Multilevel Inverters, Capacitor-Clamped Multilevel Inverters and Multilevel Inverters using H-Bridge Converters. Soft-Switching Multilevel Inverters: Notched DC-Link Inverters for Brushless DC Motor Drive - Resonant Circuit, Design Consideration, Control Scheme and waveform analysis. Resonant Pole Inverter: Operating Principle, Topology of the Resonant Pole Inverter, Design Considerations waveform analysis.

Unit - V:Improved AC-AC Converters (09 hours)

DC-Modulated Single-Phase Single-Stage AC/AC Converters: Bidirectional Exclusive Switches S_M–S_s, Mathematical Modeling of DC/DC Converters, DC-Modulated Single-Stage Buck-Type AC/AC Converter, DC-Modulated Single-Stage Boost-Type AC/AC Converter, DC-Modulated Single-Stage Buck–Boost-Type AC/AC Converter. DC-Modulated P/O Luo-Converter-Type AC/AC Converter and DC-Modulated Two-Stage Boost-Type AC/AC Converter. DC-Modulated Multiphase AC/AC Converters: Types - DC-Modulated Three-Phase Buck-Type AC/AC Converter, Boost-Type AC/AC Converter and Buck–Boost-Type AC/AC Converter. Matrix Converter – Principle of operation.

Total hours: 45

TEXT BOOKS:

1. Fang Lin Luo and Hong Ye, *Power Electronics Advanced Conversion Technologies*, 2nd Edition, CRC Press, 2018.
2. Sergio Alberto Gonzalez, Santiago Andres Verne & Maria Ines Valla, *Multilevel Converters for Industrial Applications*, 1st Edition, CRC Press, 2014.

REFERENCE BOOKS:

1. Muhammad H. Rashid, *Power Electronics: Circuits, Devices and Applications*, 4th Edition, Pearson Education, 2014.
2. Ned Mohan, T. M. Undeland, W.P. Robbins, *PowerElectronics: Converters, Applications and Design*, 3rd Edition, Wiley, 2007.

M. Tech. – II Semester

(19MT28304) MULTILEVEL INVERTERS

(Program Elective – 3)

Int. Marks	Ext. Marks	Total Marks	L	T	P	C
40	60	100	3	-	-	3

PRE-REQUISITES: Courses on Power Electronic Converters and Power Semiconductor Devices & Modeling.

COURSE DESCRIPTION: Symmetric and Asymmetric multilevel inverter; Diode Clamped Multilevel Converter – Types and operation; Flying Capacitor Multilevel Converter: Types and operation; Cascaded Asymmetric Multilevel Converter: Types and operation;Application of Multilevel Inverter fed Drive.

COURSE OUTCOMES: On successful completion of the course, students will be able to

CO1. Demonstrate the knowledge of multilevel and control techniques to design a three level inverter.

CO2. Demonstrate the knowledge of various topologies of multilevel inverter and use appropriate control technique to model and evaluate their performance parameters.

CO3. Select appropriate multilevel inverter and control techniques to provide feasible solutions.

DETAILED SYLLABUS:

Unit - I:Introduction (08 hours)

Generalized topology with a Common DC Bus - Basic cell, Generalized topology, Characteristics and Three-level generalized Topology. Filtering circuit - Inductor as a low pass filter and capacitor as a low pass filter. Sine Triangle Pulse Width Modulation (PWM) and power switches requirements. H-bridge multilevel inverters - operation, topology, waveforms and advantages.

Unit - II:Diode Clamped Multilevel Converter (10 hours)

Diode Clamped Topology - Neutral Point Clamped (NPC) Converter topology, Four level diode clamped topology, Five level diode clamped topology and n-Level Diode Clamped Multilevel Converter (DCMC) topologies. Converter structure and functional description - Voltage clamping and switching logic. Modulation of Multilevel Converters - Multilevel Space Vector Modulation - Hexagonal co-ordinate System, Nearest three vectors identification, Duty cycle calculation, Voltage balance control - Capacitor voltage calculation, Voltage balance optimization and Flow diagram.

Unit - III: Flying Capacitor Multilevel Converter (10 hours)

Voltage on the flying capacitor, Four level flying capacitor topology, Five level flying capacitor multilevel inverter and charge balance on the flying capacitors. Modulation scheme for the Flying Capacitor Multilevel Converter (FCMC) - Phase Shifted Carrier Pulse Width Modulation (PSPWM) - Charge balance using PSPWM. Dynamic voltage balance of the FCMC - Dynamic model and Tuned balancing network - Root locus analysis.

Unit - IV: Cascaded Asymmetric Multilevel Converter(08 hours)

Symmetric topologies without a Common DC Link - Five level Cascaded Cell Multilevel Converter (CCMC), Asymmetric topologies: Hybrid Asymmetric topologies - Hybrid Asymmetric Topologies and CCMC with Different Values of Voltage Sources, Combining Different Topologies and Cascade Asymmetric Multilevel Converter. General Characteristics of the Cascaded Asymmetric Multilevel Converter (CAMC) - Modulation Strategy and Averaged Voltage. Comparison of the Five-Level Topologies - DCMC, FCMC, CCMC and CAMC.

Unit - V:Application of Multilevel Inverter (09 hours)

Medium-Voltage Motor Drive Built with Diode Clamped Multilevel Converter (DCMC): Back-to-Back DCMC Converter, Unified Predictive Controller of the Back-to-Back DCMC in an IM Drive Application - Control of the Back-to-Back DCMC Converter, Load converter - Predictive torque control, Line converter - Predictive power control, Current and Power calculations, Dynamic active power reference design and Switching transition constraint, Performance evaluation - Mechanical load variation, Voltage sag, Energy recovery and Effectiveness of the DC Bus balancing algorithm.

Total hours: 45

TEXT BOOKS:

1. Sergio Alberto Gonzalez, Santiago Andres Verne & Maria Ines Valla, *Multilevel Converters for Industrial Applications*, 1st Edition, CRC Press, 2014.
2. Krishna Kumar Gupta & Pallavee Bhatnagar, *Multilevel Inverters Conventional and Emerging Topologies and their Control,* 1st Edition, Academic Press, 2018.

REFERENCE BOOKS:

1. Muhammad H. Rashid, *Power Electronics: Circuits, Devices and Applications*, 4th Edition, Pearson Education, 2014.
2. Ned Mohan, T. M. Undeland, W.P. Robbins, *PowerElectronics: Converters, Applications and Design*, 3rd Edition, Wiley, 2007.

M. Tech. – II Semester

(19MT28305) SOLAR ENERGY CONVERSION SYSTEMS

(Program Elective-3)

(Common to EPS and PED)

Int. Marks	Ext. Marks	Total Marks	L	T	P	C
40	60	100	3	-	-	3

PRE-REQUISITES: Courses on Power Electronic Converters.

COURSE DESCRIPTION: Solar energy conversion system; Types of photovoltaic systems – Stand-alone, hybrid and grid connected systems; Energy storage systems; Applications.

COURSE OUTCOMES: On successful completion of the course, students will be able to

CO1.Demonstrate knowledge on solar cell and analyze the behavior of solar cells for different irradiations.

CO2.Apply the knowledge of solar modules, energy storage system and MPTT to design the stand-alone and grid connected PV systems for various real time applications.

DETAILED SYLLABUS:

Unit - I: Photovoltaic Basics (09 hours)

Structure and working of Solar Cells - Types, Electrical properties and Behaviour of Solar Cells - Cell properties and design - PV Cell Interconnection and Module Fabrication - PV Modules and arrays – open circuit (Voc) and short circuit characteristics of a PV array- Basics of Load Estimation.

Unit - II: Stand Alone PV System (09 hours)

Solar modules – storage systems – power conditioning and regulation - MPPT- protection – stand alone PV systems design – sizing.

Unit - III: Grid Connected PV Systems (09 hours)

Schematics, Components, solar converters –state of charge characteristics (SOC) - Charge Conditioners, Interface Components - Balance of system Components - PV System in Buildings-Micro Grid structure.

Unit - IV:Design of PV Systems (09 hours)

Radiation and load data - Design of System Components for different PV Applications - Sizing and Reliability - Simple Case Studies.

UNIT - V: Applications (09 hours)

Water pumping, Battery chargers, Solar car, Direct-drive applications, Space and Telecommunications.

Total hours: 45

TEXT BOOKS:

1. SolankiC.S., *Solar Photovoltaics: Fundamentals, Technologies and Applications*,PHI Learning Pvt. Ltd.,2015.
2. Stuart R.Wenham, Martin A.Green, Muriel E. Watt and Richard Corkish, *Applied Photovoltaics*, Earthscan, 2007.
3. Earthscan,UK.Eduardo Lorenzo G. Araujo, *Solar electricity engineering of photovoltaic systems*, Progensa, 1994.

REFERENCE BOOKS:

1. Frank S. Barnes & Jonah G. Levine, *Large Energy storage Systems Handbook*, CRCPress, 2011.
2. McNeils, Frenkel, Desai, *Solar & Wind Energy Technologies*, Wiley Eastern, 1990.
3. S.P. Sukhatme, *Solar Energy*, Tata McGraw Hill, 1987.
4. Nikos Hatziargyriou - Microgrids- Architectures and control, Wiley, IEEE press, 2013.

M. Tech. – II Semester

(19MT28306) SPECIAL ELECTRICAL MACHINES

(Program Elective - 3)

Int. Marks	Ext. Marks	Total Marks	L	T	P	C
40	60	100	3	-	-	3

PRE-REQUISITES: Courses on Electrical Machines, Control Systems, power electronics at UG level.

COURSE DESCREPTION: Constructional features, operating principles, characteristics and control of synchronous reluctance motor, stepping motor, switched reluctance motor, permanent magnet synchronous motor, permanent magnet brushless DC motor.

COURSE OUTCOMES: On successful completion of the course, students will be able to

CO1. Demonstrate potential knowledge on construction and characteristics of synchronous reluctance motors.

CO2. Analyze and design appropriate power circuit configuration for stepper motor drive of various configurations to obtain better performance characteristics.

CO3. Demonstrate potential knowledge on construction of switched reluctance motors and design controllers for SRM using Microprocessor.

CO4. Apply the knowledge on construction of permanent magnet synchronous motors and analyze their performance characteristics with the effects of various control strategies.

CO5. Apply the knowledge of various types of permanent magnet brushless DC motor drives to develop chip based controllers.

DETAILED SYLLABUS:

Unit - I: Synchronous Reluctance Motors (08 hours)

Constructional features: Axial and radial air gap motors. Operating principle, characteristics, reluctance torque and phasor diagram. Linear induction motor.

Unit - II: Stepper Motors (10 hours)

Constructional features, principle of operation of Variable Reluctance (VR) and hybrid motors. Single and multi-stack configurations, theory of torque predictions, linear and non-linear analysis, dynamic characteristics, drive systems and circuit for open loop control, closed loop control of stepper motor.

Unit - III: Switched Reluctance Motors (07 hours)

Constructional features, principle of operation, torque equation, power controllers and characteristics of SRM. Microprocessor based power controller for SRM.

Unit - IV: Permanent Magnet Synchronous Motors (10 hours)

Principle of operation, EMF, power input and torque expressions, phasor diagram, power controllers, torque-speed characteristics, self-control, vector control, current control schemes.

Unit - V: Permanent Magnet Brushless DC Motors (10 hours)

Commutation in DC motors, difference between mechanical and electronic commutator. Hall sensors, optical sensors. Multiphase brushless motor. Square wave permanent magnet brushless motor drives - Torque and EMF equation, torque-speed characteristics. Microprocessor based controller.

Total hours:45

TEXT BOOKS:

1. Miller.T.J.E., *Brushless permanent magnet and reluctance motor drives*, Clarendon Press, Oxford, 1989.
2. Kenjo.T, *Stepping motors and their microprocessor control,* Clarendon Press, Oxford, 1989.

REFERENCE BOOKS:

1. Kenjo.T and Naganori.S, *Permanent Magnet and brushless DC motors,* Clarendon Press, Oxford, 1989.
2. Bimal.K.Bose, *Modern Power Electronics and AC Drives,* Pearson Education (Singapore) Pte. Ltd., New Delhi, 2002.
3. R.Krishnan, *Electric Motor Drives – Modeling, Analysis and Control,* Prentice-Hall of India Pvt. Ltd., New Delhi, 2010.

M. Tech. – II Semester

(19MT20706) FLEXIBLE AC TRANSMISSION SYSTEM

(Program Elective – 4)

(Common to EPS and PED)

Int. Marks	Ext. Marks	Total Marks	L	T	P	C
40	60	100	3	-	-	3

PRE-REQUISITES: Power Electronics and Power Systems at UG level.

COURSE DESCRIPTION: Need for flexible AC transmission systems; objectives of shunt and series compensations, phase angle regulators; FACTS controllers: shunt, series and combined; coordination of various FACTS controllers.

COURSE OUTCOMES: On successful completion of the course, students will be able to

CO1. Apply the conceptual knowledge of compensation techniques and appropriate conventional and FACTS devices for active and reactive power flows in parallel and meshed systems.

CO2. Analyze the active and reactive power flow, transient stability enhancement, power oscillation damping and optimal operation through various FACTS devices/controllers and their coordination.

DETAILED SYLLABUS:

Unit - I: Introduction to AC Transmission Systems (7 hours)

Overview of interconnected power system. Power flow in AC systems – Expression for real and reactive power flow between two nodes of a power system, controllable parameters. Power flow in parallel and meshed system. Overview of compensated transmission lines – shunt and series compensation. Conventional controllers for real and reactive power flows – merits and demerits. FACTS – benefits, types of FACTS controllers.

Unit - II: Static Shunt Compensation (10 hours)

Expression for real and reactive power flow with mid-point voltage regulation. Variable impedance type static VAR generators - V-I characteristics and control schemes of TCR, TSR, TSC. QD-QO characteristic and control scheme of TSC-TCR. Switching converter type VAR generators – V-I characteristics and control schemes of STATCOM. Hybrid VAR generators – V-I characteristics of SVC and STATCOM, regulation of V-I slope. Applications of static shunt compensators – Voltage regulation, improvement in transient stability, prevention of voltage instability, power oscillation damping. Comparison of static shunt compensators.

Unit - III: Static Series Compensation (10 hours)

Expression for real and reactive power flow with series line compensation. Variable impedance type series compensators: V-I characteristics and control schemes of GCSC, TSSC, TCSC- modes of operation. Sub-synchronous resonance. Switching converter type series compensator – V-I characteristics, internal and external control schemes of SSSC. Applications of static series compensators – improvement in transient stability, power oscillation damping. Comparison of static series compensators.

Unit - IV: Static Phase Angle Regulators and Combined Compensators

(10 hours)

Power flow control by phase angle regulators - Concept of voltage and phase angle regulation. Operation and control of TCVR and TCPAR. Switching converter type phase angle regulators. Objectives of TCPAR - improvement of transient stability, power oscillation damping. UPFC – Principle, expression for real and reactive power between two nodes of UPFC, independent real and reactive power flow control using UPFC, control schemes of UPFC - operating principle and characteristics of IPFC.

Unit - V: Co-ordination of FACTS Controllers (8 hours)

FACTS controller interactions – interaction between multiple SVC's – interaction between multiple TCSC's – SVC-TCSC interaction – Coordination of multiple controllers using linear control techniques. Comparative evaluation of different FACTS controllers: performance comparison and cost comparison.

Total hours: 45

TEXT BOOKS:

1. Narain G. Hingorani, Laszi Gyugyi, *Understanding FACTS: Concepts and Technology of Flexible AC Transmission Systems*, Wiley-IEEE Press, 1999.
2. R. Mohan Mathur and Rajiv k. Varma, *Thyristor based FACTS Controllers for Electrical Transmission Systems*, Wiley-IEEE Press, 2002.

REFERENCE BOOKS:

1. Xiao-Ping Zhang, ChristianRehtanz, BikashPal, *Flexible AC Transmission Systems: Modeling and Control*, Springer Power Systems Series, 2006.
2. T.J.E. Miller, *Reactive Power Control in Electric Systems*, Wiley, 1982.

M. Tech. – IISemester

(19MT28307) HYBRID ELECTRIC VEHICLES

(Program Elective –4)

Int. Marks	Ext. Marks	Total Marks	L	T	P	C
40	60	100	3	-	-	3

PRE-REQUISITES: Courses on Power Electronics, Special Electrical Machines, Power Semiconductor Drives at UG Level

COURSE DESCRIPTION: Transportation vehicles and their impact in society; Concept and configurations of Electric Vehicles (EV); Principle, Types and operation of Hybrid-Electric Vehicles (HEVs); Power Electronic converters in HEVs; Different motor drives & energy storage technologies in EVs and HEVs.

COURSE OUTCOMES: On successful completion of the course, students will be able to

CO1. Demonstrate knowledge on fundamental concepts of Electric Vehicles (EVs) and Hybrid-Electric Vehicles (HEVs) and apply the appropriate power converter & energy storage techniques to analyze and design EVs and HEVs for various applications.

CO2. Apply the knowledge of various types of AC & DC motor drives and analyze their performance characteristics with the effects of various control strategies.

DETAILED SYLLABUS:

Unit - I: Electric and Hybrid Electric Vehicles (09 hours)

Environmental impact and history of modern transportation, history of transportation electrification, Electric Vehicles (EVs) - Introduction, configurations and traction motor characteristics; Hybrid-Electric Vehicles (HEVs) - Concept and architectures; Series HEV - Configuration, operation, advantages and disadvantages; HEVs - Interdisciplinary nature, challenges and key technologies.

Unit - II: Power Electronics in HEVS (10 hours)

Introduction, principle of power electronics, rectifiers used in HEVs, Buck converter used in HEVs. Non-isolated bidirectional DC-DC Converter - operating principle, torque and power capability, current ripple and regenerative braking. Isolated bidirectional DC - DC converter - principle, steady state operations, output voltage and output power. Battery chargers - forward, fly back and bridge converters.

Unit - III: Electric Propulsion Systems (10 hours)

Introduction, Typical functional block diagram and classification of electric motor drive, DC motor drives - Control methods, class A and B choppers, two and four quadrant chopper control. Induction Motor drives - Operating principle, steady - state performance, v/f control and power electronic control. PMBLDC Motor drives - Construction, advantages and disadvantages, performance analysis and control. Switched Reluctance Motor drives - SRM basic magnetic structure, torque production, converter topologies.

Unit - IV: Energy Storage Technologies (10 hours)

Battery - basic theory and characterization, battery technologies, Types – lead acid batteries, nickel-based batteries and lithium-based batteries. Ultra-capacitors - Features, Basic Principles, Performance, Battery modeling based on electric equivalent circuit, Modeling of ultra -capacitors, Battery charging control and Flywheel Energy Storage System. Fuel Cells - modeling and block diagrams of hybrid fuel cell energy storage systems.

Unit–V: Applications of Hybrid Electric Vehicles (06 hours)

Introduction, Hydraulic Hybrid Vehicles (HHV) - Principle and operation of regenerative braking. Hybrid off road vehicular system, electric or hybrid ships and locomotives. Military applications - Electromagnetic launchers and hybrid-powered ships.

Total hours: 45

TEXT BOOKS:

1. MehrdadEhsani, Yimin Gao and Ali Emadi, *Modern Electric, Hybrid Electric and Fuel Cell Vehicles*,2nd edition, CRC Press, 2015.
2. Chris Mi, M. AbulMasrur, David WenzhongGao, *Hybrid Electric Vehicles Principles and Applications with Practical Perspectives*, Wiley, 2011.

REFERENCE BOOKS:

1. Iqbal Husain, *Electric and Hybrid Vehicles Design Fundamentals,* 2nd edition, CRC Press, 2011.
2. Jack Erjavec, *Hybrid, Electric & Fuel-Cell Vehicles*, 2nd edition,Delmar Cengage learning, 2013.

M. Tech. – II Semester

(19MT28308) SWITCHED MODE POWER SUPPLIES AND UPS

(Program Elective - 4)

Int. Marks	Ext. Marks	Total Marks	L	T	P	C
40	60	100	3	-	-	3

PRE-REQUISITES: Courses on Power Electronic Converters, Power Semiconductor Devices & Modeling.

COURSE DESCRIPTION:DC-DC Converters and Switching Mode Power Converters; Resonant Converters – Types and operating waveforms; ZCS and ZVS Resonant converters; Power conditioners, UPS and Filters – ON and OFF line operation.

COURSE OUTCOMES: On successful completion of the course, students will be able to

CO1. Demonstrate the knowledge of various switch mode DC–DC Converters and use appropriate control technique to design and analyze with different modes of operation.

CO2. Understand the knowledge of resonant converter and use appropriate control technique to model and evaluate their performance parameters.

CO3. Demonstrate the knowledge of power conditioners, UPS and filters to design and analyze for different operating conditions.

DETAILED SYLLABUS:

Unit - I:DC-DC Converters **(09 hours)**

Performance analysis of buck, boost, buck-boost, cuk, sepic and quadratic converters – Modes of operation, Equivalent circuits and steady state waveforms.

Unit - II:Switching Mode Power Converters **(09 hours)**

Performance analysis of forward, fly-back, push-pull, Luo, half-bridge and full-bridge Converters – Modes of operation, Equivalent circuits and steady state waveforms.

Unit - III: Resonant Converters **(09 hours)**

Series Resonant Inverters: Series Resonant Inverter with unidirectional switches – Modes of operations, Waveforms, Types – Based on coupled inductors, Half-Bridge and Full-Bridge resonant inverters. Series Resonant Inverter with bidirectional switches – Types – Half-Bridge and Full-Bridge resonant inverters.

Parallel Resonant inverters, Voltage control of resonant inverters, Class E resonant inverter and rectifiers.

Unit - IV: ZCS and ZVS Resonant Converters (09 hours)

Zero-Current-Switching Resonant Converter: Types – L-Type and M-Type ZCS, Equivalent circuit, Modes of operation and Waveforms. Zero-Voltage-Switching Resonant Converters: Equivalent circuit, Modes of operation, Waveforms and Two quadrant ZVS resonant converters. Resonant DC-link inverters – Basic concept, Waveforms, Three phase DC-link inverter – Operation and Waveforms. Active clamp dc-link resonant inverter – Operation and Waveforms. Comparison of ZVS and ZCS.

Unit - V:Power Conditioners, UPS & Filters (09 hours)

Power line disturbances- Power conditioners –UPS: offline UPS, Online UPS, Applications – Filters: Voltage filters, Series-parallel resonant filters, filter without series capacitors, filter for PWM VSI, current filter, DC filters – Design of inductor and transformer for PE applications – Selection of capacitors.

Total hours: 45

TEXT BOOKS:

1. Muhammad H. Rashid, *Power Electronics: Circuits, Devices and Applications*, Pearson Education, 4th Edition, 2014.
2. Ned Mohan, T. M. Undeland, W.P. Robbins, *Power Electronics: Converters, Applications and Design*, Wiley, 3rd Edition, 2007.

REFERENCE BOOKS:

1. M. D. Singh & K. B. Kanchandhani, *Power Electronics*, Tata McGraw – Hill Publishing Company, New Delhi, 3rd Edition, 2008.
2. Dr. P. S. Bimbhra, *PowerElectronics*, Khanna Publishers, New Delhi, 4th Edition, 2012.

M. Tech. – II Semester

(19MT28309) WIND ENERGY CONVERSION SYSTEMS

(Program Elective-4)

(Common to EPS and PED)

Int. Marks	Ext. Marks	Total Marks	L	T	P	C
40	60	100	3	-	-	3

PREREQUISITE(S): Courses on Power Electronics, control systems in UG level.

COURSE DESCRIPTION: Fundamentals of wind energy and its measurement; wind turbine design and basic aerodynamics principles; need of usage of wind generators; wind turbine control, monitor and implementation in the wind farm and site selection; power quality issues and mitigation methods of wind power integration in the power system.

COURSE OUTCOMES: On successful completion of the course, students will be able to

CO1. Demonstrate knowledge on various components, types, characteristics and measurements of wind turbines.

CO2. Apply the knowledge of aerodynamics forces to analyze wind turbine blade rotation.

CO3. Use the knowledge of various design procedures and converters for designing modern wind turbines and to integrate.

CO4. Demonstrate knowledge on various types of control and monitoring techniques used in WECS.

CO5. Demonstrate knowledge on power quality problems in WECS and apply suitable mitigation techniques/ custom power devices to improve the power quality.

DETAILED SYLLABUS:

Unit - I:Wind Energy Fundamentals and Measurements (08 hours)

wind power scenario in India; basics of wind characteristics: extractable limits of wind power; estimation of wind power potential; gust/extreme wind speeds; wind turbulence wind measurement and instrumentation; horizontal/vertical axis wind turbines; wind turbine components, braking, yaw system, tower.

Unit - II:Design and Aerodynamics of Wind Turbine (10 hours)

Analysis of semi Review on basic aerodynamics, Airfoils and General Concepts of Aerodynamics, types and characteristics of wind turbine, Blade Design for Modern Wind Turbines, blade element theory, Betz limit, Generalized Rotor Design Procedure, turbine design: Design procedure, topologies , Wind Turbine Standards, Technical Specifications, and Certification, Wind Turbine Design Loads, power curve prediction.

Unit - III:Wind Turbine Generators (09 hours)

Fixed speed and variable speed systems, Electrical machines for wind energy systems, synchronous and asynchronous generators and its performance, Integration of wind energy systems to electrical networks, converters, inverters, directly connected, wind energy storage solutions.

Unit - IV:Wind Turbine Control, Testing and Applications (12 hours)

Types of Control Systems in Wind Turbines, Overview of Wind Turbine Control Systems, Typical Grid-connected Turbine Operation, and Typical Constant-speed and variable speed Operating Schemes, Supervisory Control Overview Implementation, overview of testing methods.
Applications: hybrid power systems, special purpose applications, overview of energy storage, site selection and environmental impacts.

Unit - V:Power Quality Issues in Integration of WECS (06 hours)

Stand alone and Grid connected wind systems, Power Quality issues, Impact of power quality problems on WECS, Harmonic reduction and Power factor improvement, Mitigation of power quality problems, and role of custom power devices in Distributed Generation.

Total hours: 45

TEXT BOOKS:

1. J. F. Manwell, J. G. McGowan and A. L. Rogers, *Wind Energy Explained – Theory, Design and Application*, Wiley, 2009.
2. G.D. Rai, *Non - Conventional Energy Resources*, Khanna Publishers, 2002.

REFERENCE BOOKS:

1. V. Daniel Hunt*, Wind power: a handbook on wind energy conversion systems,* 4th Edition, Van Nostrand Reinhold Co., 1981, Khanna Publishers, New Delhi, 2012.
2. Arindam Ghosh, Gerard Ledwich, *Power Quality Enhancement Using Custom power devices Power Devices,* Springer,2002.
3. Roger C. Dugan, Mark F. Mc Granaghan, Surya Santoso and H. Wayne Beaty, *Electrical Power Systems Quality,* 2nd edition, TATA McGraw Hill, 2008.

M. Tech. – II Semester

(19MT28331)ELECTRICAL DRIVES LAB

Int. Marks	Ext. Marks	Total Marks	L	T	P	C
50	50	100	-	-	4	2

PRE-REQUISITES: Courses on Power converters.

COURSE DESCRIPTION: Design and development of various AC and DC drives.

COURSEOUTCOMES: On successful completion of the course, students will be able to

CO1. Identify appropriate devices, domain specific tools and techniques to develop and control power electronic converters fed drive.

CO2. Analyze and evaluate the performance of Power converters fed drive by practicing professional code of ethics.

CO3. Prepare laboratory reports that clearly communicate experimental information.

CO4. Function effectively as an individual to solve various problems.

PRACTICAL EXERCISES/LIST OF EXPERIMENTS: Conduct any **Two Experiments** from the following:

1. Single phase half controlled rectifier fed DC motor using IGBT.
2. Single phase half controlled rectifier fed DC motor using MOSFET.
3. Single phase fully controlled rectifier fed DC motor using IGBT.
4. Single phase fully controlled rectifier fed DC motor using MOSFET.
5. DC-DC converter fed DC Motor using IGBT.
6. DC-DC converter fed DC Motor using MOSFET.
7. Single phase inverter fed induction motor using IGBT.
8. Three phase three level inverter (MLI) fed induction motor drive.
9. Five level cascaded multilevel inverter fed induction motor drive.

M. Tech. – II Semester

(19MT28332)ELECTRICAL DRIVES SIMULATION LAB

Int. Marks	Ext. Marks	Total Marks	L	T	P	C
50	50	100	-	-	4	2

PRE-REQUISITES: Courses on Power converters.

COURSE DESCRIPTION: Design and simulation of various AC and DC drives.

COURSEOUTCOMES: On successful completion of the course, students will be able to

CO1. Identify appropriate devices, domain specific tools and techniques to develop and control power electronic converters fed drive.

CO2. Analyze and evaluate the performance of Power converters fed drive by practicing professional code of ethics.

CO3. Prepare laboratory reports that clearly communicate experimental information.

CO4. Function effectively as an individual to solve various problems.

LIST OF EXPERIMENTS: Conduct any **TEN Experiments** from the following using MATLAB

1. Single phase half-wave converter fed DC motor.
2. Single phase Semi converter fed DC drive.
3. Single phase full controlled fed DC drive.
4. Single phase inverter fed induction motor fed drive.
5. Speed control of stepper motor fed drive.
6. Speed control of universal motor using AC voltage controller.
7. Speed Control of Induction motor using cyclo converter.
8. Step up chopper fed DC drive.
9. Step down chopper fed DC drive.
10. Speed control of single phase induction motor using AC voltage controller.
11. Speed control of Permanent Magnet Synchronous motor fed drive.
12. Speed Control Brushless DC Motor fed drive.
13. Speed control of Switched Reluctance Motor fed drive.

M. Tech. – II Semester

(19MT2AC01) STATISTICS WITH R

(Audit Course)

(Common to All M. Tech. Programs)

Int. Marks	Ext. Marks	Total Marks	L	T	P	C
-	-	-	2	-	-	-

PRE-REQUISITES: A course on Statistics.

COURSE DESCRIPTION: Concepts of R programming basics, Bivariate and multivariate data, Confidence intervals, Goodness of fit, Analysis of variance.

COURSE OUTCOMES: On successful completion of the course, students will be able to

CO1. Import, manage, manipulate, and structure data files using R programming.

CO2. Implement models for statistical analysis of a given dataset and visualize the results to identify trends, patterns and outliers in data.

DETAILED SYLLABUS:

Unit - I:Introduction (5 hours)

Data, R's command line, Variables, Functions, The workspace, External packages, Data sets, Data vectors, Functions, Numeric summaries, Categorical data.

Unit - II:Bivariate and Multivariate Data (7 hours)

Lists, Data frames, Paired data, Correlation, Trends, Transformations, Bivariate categorical data, Measures of association, Two-way tables, Marginal distributions, Conditional distributions, Graphical summaries, Multivariatedata - Data frames, Applying a function over a collection, Using external data, Lattice graphics, Grouping, Statistical transformations.

Unit - III:Populations (6 hours)

Populations, Discrete random variables, Random values generation, Sampling, Families of distributions, Central limit theorem, Statistical Inference - Significance tests, Estimation, Confidence intervals, Bayesian analysis.

Unit - IV:Confidence Intervals (6 hours)

Confidence intervals for a population proportion, p - population mean, Other confidence intervals, Confidence intervals for differences, Confidence intervals for the median, Significance test - Significance test for a population proportion, Significance test for the mean (t-tests), Significance tests and confidence intervals, Significance tests for the median.

Unit - V:Goodness of FIT (6 hours)

The chi-squared goodness-of-fit test, The multinomial distribution, Pearson's χ^2-statistic, chi-squared test of independence and homogeneity, Goodness-of-fit tests for continuous distributions, ANOVA - One-way ANOVA, Using *lm* for ANOVA.

Total hours: 30

TEXT BOOKS:

1. John Verzani, *Using R for Introductory Statistics*, CRC Press, 2nd Edition, 2014.
2. Sudha G Purohit, Sharad D Gore, Shailaja R Deshmukh, *Statistics Using R*, Narosa Publishing house, 2nd Edition, 2015.

REFERENCE BOOKS:

1. Francisco Juretig, *R Statistics Cookbook*, Packt Publishing, 1st Edition, 2019.
2. Prabhanjan N. Tattar, Suresh Ramaiah, B. G. Manjunath, *A Course in Statistics with R*, Wiley, 2018.

M. Tech. – III Semester

(19MT38331)INTERNSHIP

Int. Marks	Ext. Marks	Total Marks	L	T	P	C
-	100	100	-	-	-	2

PRE-REQUISITES: -

COURSE DESCRIPTION: Acquaint students with the industrial environment; Create competent professionals for the industry; Gain professional experience and understand engineer's responsibilities and ethics.

COURSE OUTCOMES: On successful completion of the course, students will be able to

CO1. Develop problem solving skills, critical thinking skills though designing and developing solutions for complex problems.

CO2. Utilize appropriate modern tools and techniques for implementing the proposed solutions.

CO3. Discern various challenges in developing solutions for complex problems, design and conduct experiments to evaluate alternative solutions for the chosen engineering problems.

CO4. Function effectively as an individual and participate well as a team member to build professional network for growth in career.

CO5. Develop communication, enrich professional, interpersonal and technical skills pertaining to the internship experience.

CO6. Understand the industry/organization customs and practices that will help to develop a solid work ethic and professional demeanor, as well as a commitment to ethical conduct and social responsibility.

CO7. Utilize real work experiences to explore their interests, career alternatives that will help with future education or employment through and develop professional skills and competencies to engage in lifelong learning.

M. Tech. – III Semester

(19MT38332)PROJECT WORK PHASE-I

Int. Marks	Ext. Marks	Total Marks	L	T	P	C
50	50	100	-	-	-	10

PREREQUISITES: -

COURSE DESCRIPTION: Identification of topic for the project work, Literature survey, Collection of preliminary data, Critical study and analysis of the topic identified, Time and cost analysis.

COURSE OUTCOMES: On successful completion of the course, students will be able to

CO1. Apply contextual knowledge to identify a domain of interest and a specific problem in core and allied areas of discipline.

CO2. Conduct a systematic literature review, analyze, cognize and comprehend the extracted information to recognize the current status of research pertinent to the chosen problem.

CO3. Discern various issues, challenges and identify alternative solutions for the chosen engineering problems.

CO4. Function effectively as an individual to recognize the opportunities in the chosen domain of interest and engage in independent learning.

CO5. Write and present a substantial technical report/document to present the findings on the chosen problem.

CO6. Acquire intellectual integrity through understanding the need for ethics in research, profession and its impact on the society.

M. Tech. – IV Semester

(19MT48331)PROJECT WORK PHASE-II

Int. Marks	Ext. Marks	Total Marks	L	T	P	C
150	150	300	-	-	-	16

PREREQUISITES: Project Work Phase-I

COURSE DESCRIPTION: Identification of topic for the project work; Literature survey; Collection of preliminary data; Identification of implementation tools and methodologies; Performing critical study and analysis of the topic identified; Time and cost analysis; Implementation of the project work; Writing of thesis and presentation.

COURSE OUTCOMES: On successful completion of the course, students will be able to

CO1. Investigate, conceptualize and design optimal solutions for the chosen engineering problems.

CO2. Utilize appropriate modern tools and techniques for implementing the proposed solution.

CO3. Design and conduct experiments, visualize, analyze and interpret results to test and evaluate the proposed solution.

CO4. Function effectively as an individual to recognize the opportunities in the chosen domain of interest and engage in independent learning.

CO5. Write and present a substantial technical report/document to present the findings on the chosen problem.

CO6. Acquire intellectual integrity through understanding the need for ethics in research, profession and its impact on the society.

CO7. Engage in lifelong learning for development of technical competence in the advanced fields of Power electronics and drives to contribute to the development of scientific/technological knowledge.