Post Graduate Programme

M. Tech.
Power Electronics & Electrical Drives

Proposed Curriculum

सरदार वल्लभभाई राष्ट्रीय प्रोद्योगिकी संस्थान, सूरत
SARDAR VALLBHBHAI NATIONAL INSTITUTE OF TECHNOLOGY, SURAT
विधुत इंजीनियरिंग विभाग
DEPARTMENT OF ELECTRICAL ENGINEERING

Teaching Scheme of M. Tech. (Power Electronics and Electrical Drives)

Semester – I

Sl. No.	Subject	Code	Scheme	Credit
1.	Power Electronics- I	EEPE101	4-0-2	05
2.	Modeling of Electrical Machines and DC Drives	EEPE102	4-0-2	05
3.	Adaptive Control and Soft Computing	EEPE103	3-0-0	03
4.	Solar and Wind Energy Conversion and Control	EEPE104	3-0-2	04
5.	Core Elective – 1	EEPE1XX	3-0-0	03
6.	Core Elective – 2	EEPE1XX	3-0-0	03
7.	Real Time Simulation of Power Electronic Circuits	EEPE105	0-0-2	01
			Total Credit	**24**

Semester – II

Sl. No.	Subject	Code	scheme	Credit
1.	Power Electronics- II	EEPE201	4-0-2	05
2.	AC Drives	EEPE202	4-0-2	05
3.	Digital Control of Power Converters	EEPE203	3-0-2	04
4.	Core Elective – 3	EEPE2XX	3-0-0	03
5.	Core Elective – 4	EEPE2XX	3-0-0	03
6.	Institute Elective - 1	EEPE2XX	3-0-0	03
7.	Real Time Simulation of Power Electronic Converter Applications	EEPE204	0-0-2	01
			Total Credit	**24**

Semester – III

Sl. No.	Subject	Code	scheme	Credit
1.	Seminar	EEPE301	0-0-4	02
2.	Dissertation (Part-I)	EEPE302	0-0-12	06
			Total Credit	**8**

Semester – IV

Sl. No.	Subject	Code	scheme	Credit
1.	Dissertation (Part-II)	EEPE401	0-0-24	12
			Total Credit	**12**
			Grand Total Credit	**68**

19/12/22

List of Elective Courses Offered

Core Elective – 1 (EEPE1XX)		
S. No.	Code	Subject
(1)	EEPE111	Power Quality Disturbance and its Mitigation
(2)	EEPE112	High Power Converter Topologies and Control
(3)	EEPE113	Digital Signal Processing
(4)	EEPE114	Microcontroller-Based System Design
(5)	EEPE115	Physical Phenomena of Electrical Machines
Core Elective – 2 (EEPE1XX)		
S. No.	Code	Subject
(1)	EEPE121	Advanced Numerical Methods and Applications
(2)	EEPE122	System Theory
(3)	EEPE123	Control Techniques In Switch-Mode Power Converters
(4)	EEPE124	Design of Magnetic Components for Power Converters
(5)	EEPE125	Electric Vehicle Technology
Core Elective – 3 (EEPE2XX)		
S. No.	Code	Subject
(1)	EEPE211	Charging Infrastructure for Electric Vehicles
(2)	EEPE212	Special Electrical Machines and Drives
(3)	EEPE213	Advanced Power Converters for Renewable Applications
(4)	EEPE214	Distributed Power Generation and Micro-grid
(5)	EEPE215	HVDC Transmission
(6)	EEPE216	Condition Monitoring & Fault Diagnosis of Electrical Machines
Core Elective – 4 (EEPE2E2XX)		
S. No.	Code	Subject
(1)	EEPE221	Advanced Energy Storage Devices and Applications
(2)	EEPE222	Instrumentation for Drives
(3)	EEPE223	Application of Power Electronics to Power System
(4)	EEPE224	Model Predictive Control for Power Electronics Applications
(5)	EEPE225	Electrical Machines For Renewable Energy Generation
Institute Elective – 1 (EEPE2IEXX)		
S. No.	Code	Subject
(1)	EEPE231	Artificial Intelligence and Machine Learning
(2)	EEPE232	Modern Industrial Drives and Automation
(3)	EEPE233	Advanced Optimization Methods
(4)	EEPE234	Smart Grid Technology

M. Tech. (Electrical), Semester – I

EEPE101: POWER ELECTRONICS – I

L	T	P	C
4	0	2	5

1. COURSE OUTCOMES (COs)

Upon completion of the course, the students will be able to:

CO1	classify the power semi-conductor devices, select the devices suitable to the application
CO2	analyze DC-DC converters, Inverters and Line Commutated Converters
CO3	learn different control techniques for Inverters
CO4	model the converter and design the controller
CO5	learn advanced converters

2. SYLLABUS

- **REVIEW OF POWER SEMICONDUCTOR DEVICES** **(02 Hours)**

  Static and Switching Characteristics of Power semiconductor devices, Device Loss Calculation, Applications.

- **LINE COMMUTATED CONVERTERS** **(10 Hours)**

  Principle of phase control, Review of single phase and three-phase converters, Multi-pulse converters, Three-phase AC voltage controllers

- **DC-DC CONVERTERS** **(12 Hours)**

  Buck converter, Boost converter, Buck–Boost converters, CUK converter, Fly-back converter, Forward converter, Push–pull converter, Full bridge and Half bridge converters, SEPIC Converter, Power Circuit Design considerations, Small Signal Modeling of DC-DC Converters, Closed loop control, Controller Design.

- **PWM INVERTERS** **(18 Hours)**

  Voltage Source Inverter Topologies: Single phase, 3-phase bridge inverter with R, RL, RLE load, Current source inverters, Applications, **Modulation Techniques:** single-pulse and multi pulse modulation, Selective Harmonic Elimination Technique, Delta modulation, Sinusoidal PWM, Space Vector PWM, Comparison of PWM techniques

Total Hours: 42

3. LIST OF EXPERIMENTS

1. Study of MOSFET IGBT Characteristics.
2. Study of single-phase controlled rectifiers with R and R-L load.
3. Study of single-phase AC voltage controller using SCR as well as using TRIAC with R and R-L load.
4. Study of single-phase SCR full bridge inverter circuit.
5. Study of three-phase SPWM inverter.
6. Study of three-phase fully controlled rectifier with R and R-L load.
7. Study of three-phase AC voltage Regulator.
8. Study of single-phase IGBT based full bridge inverter circuit.
9. Simulation of DC - DC Converter: (i) Buck Converter; (ii) Boost Converter; and (iii) Buck-Book Converter.
10. Simulation of single phase controlled rectifier different configurations with R, R-L, R-L-E load.
11. Simulation of three phase controlled rectifier different configurations with R, R-L, R-L-E load.
12. Simulation of single phase AC voltage controlled rectifier different configurations.
13. Simulation of three phase AC voltage controlled rectifier different configurations.
14. Simulation of single phase inverter: (i) Square wave; (ii) Quasi square wave; (iii) Selective harmonic elimination and (iv) sine PWM.
15. Simulation of three phase inverter: (i) 120^0; (ii) 180^0 mode; (iii) Selective harmonic elimination and (iv) sine PWM.

4. BOOKS RECOMMENDED:

1. Rashid, M. H., "Power Electronics Circuits, Devices, and Applications, Prentice-Hall of India Pvt. Ltd., New Delhi, 2nd edition, 1999.

2. Ned Mohan, Tore M. Undeland and William P. Robbins, “Power Electronics Converters, Applications, and Design”, John Willey & Sons, Inc., 2nd Edition, 1995.
3. Erickson Robert W., Maksimovic Dragan, "Fundamentals of Power Electronics", Kluwer Academic Publishers Group (Netherlands), 2001.
4. A. Pressman, “Switching Power Supply Design”, McGraw-Hill, 1998.
5. Bin Wu “High-Power Converters and Ac Drives” John Wiley & Sons, Inc., Hoboken, New Jersey.

M. Tech. (Electrical), Semester – I

EEPE102: MODELING OF ELECTRICAL MACHINES AND DC DRIVES

L	T	P	C
4	0	2	5

1. COURSE OUTCOMES (COs)

Upon completion of the course, the students will be able to:

CO1	Explain the basic principle of electrical machines and Electric Drives
CO2	Derive the equations for reference frame theory
CO3	Estimate the performance of Induction and Synchronous Machines
CO4	Analyse the performance of DC Drives and Linear Machines
CO5	Apply the reference frame theory on Induction and Synchronous Machines in real life problem.
CO6	Apply the control methods of DC drives and Linear machines in real world.

2. SYLLABUS

- **BASIC PRINCIPLE OF ELECTRICAL MACHINES (08 Hours)**
  Introduction, Magnetically coupled circuit, Electromagnetic energy conversion, machine winding and air gap EMF, winding inductance and voltage equations, equation of transformation, Reference-Frame Theory.

- **SYMMETRICAL INDUCTION MACHINES (10 Hours)**
  Introduction, voltage and torque equations in machine variables, voltage and torque equations in arbitrary reference frame, Analysis of steady state and dynamic operation.

- **SYNCHRONOUS MACHINES (10 Hours)**
  Introduction, voltage and torque equations in machine variables, voltage equations in rotor reference frame, Analysis of steady state and dynamic operation.

- **LINEAR MACHINES (09 Hours)**
  Energy conversion, Forces in Electromagnetic Fields, Materials for LEMs, Classifications and Applications of Linear Electric Machines.

- **FUNDAMENTALS OF ELECTRIC DRIVES (09 Hours)**
  Introduction, Choice of Electrical Drives, Dynamics of Electrical Drives, Concept of Multi-quadrant operation, Components of load torques, Selection of motor power rating, Speed torque, speed control, Starting, Braking, applications in Industrial and transportation sector.

- **DC DRIVES (10 Hours)**
  Modelling, Rectifier fed DC drive, Chopper controlled DC drives, Close loop control of DC drive. Analysis of steady state and dynamic operation.

Total Hours: 56

3. LIST OF EXPERIMENTS

1. To control the speed of DC motor using dual converter without circulating current.
2. To control the speed of DC motor using chopper.
3. To control the speed of DC motor using 1-Φ full convertor.
4. To control the speed of DC motor using 3-Φ full convertor.
5. To study and simulate Clarke and Park transformations
6. To study and simulate the mathematical model of induction machine using
   (i) arbitrary reference frame
   (ii) rotor reference frame

(iii) synchronously reference frame.

7. To study and simulate the mathematical model of cylindrical rotor synchronous machine
8. To study and simulate the mathematical model of salient rotor synchronous machine

4. BOOKS RECOMMENDED:

1. P. C. Krause, Oreg Wasynczuk, Scott D. Sudhoff P.C.Krause, Oreg Wasynczuk, Scott D. Sudhoff "Analysis of Electric Machinery and drive systems", IEEE Press, 2002.
2. P. S. Bhimbra, "Generalised Theory of Electrical Machines", Khanna Publications, Delhi, 2000.
3. G. K. Dubey, "Fundamentals of Electrical Drives" Narosa, 2nd Edition, 2013.
4. S.K. Pillai, A First Course on Electrical Drives, New Age international publishers,Delhi,2010
5. G.K. Dubey "Power semiconductor controlled Drives",Prentice Hall international, New Jersey, 1989.
6. R. Krishnan, Electric motor drives Modeling, Analysis and Control, Person India Education, Delhi, 2003.
7. Ion Boldea, Linear Electric Machines, Drives, and MAGLEVs Handbook, CRC Press, Taylor & Francis Group, New York, 2017.

M. Tech. (Electrical), Semester – I

EEPE103: ADAPTIVE CONTROL AND SOFT COMPUTING

L	T	P	C
3	0	0	3

1. COURSE OUTCOMES (COs)

Upon completion of the course, the students will be able to:

CO1	Explain the basic principle of adaptive control
CO2	Explain the basic principle of soft computing
CO3	Understanding of adaptive filter and LMS
CO4	Analyse and control of ANN and Fuzzy based system
CO5	Performance of the Adaptive system with real world problem
CO6	Performance of the soft computing with real world problem

2. SYLLABUS

- **ADAPTIVE CONTROL** **(21 Hours)**

  Adaptive Schemes, Adaptive Control Problem; Applications, Regression Models, Recursive Least Squares, Real-Time Parameter Estimation, Direct and Indirect Self-Tuning Regulators Pole Placement Design, MDPP, Model Reference Adaptive Systems, MIT Rule, Design of MRAS Using Lyapunov Theory, PI and PID controller-conventional and auto gain tuning, Parameter Identifiers and Adaptive Observers- Luenberger Observer and others, Parameter estimation algorithms and its application, Adaptive filter-Method of steepest descent, stability, least mean square adaptive filter, comparison, convergence and robustness, Methods of least mean square, applications.

- **SOFT COMPUTING** **(21 Hours)**

  Introduction, ANN models; Feed Forward Network; Radial Basis Function; Learning process; Supervised and unsupervised learning- adaptive neural network, back propagation, RBFN, Kohonen self-organizing Maps, LVQ; Least mean square algorithm; Back propagation algorithm; Applications in pattern recognition and other engineering problems; Case studies; Identification and control of linear and nonlinear systems; Fuzzy set operations and concept; Fuzzy control systems; fuzzy rules, reasoning and inference system , Classical fuzzy control problems; Genetic Algorithm; Adaptive fuzzy systems; Hybrid Systems; Application of soft computing techniques in physical systems.

Total Hours: 42

3. BOOKS RECOMMENDED:

1. Karl Johan Astrom and Bjom Wittenmark, “Adaptive Control”, Second edition, Dover Publication Inc.,Mineila, New York,1995
2. Shankar Sastry and Marc Bodson , “Adaptive Control: Stability, Convergence and Robustness”, PHI- Prentice Hall Information- Prentice Hall Advanced Reference Series (Eastern Economy Edition), 1989
3. Karl Johan Astrom, “Adaptive Control”, Pearson Education, 2001.
4. Petros A Loannou, Jing, “Robust Adaptive Control” Prentice-Hall, 1995.
5. Benjamin C. Kuo, Automatic Control System, PHI learning Private limited, Delhi, 2013.
6. Simon Haykin , Adaptive filter Theory, Pearson education Inc., Delhi, 2002.
7. Jang, T. Sun and E. Mizutani, “Neuro-Fuzzy and Soft computing: a computational approach to learning and machine intelligence”, Pearson Education Inc, Delhi, 1997.
8. S.N. Sivanandam and S.N. Deepa, “Principles of soft computing, 2ed edition, Wiley India, New Delhi, 2011.
9. G. J. Klir, Boyuan, Fuzzy sets and fuzzy logic, Prentice Hall of India (P) Ltd, 1997.
10. Vose Michael D., Simple Genetic Algorithm - Foundations and Theory, Prentice Hall of India.

M. Tech. (Electrical), Semester – I

EEPE104: SOLAR AND WIND ENERGY CONVERSION AND CONTROL

L	T	P	C
3	0	2	4

1. COURSE OUTCOMES (COs)

Upon completion of the course, the students will be able to:

CO1	Understand and explain present energy status and renewable energy needs
CO2	Analyse the photovoltaic fundamentals and the photovoltaic applications
CO3	Analyse the wind turbine characteristics and the wind power system generation
CO4	Understand and select different electrical machines and power converters for wind energy generation
CO5	Explain different hybrid renewable energy generation systems and their power control

2. SYLLABUS

- **PRESENT STATUS OF FOSSIL FUELS BASED GENERATION AND NEED FOR RENEWABLES (04 Hours)**
  Present status of fossil fuel resources in the world and India, limitations of the fossil fuel electricity generation, need for renewable energy and present status in India.

- **SOLAR PHOTOVOLTAICS DEVICES AND CHARACTERISTICS (05 Hours)**
  Review of p-n junction diode, exposure to sunlight, PV characteristics and environmental impact, PV devices and modelling, need for maximum power point tracking.

- **PHOTOVOLTAICS POWER ELECTRONICS CONVERTERS, THEIR CONTROL AND GRID INTEGRATION (05 Hours)**
  PV-MPPT algorithms, basic DC-DC converters (buck, boost, buck-boost) and their controls, single-phase and three-phase grid connected PV inverters and their control, design of standalone PV systems for irrigation pump and domestic applications.

- **PHOTOVOLTAIC-BATTERY ENERGY STORAGE (05 Hours)**
  Types of batteries, battery terminology, characteristics and modelling, battery charging methods, integrating battery-charge control with MPPT, design of standalone PV-battery system.

- **WIND TURBINES AND CHARACTERISTICS (05 Hours)**
  Wind data in terms of speed-frequency distribution, power density-speed duration curves, different wind turbines and their characteristics, wind power and energy computations, components of wind turbine system.

- **ELECTRICAL MACHINES, POWER ELECTRONICS CONVERTERS AND GRID INTERFACE FOR WIND ENERGY (05 Hours)**
  Fixed and variable wind speed turbines, induction and synchronous machines for wind energy conversion, different power electronics interface based on full and partial converters, wind-MPPT algorithms, wind-farm configurations.

- **SOLAR AND WIND HYBRID SYSTEMS (05 Hours)**
  Hybrid systems and their needs, solar-diesel-battery systems, wind-solar-battery system, solar-wind-fuel cell system and its control.

Total Hours: 42

3. LIST OF EXPERIMENTS

1. To control the speed of DC motor using dual converter without circulating current.
2. To control the speed of DC motor using chopper.
3. To control the speed of DC motor using 1-Φ full convertor.

4. To control the speed of DC motor using 3-Φ full convertor.
5. To study induction motor variable frequency drive.
6. To control the speed of switched reluctance motor (SRM).
7. To study BLDC motor speed control using PWM technique.
8. To study speed control of permanent magnet synchronous motor (PMSM) using DSP based trainer kit.

4. BOOKS RECOMMENDED:

1. Chetan Singh Solanki, Solar Photovoltaics: Fundamentals, Technologies and Applications, Third Edition, PHI Learning Private Limited, New Delhi, 2015.
2. Weidong Xiao, Photovoltaic Power Systems: Modelling, design and control, First Edition, John Wiley & Sons Limited, NJ USA, 2017.
3. Thomas Ackermann, Wind Power in Power System, John Willey & Sons, 2005.
4. J. K. Nayak and S. P. Sukhatme, Solar Energy - Principles of Thermal Collection and Storage, Fourth Edition, Tata McGraw Hill, New Delhi, 2017.
5. R. Teodorrescu, Marco Liserre and Pedro Rodriguez, Grid Converters for Photovoltaic and Wind Power Systems, First Edition, John Wiley & Sons Limited, UK, 2011.

M. Tech. (Electrical), Semester – I (Core Elective – 1)

EEPE111: POWER QUALITY DISTURBANCE AND ITS MITIGATION

L	T	P	C
3	0	0	3

1. COURSE OUTCOMES (COs)

Upon completion of the course, the students will be able to:

CO1	Explain the basic power quality terms and problems
CO2	Analysis of power quality terms and problems
CO3	Estimate the performance of power filters and power factor converters
CO4	Analyse the performance control algorithm
CO5	Apply the techniques and filter devices and power factor converters in real life problem
CO6	Apply the control methods of custom power devices in real world

2. SYLLABUS

- **POWER QUALITY** **(08 Hours)**

  Origin of power quality variation & events, power quality indices, causes and effects of power quality disturbances, Characterization of power quality events & event classification. Power quality measuring instruments, Analysis of Power outages, unbalance, distortions, voltage sag, flickers and load balancing.

- **PROCESSING OF STATIONARY & NON-STATIONARYSIGNALS** **(07 Hours)**

  Stationary signals: Overview of analysis methods, frequency domain analysis and signal transformation, estimation of harmonics & inter-harmonics.

  Non stationary signals: Power quality data analysis methods, discrete STFT for analysing time–evolving signal components, wavelet transform, block–based modelling, Statistics of variations.

- **POWER FACTOR CORRECTION & MITIGATION OF HARMONICS** **(07 Hours)**

  Modelling of networks and components under non-sinusoidal conditions: transmission and distribution systems, power quality problems created by drives and its impact on drives, other nonlinear loads, Power factor improvement techniques, Classification and design of Shunt and Series Passive Compensation, Passive filter-classification, types, operation and design, limitation, Hybrid filters.

- **CUSTOM POWERDEVICES** **(10 Hours)**

  Introduction of DSTATCOM, DVR and UPQC, Classification, Structure, direct and indirect control of power converters, operation, load compensation using DSTATCOM, Generation of reference currents, DVR, UPQC structures, Operating modes, Time domain and frequency domain control, Hybrid filters, application in real world problem.

- **POWER QUALITY ISSUES IN HOME APPLIANCES** **(10 Hours)**

  Power factor correction converters in air-conditioners, fans and pump etc, Switched Mode Power Supply, Welding Power Supply and LED Lighting in Household applications, Other power factor techniques.

Total Hours: 42

3. BOOKS RECOMMENDED:

1.Bollen Math H.J. ,GUIrene Y.H., “Signal Processing of Power Quality Disturbances”, Wilely Inter science Publication (IEEE Press),2006

2. Bhim Singh, Ambrish Chandra, and Kamal Al-Haddad, Power Quality: Problems and Mitigation Techniques, John Wiley and Sons, United Kingdom, Dec. 2014.

3.Fuchs E.F., Masoum Mohammad A.S, “Power Quality in Power Systems and Electrical Machines”, Elsevier Academic Press,2008.

4.Bollen Math H.J,”Understanding Power quality Problems: Voltage Sags and Interruptions”, IEEE Press (Standard Publishers Distributors),2001.

5. Arindam Ghosh and Gerard Ledwich, Power Quality Enhancement using Custom Power Devices, Springer Science and Business Media, New York, Dec. 2012.

6.Wakileh George J."Power System Harmonics: Fundamentals, analysis and filter Design," Springer,(first Indian reprint) 2007.

7. Hirofumi Akagi, Edson Hirokazu Watanabe and Mauricio Aredes, Instantaneous Power Theory and Applications to Power Conditioning, John Wiley and Sons, New Jersey, March, 2007

8. B. Singh, S. Singh, A. Chandra and K. Al-Haddad, "Comprehensive Study of Single-Phase AC-DC Power Factor Corrected Converters With High-Frequency Isolation," *IEEE Transactions on Industrial Informatics*, vol. 7, no. 4, pp. 540-556, Nov. 2011.

9.S. Singh and B. Singh, "A Voltage-Controlled PFC Cuk Converter-Based PMBLDCM Drive for Air-Conditioners," *IEEE Transactions on Industry Applications*, vol. 48, no. 2, pp. 832-838, March-April 2012.

10. S. Singh, B. Singh, G. Bhuvaneswari and V. Bist, "A Power Quality Improved Bridgeless Converter-Based Computer Power Supply," *IEEE Transactions on Industry Applications*, vol. 52, no. 5, pp. 4385-4394, Sept.-Oct. 2016.

11. Topics related other Research papers from IEEE, IET and science direct etc

M. Tech. (Electrical), Semester – I (Core Elective – 1)

EEPE112: HIGH POWER CONVERTER TOPOLOGIES AND CONTROL

L	T	P	C
3	0	0	3

1. COURSE OUTCOMES (COs)

Upon completion of the course, the students will be able to:

CO1	Explain the concept of high power semiconductor devices
CO2	Analysis the front end active converter
CO3	Select the voltage source converter for high power applications
CO4	Apply the PWM techniques for control of VSCs
CO5	Apply the control methods of VSCs

2. SYLLABUS

- **REVIEW OF HIGH POWER SEMICONDUCTOR DEVICES (08 Hours)**

  Introduction, Diodes, Silicon Controlled Rectifiers (SCRs), Gate Turn-Off (GTO) Thyristor, Gate Commutated Thyristor (GCT), Insulated Gate Bipolar Transistor (IGBT), Other Switching Devices, Operation of Series Connected Devices, Main Causes of Voltage Unbalance , Voltage Equalization for GCTs , Voltage Equalization for IGBTs.

- **MULTIPULSE RECTIFIERS (10 Hours)**

  Six-Pulse Diode Rectifier, Series-Type Multipulse Diode Rectifiers: 12,18,24 pulse rectifiers, Separate-Type Multipulse Diode Rectifiers: 12,18,24 pulse rectifiers, Six-Pulse SCR Rectifier, 12-Pulse SCR Rectifier, 18- and 24-Pulse SCR Rectifiers

- **MULTILEVEL VOLTAGE SOURCE CONVERTERS (12 Hours)**

  Two-Level Voltage Source Inverter, Cascaded H-Bridge Multilevel Inverters, Diode-Clamped Multilevel Inverters, Multilevel Flying-Capacitor Inverter, Space Vector PWM control of these converters

- **MODULAR MULTILEVEL CONVERTERS (12 Hours)**

  Converter Configuration, Configuration of Submodules, Comparison of Submodules, Principle of Operation, Pulse Width Modulation Schemes, Classical Control of Modular Multilevel Converter.

Total Hours: 42

3. BOOKS RECOMMENDED:

1. Bin Wu and Mehdi Narimani, “High-power converters and AC drives”, John Wiley & Sons Ltd,, IEEE press 2nd edition 2017.
2. Sixing Du, Apparao Dekka, Bin Wu, and Navid Zargari, “Modular Multilevel Converters: Analysis, Control, and Applications”, John Wiley & Sons Ltd, IEEE press, 1st edition 2018.
3. N. Mohan, T. Undeland and W. Robbins, Power Electronics: Converters Applications and Design, New York:Wiley, 2002.
4. B. K. Bose, Modern Power Electronics and AC Drives, NJ, Upper Saddle River:Prentice-Hall, 2002.
5. J. R. Rodriguez, J. W. Dixon, J. R. Espinoza, J. Pontt and P. Lezana, "PWM regenerative rectifiers: state of the art," in IEEE Transactions on Industrial Electronics, vol. 52, no. 1, pp. 5-22, Feb. 2005, doi: 10.1109/TIE.2004.841149.

M. Tech. (Electrical), Semester – I (Core Elective – 1)

EEPE113: DIGITAL SIGNAL PROCESSING

L	T	P	C
3	0	0	3

1. COURSE OUTCOMES (COs)

Upon completion of the course, the students will be able to:

CO1	classify the discrete time signals and systems and analyze the system stability.
CO2	design optimum structures for realizing IIR and FIR systems.
CO3	analyse the signals using frequency domain analysis
CO4	design and implement different types of FIR/IIR filters
CO5	apply signal processing techniques to real situation problems

2. SYLLABUS

- **DISCRETE TIME SIGNALS AND SYSTEMS** **(12 Hours)**

  Classification of discrete time signals and systems, quantization error, stability analysis, correlation, sampling theorem, aliasing, Z-transforms and its application to the analysis of LTI systems, Realization of discrete-time systems: Direct form – I, II, recursive and non-recursive realization.

- **DISCRETE TIME FOURIER TRANSFORM** **(14 Hours)**

  Definition and properties of DTFT and DFT and their inverses, efficient computation of DFT: FFT algorithms: DIT and DIF, Time-domain aliasing, Application of DFT in linear filtering: Overlap and save, Overlap and add methods.

- **DIGITAL FILTERS** **(12 Hours)**

  Concept of filtering, phase and group delays, Design of IIR filters from analog filters (Butterworth and Chebyshev) by impulse invariance and bilinear transformation, Windowing techniques for FIR filter design, Selection of window function based on the specification.

- **APPLICATIONS OF DSP** **(04 Hours)**

  Applications of DSP to power electronics/ power system/ Instrumentation.

Total Hours: 42

3. BOOKS RECOMMENDED:

1. Sanjit Mitra, Digital Signal processing, McGraw-Hill Science/Engineering/Math; 3 edition, 2005.
2. Proakis-Manolakis, Digital signal Processing, 3rd edition, PHI, 2000.
3. Oppenheim-Schetor, Discrete time signal processing, 2nd edition, Prectice Hall, 1997.
4. Schaum's outline: Digital Signal Processing, Monson H. Hayes, McGraw Hill.
5. Introduction to Digital Signal Processing by Jonny R. Johnson, Prentice Hall India Learning Private Limited.

M. Tech. (Electrical), Semester – I (Core Elective – 1)

EEPE114: MICROCONTROLLER-BASED SYSTEM DESIGN

L	T	P	C
3	0	0	3

1. COURSE OUTCOMES (COs)

Upon completion of the course, the students will be able to:

CO1	Revise basic concepts of 8051 microcontroller and embedded 'C' programming
CO2	Explain architecture of CIP 51 8 bit microcontroller with the advanced features of the controller
CO3	Describe the functionality of Programmable internal and external peripherals of CIP 51.
CO4	Write embedded 'C' code for CIP51 with the exposure of SI Lab IDE.
CO5	Develop microcontroller based prototype for automation, power electronics based electrical systems and other real world problems.

2. SYLLABUS

- **REVIEW OF 8051 ARCHITECTURE AND EMBEDDED 'C' PROGRAMMING (10 Hours)**

  Introduction, 8051 family microcontrollers, hardware architecture, input/output pins, I/O ports and circuits, general purpose registers, special function registers, timers-counters, concepts of interrupts.
  Variables and constants, storage classes, enumerations and definitions, I/O operations, control statements, functions, pointers and arrays, structure and unions, interrupt service routines.

- **INTRODUCTION TO CIP-51 CONTROLLER ARCHITECTURE (08 Hours)**

  Memory Map, Instruction Pipeline, PLL & Clock System, concept of Crossbar and Pin assignment, On Chip Peripherals: Timer/Counters, GPIO, ADC, DAC, UART.

- **HARDWARE CONCEPTS AND PROGRAMMING OF CIP-51 PERIPHERALS (14 Hours)**

  Comparator, SPI & I2C serial Communication interface, MAC unit on CIP-51, Programming of PCA, ADC, DAC. Interfacing of seven-segment LED, LCD display, relay, Pushbutton keys, Matrix key board and Stepper motor.

- **APPLICATIONS (10 Hours)**

  Design of digital Multimeter, numerical relay, control of DC – DC Converters, DC-AC inverters,

Total Hours: 42

3. BOOKS RECOMMENDED:

1. Muhammad Ali Mazidi, Rolin McKinlay and Janice Gillispie Mazidi "The 8051 Microcontroller and Embedded Systems: Using Assembly and C" Pearson 2nd edition, 2007.
2. M. Mazidi, J. G. Mazidi and R. D. McKinlay, The 8051 Microcontroller and Embedded Systems, Prentice Hall of India, 3rd edition, 2007.
3. Mark Siegesmund, Embedded C Programming: Techniques and Applications of C and PIC MCUS, Elsevier Science, 1 st Edition 2014.
4. Chew Moi, Gourab Sen Gupta "Embedded Programming" Silicon Labs 8-bit MCUniversity Program.
5. Datasheet of SILABS C8051FXXX. (www.silabs.com)
6. Application notes from SILAB C8051FXXX.

M. Tech. (Electrical), Semester – I (Core Elective – 1)

EEPE115: PHYSICAL PHENOMENA OF ELECTRICAL MACHINES

L	T	P	C
3	0	0	3

1. COURSE OUTCOMES (COs)

Upon completion of the course, the students will be able to:

CO1	To explain the basic understanding of electrical machines
CO2	To analyze the operation of induction machines
CO3	To analyze performance parameters of electrical machines
CO4	To analyze the performance synchronous machine
CO5	Performance and analysis of the electrical machines in real world application

2. SYLLABUS

- **BASIC UNDERSTANDING OF ELECTRICAL MACHINES** **(10 Hours)**

  Voltage and torque equation of electrical machines, Stray load losses, Oscillation, Vector and matrix power, linear transformation, magnetic and electric energy storage, forces, space harmonic and time harmonics, suppress space harmonics: skewing and fractional slot winding, Cause of vibration and noise, other physical phenomena.

- **INDUCTION MACHINE** **(12 Hours)**

  Single phase and three phase induction circle diagram, calculation in the region of standstill, calculation in the region of maximum torque, symmetrical components transformation- current and voltage, unbalanced operation, Dynamic braking, operation as generator, winding, losses, Rotor types- deep rotors, idle rotors, double squirrel cage rotor, starting current limitation, temperature limitation, rating and applications.

- **PHENOMENA OF CRAWLING, STRAY LOSSES, LOCKING, NOISE AND RIPPLES AND OTHERS** **(10 Hours)**

  Effect of harmonics field, Permeance waves, crawling- asynchronous and synchronous, stray losses, standstill locking, magnetic pull, Parasitic torque, Nature of noise, calculation, induced voltage ripple, Effect of harmonics in the impresses voltage, cogging and synchronous crawling, Physical phenomena and their effect on ac and dc machines.

- **SYNCHRONOUS MACHINE** **(10 Hours)**

  Balanced steady state operation, pull in phenomena, Transient and unbalance operation, Alternator operation–parallel and isolation, Hunting, Measurement of machine parameters, sudden short circuit, three phase short circuit, Elimination of field winding, Zero power factor test, toque, elimination of damper winding, line to line load, line to neutral load.

Total Hours: 42

3. BOOKS RECOMMENDED:

1. Philip L. Alger, “Induction machines -Their Behavior and uses” Second edition, Gordon and Breach science publishers, New York, 1970.
2. Charles V. Jones, “The unified theory of Electrical Machines,” Butter worths publication, London, 1967.
3. P.S. Bimbhra, Generalized theory of electrical Machines, Khanna Publishers, Delhi, 1996.
4. M.G.SAY, The Performance and Design Of Alternating Current Machines, CBS Publishers and Distributors, Delhi,2002
5. P. Vijayraghavan and R. Krishnan, “Noise in electric machines: a review,” Conference Record of 1998 IEEE

Industry Applications Conference. Thirty-Third IAS Annual Meeting (Cat. No.98CH36242), St. Louis, MO, USA, 1998, pp. 251-258 vol.1.
6. S. P. Verma, “Noise and vibrations of electrical machines and drives; their production and means of reduction,” Proceedings of International Conference on Power Electronics, Drives and Energy Systems for Industrial Growth, New Delhi, India, 1996, pp. 1031-1037 vol.2.
7. Other related research publication from IEEE, IET and science direct etc.

M. Tech. (Electrical), Semester – I (Core Elective – 2)

EEPE121: ADVANCED NUMERICAL METHODS AND APPLICATIONS

L	T	P	C
3	0	0	3

1. COURSE OUTCOMES (COs)

Upon completion of the course, the students will be able to:

CO1	learn various advanced numerical methods.
CO2	apply the numerical methods for solving problems related to electrical engineering.
CO3	modeling various systems and perform regression analysis.
CO4	analsye the convergence rate and stability of the algorithms
CO5	Select a suitable numerical method for solving the real time problems based on the accuracy, speed and stability.

2. SYLLABUS

- **ERROR ANALYSIS** **(04 Hours)**

  propagation of error, fixed point and floating point algorithms, reminder theorem

- **SOLUTION OF SYSTEM OF NONLINEAR EQUATIONS** **(06 Hours)**

  Newton-Raphson method, Method of Successive approximation, Adomian decomposition method, convergence criterion

- **REGRESSION ANALYSIS** **(12 Hours)**

  Least Square criterion (LSq), two-dimensional regression for linear and nonlinear systems, multi-dimensional regression for linear and nonlinear systems

- **SOLUTION TO ORDINARY DIFFERENTIAL EQUATIONS** **(12 Hours)**

  Single-step and multi-step explicit integration algorithms – Adam's Bashforth formula, multi-step implicit integration algorithms – Adam's Moulton formula, stability analysis.

- **SOLUTION TO PARTIAL DIFFERENTIAL EQUATIONS** **(04 Hours)**

  Specification of initial and boundary conditions, Solution by finite difference method

- **INTRODUCTION TO INTEGRAL EQUATIONS** **(04 Hours)**

  Homogenous and non-homogenous integral equations, numerical methods to solve solution to integral equations

Total Hours: 42

3. BOOKS RECOMMENDED:

1. Shastri S. S., "Introductory Methods of Numerical Analysis", Prentice Hall Ltd., 4th Edition, 2005.
2. Jain M. K., Iyengar S.R.K., Jain R.K., "Numerical Methods for Scientific and Engineering Computation", 4th Edition, 2003, New Age international Publishers, Pvt. Ltd.
3. S. D. Conte and Carl de Boor, Elementary Numerical Analysis an Algorithmic Approach, 3rd Edition, McGraw-Hill, 1980.
4. Pallab Ghosh, "Numerical Methods with Computer Programs", in C++, Printice Hall of India Private Ltd., 2006.
5. Teukolsky S. A., Vetterling W. T., Press W. H. & Flannery B. P., "Numerical recipes in 'C', 2nd Edition, Foundation Books Pvt. Ltd., 2001.
6. Leon O. Chua and Pen-Min Lin, "Computer-Aided Analysis of Electronic Circuits", Printice Hall Series in Electrical and Computer Engineering.

M. Tech. (Electrical), Semester – I (Core Elective – 2)

EEPE122: SYSTEM THEORY

L	T	P	C
3	0	0	3

1. COURSE OUTCOMES (COs)

Upon completion of the course, the students will be able to:

CO1	understand the concepts of vector spaces and subspaces
CO2	explain the concepts of Linear algebra and its application to control theory
CO3	analyze discrete time systems with Z-transforms
CO4	evaluate the stability of discrete time systems and obtain the state space representation of discrete time systems
CO5	design controllers and observers for discrete time systems

2. SYLLABUS

- **LINEAR ALGEBRA** **(20 Hours)**

  Vector spaces, Basis, Operator, range of the linear operator, null space, rank, nullity, rank-nullity theorem, matrix representation of the linear operator in the bases, orthogonal bases, Inner product spaces, Holder inequality, Cauchy-Schwartz inequality, triangular inequality, Minkowski inequality, best approximation theorem , orthogonal projection lemma, Gram- Schmidtt orthogonalization, Characteristics polynomial, minimal polynomial, eigen value and eigen vector, Diagonal form, Triangular form, Caley- Hamilton Theorem.

- **SYSTEM THEORY** **(22 Hours)**

  Introduction to Z transformation ,bilateral and unilateral Z transformation, Z transformation of the important signals, Solving Discrete LTI system using Z transformation, Pulse transfer function, Phase space analysis of the discrete LTI system, Jury Stability criterion , Schur-Cohn test, Bilinear transformation applied with Routh's stability criterion. Conservative system, Controllability, Obsrvability, Observer Design, Diaphantile equation, Full order, reduced order, minimum order observer, Gopinath Observer, Luenberger Observer.

Total Hours: 42

3. BOOKS RECOMMENDED:

1. Kenneth Hoffmann And Ray Kunze, "Linear Algebra", PHI India limited, 1971.
2. K. Ogata, "Discrete-Time Control Systems", Prentice Hall; 2nd edition, 1995.
3. Allen V. Oppenheim, S. Willsky, with S. Hamid Navab ''Signals and systems" Prentice Hall; 2nd edition, 1996.
4. K. Ogata, "Modern Control Engineering", 3rd Edition, PHI India limited, 2001.
5. I. J. Nagrath and M. Gopal, "Control System Engineering", Anshan Publishers; 5th edition, 2008.

M. Tech. (Electrical), Semester – II (Core Elective – 2)

EEPE 123: CONTROL TECHNIQUES IN SWITCH-MODE POWER CONVERTERS

L	T	P	C
3	0	0	3

1. COURSE OUTCOMES (COs)

Upon completion of the course, the students will be able to:

CO1	Explain different modulation techniques for power converters
CO2	Modeling DC-DC converters applying State-space and Circuit averaging techniques
CO3	Design and analyze voltage-mode control of DC-DC converters
CO4	Design and analyze current-mode control of DC-DC converters
CO5	Design and analyze nonlinear control of DC-DC converters

2. SYLLABUS

- **MODULATION TECHNIQUES** **(04 Hours)**

  Fixed-frequency modulation techniques: Trailing-edge PWM, Leading-edge PWM, Dual-edge PWM and Phase-shift PWM. Variable frequency modulation techniques: Constant on-time modulation, constant off-time modulation and hysteresis modulation.

- **DYNAMIC MODELLING OF CONVERTERS** **(12 Hours)**

  State-Space Averaging Technique: Deriving large-signal averaged equations for dc-dc converters, perturbation and linearization, construction of small-signal averaged equivalent circuit model, modeling the pulse-width modulator, state-space averaged models for various dc-dc converters.
  Circuit-Averaging and Averaged Switch Modeling: Deriving large-signal average model of switching network, perturbation and linearization, construction of small-signal averaged equivalent circuit of basic dc-dc converters. Advantages with circuit-averaging modeling over state-space averaging technique. Transfer functions of DC-DC converters..

- **VOLTAGE-MODE CONTROL** **(09 Hours)**

  Converter's objectives and control requirements, voltage mode control design for basic dc-dc converters using loop shaping technique, stability margins: gain and phase margins, disturbance rejection using feedforward technique, combined feedback and feedforward control.

- **CURRENT-PROGRAMMED CONTROL** **(09 Hours)**

  Concept of Current-programmed mode (CPM) control, Modelling of converter operating in CPM: a simple first-order model, drawback with first-order model, a more accurate model, Converter transfer functions with CPM control, Addition of an input filter to current-programmed converter, Simulation of CPM controlled converters, Voltage feedback loop around a current programmed converter, Loop interactions in CPM control and design of average current mode control.

- **NONLINEAR CONTROL** **(08 Hours)**

  Model based classification of Nonlinear control methods, Small-signal and large-signal model based nonlinear control, Sliding mode control, Sliding mode control design in a buck converter, boundary control techniques and selection of switching surfaces, boundary control design for a buck converter, linking switching boundary and conventional PID control to improve performance of DC-DC converters.

Total Hours: 42

3. **BOOKS RECOMMENDED:**

1. Robert Erickson, D. Maksimovic, ``Fundamental of Power Electronics, 3rd edition, Springer Nature Switzerland AG 2020.
2. Philip T. Krein, ``Elements of Power Electronics'', Oxford University press, Indian Edition 2017.
3. Christophe P. Basso, Designing Control Loops for Linear and Switching Power Supplies: A Tutorial Guide, Artech House Publishers, 1 Oct 2012.
4. Santanu Kapat, `` Control and Tuning Methods in Switch Mode Power Converters'', Online Video lectures on NPTEL India.

M. Tech. (Electrical), Semester – I (Core Elective – 2)

EEPE124: DESIGN OF MAGNETIC COMPONENTS FOR POWER CONVERTERS

L	T	P	C
3	0	0	3

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1. COURSE OUTCOMES (COs)

Upon completion of the course, the students will be able to:

CO1	explain the basic concept of magnetics
CO2	devise various design steps for inductor and transformers
CO3	Formulate area product for high frequency transformers for different isolated dc-dc converters
CO4	Design of high frequency transformers
CO5	devise the computer aided simulation for design of high frequency transformers

2. SYLLABUS

- **PRINCIPLES OF MAGENTIC THEORY** **(10 Hours)**

  Review of basic magnetics, transformer modelling, loss mechanism in magnetic devices, eddy current in winding conductors, several types of magnetic devices, their B-H loops and core vs copper loss, Magnetic materials- core materials, core shapes, core size, core assembly

- **DESIGN OF INDUTCORS** **(05 Hours)**

  Principles of inductor design, filter inductor design constraints, step by step procedure, multiple winding magnetics design, ac inductor design, coupled inductor design

- **PRINCIPLES OF TRANSFORMER DESIGN** **(10 Hours)**

  Introduction to Power Transformer- operation on no-load and load, hysteresis loss, remnant flux density, induced emf and eddy currents, turns ratio, volt-sec product, stack factor, leakage flux, equivalent circuit, power handling capacity of the transformer, area product, choice of core for the a transformer, window utilization factor, transformer polarities and dot convention, testing of polarity.

- **HIGH FREQUENCY TRANSFORMER DESIGN** **(10 Hours)**

  Area products of transformer for isolated dc-dc converters like forward, half bridge, full bridge, push-pull, and fly-back, design of transformers for aforesaid isolated dc-dc converters, design of multiple outputs transformer.

- **DESIGN OF CURRENT TRANSFORMERS** **(03 Hours)**

  Principles of bidirectional CT design, Design steps in CT, unidirectional CTS

- **COMPUTEWR AIDED DESIGN OF TRANSFORMERS** **(04 Hours)**

  Module 1-Specifications, module2- Transformer design, design data output

Total Hours: 42

3. BOOKS RECOMMENDED:

1. L. Umanand and S.R. Bhat, "Design of magnetic Components for switched mode power converters", Wiley Eastern Limited, 1st Edition.
2. Ned Mohan et al, "Power Electronics: Converters, Applications, and Design", John Wiley & Sons. Inc., 3rd Edition, 2010.
3. R.W. Erickson, Fundamental of Power Electronics, Springer (India) Private limited 2005.

M. Tech. (Electrical), Semester – I (Core Elective – 2)
EEPE125: ELECTRIC VEHICLE TECHNOLOGY

L	T	P	C
3	0	0	3

1. COURSE OUTCOMES (COs)

Upon completion of the course, the students will be able to:

CO1	Understand the basic concepts of electric vehicles and popular traction systems
CO2	Analyze the different propulsion unit and their working
CO3	Understand the drive-train topologies and advanced propulsion techniques
CO4	Analyze the various energy storage methodologies in traction systems
CO5	Understanding the Energy Management in Electric Vehicle

Pre- requisites:
1. Control Systems 2. Electrical Machines 3. Power Electronics. 4. Electric Drives.

2. SYLLABUS

- **CONVENTIONAL VEHICLES** **(08 Hours)**

  Vehicle dynamics, Basics of vehicle performance, vehicle power source characterization, transmission characteristics and mathematical models to describe vehicle performance. Introduction to Hybrid Electric Vehicles: History of hybrid and electric vehicles, social and environmental importance of hybrid and electric vehicles, impact of modern drivetrains on energy supplies.

- **HYBRID ELECTRIC DRIVETRAINS** **(12 Hours)**

  Basic concept of hybrid traction, introduction to various hybrid drive-train topologies, power flow control in hybrid drive-train topologies, fuel efficiency analysis. Electric Drive-trains; Basic concept of electric traction, introduction to various electric drive-train topologies. Power flow control in electric drive-train topologies, efficiency analysis, Sizing the drive system: Matching the electric machine and the internal combustion engine (ICE) Sizing the propulsion motor, sizing the power electronics.

- **ELECTRIC PROPULSION UNIT** **(10 Hours)**

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

- **ENERGY STORAGE** **(06 Hours)**

  Introduction to Energy Storage Requirements in Hybrid and Electric Vehicles, Battery based, Fuel Cell based, Super Capacitor based energy storage and its analysis, Hybridization of different energy storage devices. Sizing the drive system: Matching the electric machine and the internal combustion engine (ICE) Sizing the propulsion motor, sizing the power electronics selecting the energy storage technology, Communications, supporting subsystems

- **ENERGY MANAGEMENT ISSUES** **(06 Hours)**

  Classification and comparisons of different energy management strategies, implementation issues of energy management strategies, Case Studies: Design of a Hybrid Electric Vehicle (HEY), Design of a Battery Electric Vehicle (BEV).

Total Hours: 42

3. BOOKS RECOMMENDED:

1. Ali Emadi, Advanced Electric Drive Vehicles, CRC Press, 2014.
2. Iqbal Hussein Electric and Hybrid Vehicles: Design Fundamentals, CRC Pres, 2003.
3. Mehrdad Ehsani, Yi.mi Gao Sebastjan E. Gay, Ali Emadi , Modem Electric, Hybrid Electric and Fuel Cell Vehicles; Fundamentals Theory and Design, CRC Press 2004.

4. James Larminie John Lowry, Electric Vehicle Technology Explained, Wiley, 2003.
5. S. Onorio, L. Serrao and G. Rizzoni, 'Hybrid Electric Vehicles: Energy Management Strategies", Springer 2015.
6. T. Denton, ‘Electric a.ad Hybrid Vehicles’, Routledge 2016.

M. Tech. (Electrical), Semester – I

EEPE105: REAL TIME SIMULATION OF POWER ELECTRONIC CIRCUITS

L	T	P	C
0	0	2	1

1. COURSE OUTCOMES (COs)

Upon completion of the course, the students will be able to:

CO1	Understand HIL and SiL operations with real time simulators
CO2	Implement power converter model in the SiL mode
CO3	Implement power converter model in the HiL mode

2. SYLLABUS

LIST OF EXPERIMENTS

1. Basic study on real time simulators.
2. Demonstration on Analog input and output pins of real time simulator with an example.
3. Demonstration on digital input and output pins of real time simulator with an example.
4. MATLAB Integration with real time simulator.
5. Demonstration of MATLAB model in Simulation in Loop (SiL).
6. Demonstration of a MATLAB model in Hardware in Loop (HiL).
7. Demonstration of a MATLAB model in Rapid Prototype control (RPC).
8. Implementation of DC-DC converter with help of SiL/ HiL/ RPC.
9. Demonstration of a chopper fed DC drive using SiL/HiL.
10. Demonstration of closed loop speed control of chopper fed DC drive using SiL/HiL.

Total Hours: 24

3. REFERENECS:

1.https://www.opal-rt.com/power-electronics-overview/
2.https://www.typhoon-hil.com/documentation/typhoon-hil-application-notes
3.https://www.ni.com/en-in/innovations/white-papers/09/hardware-in-the-loop--hil--test-system-architectures.html

M. Tech. (Electrical), Semester – II

EEPE201: POWER ELECTRONICS – II

L	T	P	C
4	0	2	5

1. COURSE OUTCOMES (COs)

Upon completion of the course, the students will be able to:

CO1	learn different topologies of PFC converters and analyse them
CO2	model the PFC converters converter and design the controller
CO3	classify and analyze different types of resonant converters
CO4	classify and analyze various multi-level inverters and ZS Inverters
CO5	Design driver circuits, magnetic components and heat sink for devices in the converters

2. SYLLABUS

- **UNITY POWER FACTOR CONVERSION** **(06 Hours)**
  Topologies, Steady-state Analysis, Dynamic Analysis, Matrix converters, Modeling and Applications

- **RESONANT CONVERTER** **(10 Hours)**
  Introduction, Classification, Basic Resonant Circuit Concepts, Load Resonant Converter, Resonant Switch Converter, Zero Voltage and Zero Current Switching, Clamped Voltage Topologies, Resonant DC link Inverter, High Frequency Link Integral Half Cycle Converters.

- **Z-SOURCE INVERTERS** **(04 Hours)**
  Z-source networks, Z-source Inverters, Quasi-Z-Source Inverters, Applications

- **MULTI LEVEL CONVERTERS** **(12 Hours)**
  Principle, Topologies: DCMLI, FCMLI, CHBMLI, Multi-level rectifiers, Control and applications

- **DESIGN CONSIDERATIONS** **(08 Hours)**
  Gate-drive circuit design, Design of snubber circuit, design of magnetic components: inductor, high-frequency transformers, line and EMI filters, Heat sink design

Total Hours: 42

3. LIST OF EXPERIMENTS

SET - I

1. Study of single phase boost active power factor correction.
2. Study of 3-level Diode Clamped multi-level Inverter circuit.
3. Study of Series Resonant Converter.
4. Study of 12 pulse controlled and uncontrolled rectifier.
5. Study of Thyristorised APFC [Active Power Factor Correction] circuit.
6. Study of Dynamic Voltage Regulator.
7. Study of Push-Pull converter.
8. Study of open loop and closed loop response of DC-DC flyback converter.

SET – II

1. Simulation of Boost Converter based PFC circuit using control method: (i) Average Current Control; (ii) Peak Current Control; and (iii) Hysteresis Current Control.
2. Simulation of Resonant Converter Circuits: Series, Parallel.
3. Simulation of Multi Pulse Converter: (i) 12 pulse; (ii) 18 pulse; and (iii) 24 pulse.
4. Simulation of Multi-level Inverter: (i) 3-level; and (ii) 5 level.
5. Simulation of PWM rectifier.
6. Simulation of PWM AC Chopper circuit.

SET – III

1. Mini Project

4. **BOOKS RECOMMENDED:**

1. Rashid, M. H., "Power Electronics Handbook", Elsevier Academic Press, 2001.
2. Ned Mohan, Tore M. Undeland and William P. Robbins, “Power Electronics Converters, Applications, and Design”, John Willey & Sons, Inc., 2nd Edition, 1995.
3. Erickson Robert W., Maksimovic Dragan, "Fundamentals of Power Electronics", 2nd Edition, Springer New York.
4. Umanand “Power Electronics: Essentials & Applications” Wiley, 2009
5. Bin Wu, “High-Power Converters and Ac Drives” John Wiley & Sons, Inc., Hoboken, New Jersey.
6. Ersan Kabalcı “Multilevel Inverters Introduction and Emergent Topologies”, Elsevier Science, 2021.

M. Tech. (Electrical), Semester – II

EEPE202: AC DRIVES

L	T	P	C
4	0	2	5

1. COURSE OUTCOMES (COs)

Upon completion of the course, the students will be able to:

CO1	Explain the basic principle of induction and synchronous Drives
CO2	Derive the equations and design of AC motors
CO3	Estimate the performance of Induction and Synchronous Machines
CO4	Analyse the performance of AC Drives
CO5	Apply the Induction and Synchronous Machines in real life problem
CO6	Apply the control methods of AC drives in real world.

2. SYLLABUS

- **INDUCTION MOTOR DRIVES** **(28 Hours)**

  Introduction, Review of three phase I.M. analysis and performance, Analysis of I.M. fed from Non-sinusoidal supply voltage, Stator voltage control, V/f controlled induction motors, Close loop control, Slip power recovery-static scherbius and Kramer drives, PWM switching schemes, Field oriented control-direct and indirect control, Parameter sensitivity, Flux programming efficiency optimizer, stator flux oriented vector control, Sensor-less vector control-speed estimation methods, Direct torque and flux control (DTC), Parameter estimations, Applied adaptive and intelligent Control- Fuzzy and neural network, hybrid methods, Multilevel inverter fed drives and control, CSI fed induction motor drives, Applications.

- **SYNCHRONOUS MOTOR DRIVES** **(28 Hours)**

  Introduction, Sinusoidal SPM machine drives- open loop V/F control, vector control , Synchronous reluctance machine drives-current vector control, Sinusoidal IPM machine drives-vector control with maximum torque /ampere, field weakening, Vector control with stator flux orientation- feed-back signal processing, PWM square wave sequencing, Trapezoidal SPM machine drive- $2\pi/3$ angle switch on mode, voltage and current control PWM mode, torque pulsation, Wound field synchronous motor drive, Load-commutated Synchronous Motor Drives- Delay angle control, Sensor less control- Trapezoidal SPM machines, sinusoidal PM machines, PWM switching schemes, Switch reluctance motor drives: Operation, Power Converters, Control of SRM- current, flux and torque, acoustic noise and its control, sensor less control, Applications, Application of intelligent Control-Fuzzy and neural network, hybrid methods method.

Total Hours: 56

3. LIST OF EXPERIMENTS

1. Speed control and performance analysis of voltage source inverter fed three phase induction motor drives.
2. Speed control and performance analysis of multilevel inverter fed induction motor drives.
3. Speed control and performance analysis of PMSM drives
4. Speed control and performance analysis of synchronous reluctance drives.
5. Study of variable frequency drives.
6. Speed control and performance analysis of switch reluctance motor drives
7. Speed control and performance analysis of IPM drives
8. Close loop control of induction motor drives.
9. Close loop control of synchronous motor drives.
10. Generator Operation of induction machine.
11. Performance study of PMSG.

4. BOOKS RECOMMENDED:

1. B.K.Bose, “Modern Power Electronics and AC drives” Pearson Education Asia, 2003.
2. R. Krishnan, “Electric motor drives Modeling, Analysis and Control” PHI-India, 2005.
3. R. Krishnan, “Switched Reluctance Motor Drives Modeling, Simulation, Analysis, Design, And Applications,”CRC Press, New York, 2015.
4. Tze-Fun Chan and Keli Shi, “Applied Intelligent Control of Induction Motor Drives”, John Wiley & Sons, Singapore, 2011
5. S.K. Pillai, “A First Course on Electrical Drives”, New Age international publishers, Delhi, 2010.
6. G.K. Dubey, "Power semiconductor controlled Drives", Prentice Hall international, New Jersey, 1989.
7. Dewan, S. Slemon B., Straughen, A. G.R., "Power Semiconductor drives", John Wiley and Sons, NewYork 1984.
8. Rashid, M. H., "Power Electronics Handbook", Elsevier Academic Press, 2001.

M. Tech. (Electrical), Semester – II

EEPE203: DIGITAL CONTROL OF POWER CONVERTERS

L	T	P	C
3	0	2	4

1. COURSE OUTCOMES (COs)

Upon completion of the course, the students will be able to:

CO1	understand the features of 32-bit controllers
CO2	understand the fundamentals of different architectures of 32-bit microcontrollers
CO3	design programs for the 32 -bit processor using embedded C
CO4	implement algorithms on processor for power electronic converter and drives
CO5	

2. SYLLABUS

- **INTRODUCTION TO 32-BIT CONTROLLERS AND EMBEDDED 'C' PROGRAMMING (08 Hours)**

  Introduction, RISC and CISC architecture, Harvard and Von Neumann architecture, comparison of RISC based microcontrollers, Features of 32-bit architecture, addressing modes, instruction set, and Development tools. Variables and constants, storage classes, enumerations and definitions, I/O operations, control statements, functions, pointers and arrays, structure and unions, interrupt service routines.

- **STM-32 ARCHITECTURE & PROGRAMMING (16 Hours)**

  ARM Cortex M core, bus matrix, AHB and APB buses, different clock domains on MCU, Architecture, introduction to STM32CUBE MX and Programming of peripherals like GPIO, Timers, PWM Timers, UART, DAC, ADC, SPI, I2C using Embedded 'C', Hardware debugging techniques.

- **C2000 ARCHITECTURE & PROGRAMMING (16 Hours)**

  Architecture of C2000 DSP's, Instruction sets in C2000, Introduction to code composer studio (CCS) and Programming of peripherals like GPIO, UART, DAC, ADC, SPI, I2C using Embedded 'C', Hardware debugging techniques.

- **APPLICATIONS (16 Hours)**

  Understanding digital control of DC-DC converters, Generation of sine wave and viewing in DAC, control of Induction motor, PMSM, BLDC. Example programs for communication interfaces like I2C interface, RS232 interface, understanding the encoder features in C2000 for drive application.

Total Hours: 56

3. LIST OF EXPERIMENTS

1. Arithmetic operations of Signed and Unsigned Numbers
2. Memory Block Movements (Forward, reverse, overlapping)
3. Ascending and descending arrangement of data string.
4. Code conversion. (Hexadecimal, BCD, Binary, ASCII etc.)
5. Toggling of port pin with time delay.
6. Sensing of push button keys.
7. Generate different duty cycle and different switching frequency waveform using timers.
8. Generate sine wave and triangular wave using DAC
9. Measure voltage and current using ADC

4. BOOKS RECOMMENDED:

1. Trevor Martin, "The Insider's Guide to The STM 32", Published by Hitex (UK) Ltd., April 2005.
2. Joseph, Yiu, "The Definite Guide to cortex –M3/M4", Elsevier publication, 2007.
3. Datasheet and user manual of STM F4 series MCU, www.st.com.
4. Datasheet and user manual of TI digital signal controllers.

M. Tech. (Electrical), Semester – II (Core Elective – 3)

EEPE 211: CHARGING INFRASTRUCTURE FOR ELECTRIC VEHICLES

L	T	P	C
3	0	0	3

1. COURSE OUTCOMES (COs)

Upon completion of the course, the students will be able to:

CO1	explain the basic concept of EV battery charging
CO2	devise various power electronic converters to EV battery chargers
CO3	devise different control techniques for EV battery charging
CO4	explain the different types of connectors
CO5	decide the suitability of EV chargers for applications in emerging areas

2. SYLLABUS

- **ELECTRIC VEHICLE CHARGING INFRASTRUCTURE** **(12 Hours)**

  History of EV, Components of Electric Vehicle, Comparison with Internal combustion Engine : Technology, Comparison with Internal combustion Engine: Benefits and Challenges, EV classification and their electrification levels, EV Charging Technology-Electric Vehicle Supply Equipment (EVSE), types of EVSE, Options for EV Charging, Charger Specifications and PCS Infrastructure, Location of PCS/ FCB CS in local area/ building precincts

- **TYPES OF EV CHARGERS** **(10 Hours)**

  Electric Vehicle Technology and Charging Equipments, Basic charging Block Diagram of Charger,
  Difference between Slow charger and fast charger, Slow charger design rating, Fast charger design rating, AC charging and DC charging, On-board and off-board charger specifications, EVSE associated charge times calculation

- **SELECTION AND SIZING OF COMMON TYPES OF CONNECTORS AND APPLICATIONS** **(10 Hours)**

  Selection of AC charger type-1, type -2 and type -3, Communication between AC charger and EV Selection of DC charger connector GB/T, CHAdeMO, CCS-1 and CSS-2, Communication methodology of DC fast chargers, IS/ IEC/ARAI/ standard of Charging topology ,Communication and connectors (IEC 61851-1, IEC 61851-24,62196-2), Selection sizing of Charger connector cable

- **ADVANCED EV CHARGERS WITH MULTIFUNCTIONAL FEATURES** **(10 Hours)**

  EV Chargers with bidirectional power flow capability, Multifunctional operation-G2V, V2G, V2V, V2L etc.

Total Hours: 42

3. BOOKS RECOMMENDED:

1. Iqbal Hussein Electric and Hybrid Vehicles: Design Fundamentals, CRC Pres, 2003.
2. S. Onorio, L. Serrao and G. Rizzoni, 'Hybrid Electric Vehicles: Energy Management Strategies", Springer 2015.
3. Ottorino Veneri, Technologies and Applications for Smart Charging of Electric and Plug-in Hybrid Vehicles, Springer, 2017
4. Sobodh Sarkar, Electric Vehicle Service Equipment - EVSE - Comprehensive Design Inputs of Level 1,2 & 3 Chargers: Circuits, Design & Infrastructure of EVSE, 2019

M. Tech. (Electrical), Semester – II (Core Elective – 3)

EEPE 212: SPECIAL ELECTRICAL MACHINES AND DRIVES

L	T	P	C
3	0	0	3

1. COURSE OUTCOMES (COs)

Upon completion of the course, the students will be able to:

CO1	Explain the basic principle of Special Machines Drives
CO2	Derive the equations and design of Special Machines Drives
CO3	Estimate the performance of Special Machines
CO4	Analyse the performance of Special Machines
CO5	Apply the special machines in real life problem
CO6	Apply the control methods of special machines in real world

2. SYLLABUS

- **STEPPING MOTORS** **(08 Hours)**

  Constructional features, principle of operation, Types of stepper motors: VR Stepper motor, PM stepper motor, Hybrid stepper motor, torque production in VR stepper motor, modes of excitation, Dynamic characteristics, Drive systems and circuit for open loop control, Closed loop control of stepping motor, Design and Applications.

- **SWITCHED RELUCTANCE MOTORS** **(08 Hours)**

  Constructional features, principle of operation, design, steady state performance, methods for inductance calculation, Torque equation, Power converters, speed torque characteristics, closed loop control for Switched Reluctance drives, current and torque control, acoustic noise control, sensor-less operation, applications.

- **PERMANENT MAGNET BRUSHLESSDC MOTORS** **(08 Hours)**

  Commutation in DC motors, difference between mechanical and electronic Commutators, Hall sensors, Optical sensors, Multi phase Brushless motor, Square Wave permanent magnet brushless motor drives, torque and EMF equation, torque speed characteristics of Permanent Magnet Brushless DC Motors- controllers PMDC Motor, sine wave permanent magnet brushless motor drives, Applications.

- **SERVO MOTORS** **(03 Hours)**

  Symmetrical components applied to two - phase servo motors - equivalent circuit and performance based on symmetrical components - servo motor torque - speed curves.

- **FRACTIONAL KILOWATT MOTORS** **(04 Hours)**

  universal motor, reluctance motor, hysteresis motor, repulsion motor, essential parts, torque - characteristics, design and control, and applications.

- **LINEAR MACHINES** **(06 Hours)**

  Linear Induction Motors-Theory and performance, design for medium to high speed, Superconducting Magnet Linear Synchronous Motors, Linear Reluctance Synchronous Motors and Applications.

- **MACHINE DESIGN** **(05 Hours)**

  Fundamentals of machine design, Design philosophy, Materials, Stresses in machines, Machine design using FEM package.

Total Hours: 42

3. **BOOKS RECOMMENDED:**

1. Miller. T.J.E., “Brushless Permanent Magnet and Reluctance Motor Drives”, Clarendon Press, Oxford, 1989.
2. Kenjo. T and Nagamori. S, ”Permanent Magnet and Brush less DC Motors", Clarendon Press, Oxford,1989.
3. Kenjo.T, "Stepping Motors and their Microprocessor Control", Clarendon Press, Oxford, 1989.
4. Krishnan R. "Switched Reluctance Motor Drives", Modelling, Simulation, Analysis, Design and applications, CRC press, 2006.
5. Hughes, “Electric Motors & Drives”, Newnes; 3rd edition,2005.
6. Ion Boldea, Linear Electric Machines, Drives, and MAGLEVs Handbook, CRC Press, Taylor & Francis Group, New York, 2017.
7. Jacek F. Gieras, Zbigniew J. Piech and Bronislaw Z. Tomczuk, “Linear Synchronous Motors:Transportation and Automation Systems,” Second Edition, CRC Press, Taylor & Francis Group,New York,2012
8. Toro. V. D, “Electric machines and power systems”, Prentice Hall of India, 1985.
9. Veinott, “Fractional horse power electric motors”, Mc Graw Hill, 1948

M. Tech. (Electrical), Semester – II (Core Elective – 3)

EEPE 213: ADVANCED POWER CONVERTERS FOR RENEWABLE APPLICATIONS

L	T	P	C
3	0	0	3

1. COURSE OUTCOMES (COs)

Upon completion of the course, the students will be able to:

CO1	Analyze and understand power converter interfaced solar PV systems
CO2	Select and design passive filters for grid-connected solar and wind systems
CO3	Analyze and understand converter topologies for solar PV systems
CO4	Analyze and understand converter topologies for wind turbine systems
CO5	Design and analyze converter control for solar and wind turbine systems

2. SYLLABUS

- **POWER CONVERTERS FOR SOLAR PV SYSTEMS** **(18 Hours)**

  PV system classifications, requirements, and challenges: Standalone, grid-feeding and hybrid PV systems, Grid-feeding inverters: central, string and micro-Inverters, single-stage and two-stage inverter configurations, Grid requirements for PV, DC and AC side filtering requirements and design, issue of leakage/residual current and remedial techniques, Control structure: MPPT and grid-current control.

  PV inverters derived from H-bridge topology: Basic full-bridge inverter, H5 inverter (SMA), HERIC inverter, REFU inverter, full-bridge inverter with DC Bypass (FB – DCBP), full-bridge Zero Voltage Rectifier (FB – ZVR)

  High Voltage-Gain DC-DC Converters: Magnetic coupling based isolated/non-isolated converters, voltage multiplier cell, switched inductor and switched capacitor based converters, voltage lift converters, Z-source and resonant converters

  PV Power Control: Grid Synchronization and PLL, MPPT & grid current control with above mentioned converters

- **POWER CONVERTERS FOR WIND TURBINE (WT) SYSTEMS** **(18 Hours)**

  WT system classifications and requirements: Power conversion structures for variable speed wind turbine systems with IG, DFIG and PMSM; Grid requirements for WT systems, Conventional unidirectional and bi-directional power converters for WT systems.

  Multilevel Power Converters: Three-Level Neutral-Point Diode Clamped Back-To-Back Topology (3L-NPC BTB), Three-Level H-Bridge Back-to-Back Topology (3L-HB BTB), Five-Level H-Bridge Back-to-Back Topology (5L-HB BTB), Three-Level Neutral-Point Diode Clamped Topology for Generator Side and Five-Level H-Bridge Topology for Grid Side (3L-NPC + 5L-HB).

  Introduction to Matrix Converters: Principle of operation, various configurations and applications.

- **MULTI-INPUT DC-DC CONVERTERS FOR RENEWABLE APPLICATIONS:** **(06 Hours)**

  Various multi-input DC-DC converter topologies, integration of PV, Wind and Fuel Cell sources.

Total Hours: 42

3. BOOKS RECOMMENDED:

1. Remus Teodorescu et al, ``Grid converters for photovoltaic and wind power systems'', John Willey & Sons Ltd., 2011.
2. Sudipta Chakraborty et al, ``Power Electronics for Renewable and Distributed Energy Systems: A Sourcebook of Topologies, Control and Integration'', Springer Science & Business, 2013.
3. Ashok L. Kumar et al,`` Power electronic converters for solar photovoltaic systems'', Academic Press, 2020.
4. Nicola Femi et al, ``Power Electronics and control for maximum Energy Harvesting in Photovoltaic Systems'', CRC Press, 2013.

M. Tech. (Electrical), Semester – I (Core Elective – 2)

EEPE214: DISTRIBUTED POWER GENERATION AND MICRO-GRID

L	T	P	C
3	0	0	3

1. COURSE OUTCOMES (COs)

Upon completion of the course, the students will be able to:

CO1	Explain the basic principle of micro grid
CO2	Understanding of distributed energy resources
CO3	Analyse and control of Solar and wind Energy System
CO4	Analyse and control of Hybrid Energy System
CO5	Performance of the system with integration of real world problem
CO6	Economic aspect of micro grid

2. SYLLABUS

- **INTRODUCTION** **(08 Hours)**

  The basic concepts of power grid, Distributed power generation, the electric grid vs microgrids: technical and historic perspective, concept of microgrid, typical configuration of microgrid, AC and DC microgrids, interconnection of microgrids, technical and economical advantages of microgrid, challenges and disadvantages of microgrids, Islanding, need and benefits, different methods of islanding detection, modelling a microgrid system.

- **DISTRIBUTED ENERGY RESOURCES AND GENERATOR CONFIGURATION** **(10 Hours)**

  Introduction, Combined heat and power (CHP) systems, Solar photovoltaic (PV) systems, Wind energy conversion systems (WECS) , Small-scale hydro electric power generation, Storage devices: Batteries: Lead acid, nickel metal hydrate, and lithium ion batteries, ultra-capacitors, flywheels, Hydrogen energy storage Advantages and disadvantages of DG, Wind turbine, small hydro, diesel engine Driven Generators-squirrel-cage induction Generator, Synchronous Reluctance Generator, Permanent magnet Synchronous Generator, Doubly Fed Induction Generator and others, Control approach- voltage, frequency and power quality features, Generation of Power Using Geothermal Resources, Tidal and other sources.

- **SOLAR AND WIND ENERGY SYSTEM** **(07 Hours)**

  The solar energy conversion process, photovoltaic power conversion, power converters, photovoltaic characteristic, photovoltaic efficiency, design of photovoltaic system and control, MPPT, storage system based on a single cell battery, the energy yield of a photovoltaic module and the angle of incident, Wind power, selection of wind turbine, power flow analysis, power converters for single and three system, control approach for mitigation of power quality problem, isolated and grid connected system.

- **HYBRID ENERGY SYSTEM** **(10 Hours)**

  Diesel engine, Battery, wind turbine, small Hydro and PV based system- Configuration and various system combinations, Power Converters used for micro-grid applications, control approach for power quality, Configuration and control in isolated and grid connected system, AC and DC interconnection, Micro grid for rural area- overview, planning, specific characteristics.

- **PROTECTION ISSUES FOR MICROGRIDS** **(03 Hours)**

  Introduction, Islanding, Different islanding scenarios, Major protection issues of standalone Microgrid - Impact of DG integration on electricity market, environment, distribution system, communication.

- **INTRODUCTION TO SMART METERS** **(04 Hours)**

  Electricity tariff - one-part tariff, two tariff and maximum demand tariff - Dynamic pricing: Time of-use (TOU) pricing, critical-peak pricing (CPP) and Real Time, Pricing- Automatic Meter Reading (AMR).

Total Hours: 42

3. BOOKS RECOMMENDED:

1. Ali Keyhani Mohammad Marwali and Min Dai, “Integration of green and Renewable Energy in Electric Power Systems” John Wiley publishing company, New Jersey. 2010.
2. S. Chowdhury, S. P. Chowdhury, P. Crossley, “Microgrids and Active Distribution Networks”, IET Power Electronics Series, 2012
3. Ali Keyhani, Design of Smart Power Grid Renewable Energy Systems, ISBN: 978-0-470-62761-7, John Wiley and Sons, New Jersey, 2012
4. James Momoh, Smart Grid: Fundamentals of Design and Analysis, John Wiley & Sons, New Jersey,2012
5. R. C. Durgan, M. F. Me Granaghen, H. W. Beaty, “Electrical Power System Quality”, McGraw-Hill
6. Remus Teodorescu, Marco Liserre, Pedro Rodriguez, Grid Converters for Photovoltaic and Wind Power Systems, ISBN: 978-0-470-05751-3, Wiley
7. Qing Chang Zhong and Tomas Hornik, “ Control of power inverters in renewable energy and smart grid integration,” John Wilely& Sons, Limited, New Delhi, 2013.
8. William E. Glassley, “Geothermal Energy: Renewable energy and environment”, CRC Press, 2010
9. Rajeev kumar chauhan, Kalpana chauhan and Sri Niwas Singh, Microgrids for Rural Area: Reserach and case studies,The Institution of Engineering and Technology, London, United Kingdom, 2020
10. M. Rezkallah, A. Chandra, B. Singh and S. Singh, “Microgrid: Configurations, Control and Applications,” *IEEE Transactions on Smart Grid*, vol. 10, no. 2, pp. 1290-1302, March 2019.
11. S. Puchalapalli, S. K. Tiwari, B. Singh and P. K. Goel, “A Microgrid Based on Wind-Driven DFIG, DG, and Solar PV Array for Optimal Fuel Consumption,” *IEEE Transactions on Industry Applications*, vol. 56, no. 5, pp. 4689-4699, Sept.-Oct. 2020.
11.Topic related other Research papers from IEEE, IET and science direct etc

M. Tech. (Electrical), Semester – II

EEPE 215: HVDC TRANSMISSION

L	T	P	C
3	0	0	3

1. COURSE OUTCOMES (COs)

Upon completion of the course, the students will be able to:

CO1	explain the configurations, advantages and applications of HVDC Transmission
CO2	analyse the operation of HVDC converters
CO3	analyse HVDC control methods for power flow.
CO4	calculate the harmonics and filters parameters
CO5	analyse the Faults in HVDC System and their Protection
CO6	explain the Parallel Operation of AC-DC Systems

2. SYLLABUS

- **INTRODUCTION TO HVDC** **(05 Hours)**

  Historical development in DC Transmission, Advantages & Disadvantages of DC Transmission over Ac Transmission, DC Transmission Systems: Mono-polar, bi-polar and homo-polar lines, back-to-back HVDC systems, Components of HDVC Transmission System, classification, Main applications of DC Transmission

- **CONVERTER OPERATION** **(10 Hours)**

  Choice of converter configuration, 6-pulse and 12-pulse rectifiers and inverters; Equivalent circuits of rectifier and inverter, relations between ac and dc quantities.

- **CONVERTER CHARTS** **(03 Hours)**

  Charts with dc voltage and current as rectangular coordinates, charts with active and reactive powers as rectangular coordinates and their relation.

- **HVDC CONTROL SYSTEMS** **(06 Hours)**

  Constant current control, constant excitation angle control, VDCOL, constant ignition angle control, Individual phase control and equidistant pulse control; Valve blocking and by-passing; Starting, stopping and power flow reversal, advanced controller.

- **HARMONICS AND FILTERS** **(04 Hours)**

  Characteristic and non-characteristic harmonics, input harmonics, output harmonics, problems due to harmonics, ac and dc filters.

- **FAULTS IN HVDC SYSTEM AND THEIR PROTECTION** **(04 Hours)**

  DC line faults, clearing line faults, converter faults, ac system faults, rectifier side and inverter side faults; DC circuit breakers, overvoltage protection.

- **PARALLEL OPERATION OF AC-DC SYSTEMS** **(04 Hours)**

  Influence of ac system strength on ac-dc interaction, effective short-circuit ratio (ESCR), problems with low ESCR systems

- **RECENT DEVELOPMENTS IN HVDC TRANSMISSION** **(06 Hours)**

Problems encountered with classical (CSC based) HDVC Transmission Systems and their overcome by VSC based HVDC systems, Operation Principle and control of VSC Based HVDC Transmission, VSC-HVDC Under AC and DC Fault Conditions, HVDC light.

Total Hours: 42

3. BOOKS RECOMMENDED:

1. E. Kimbark, Direct Current Transmission by Wiley International New York, 1971.
2. K.R. Padiyar, HVDC Power Transmission System, New Age International Private Limited, 2008.
3. E.Ulmann, Power Transmission by Direct Current, Springer-Verlag, 1975
4. P. Kundur, Power System stability and control, Tata McGraw Hill education, 1994.
5. J. Arrillaga, High Voltage Direct Current Transmission, IEE Power Engineering series, London, 1998
6. J. Arrillaga, Y. H. Liu and N. R. Watson, Flexible Power Transmission: The HVDC Option, John Wiley and Sons, New York, 2007.
7. Nagwa F. Ibrahim and Sobhy S. Dessouky,Design and Implementation of Voltage Source Converters in HVDC Systems, Springer Nature, Switzerland, 2021.
8. Chan-Ki Kim,Vijay K. Sood,Gil-Soo Jang,Seong-Joo Lim and Seok-Jin Lee, HVDC Transmission Power Conversion Applications in Power Systems, John Wiley & Sons, Singapore, 2009.

M. Tech. (Electrical), Semester – II (Core Elective – 3)

EEPE 216: CONDITION MONITORING & FAULT DIAGNOSIS OF ELECTRICAL MACHINES

L	T	P	C
3	0	0	3

1. COURSE OUTCOMES (COs)

Upon completion of the course, the students will be able to:

CO1	explain the basic understanding of condition monitoring
CO2	modeled and analyze electrical machines
CO3	analyze performance of fault diagnostics methods
CO4	analyze the performance using soft computing method
CO5	Implementation and Performance of the techniques in real world problem

2. SYLLABUS

- **CONDITION MONITORING** **(07 Hours)**

  Needs, offline and online monitoring, type of faults-stator, rotor, Bearing, broken rotor faults, eccentricity faults, Insulation ageing mechanisms, Insulation failure modes, Failures in electrical machines, Thermal Monitoring of the Induction Machine, Instrumentation requirements.

- **MODELING OF ELECTRICAL MACHINES** **(07 Hours)**

  Introduction, winding and modified approach, validation of inductance calculation, indirect application of magnetic equivalent circuit analysis of synchronous and induction motors, direct approach of magnetic equivalent circuit, Methodology for monitoring the induction machine.

- **FAULT DIAGNOSTICS METHODS** **(11 Hours)**

  Fault Diagnostics using FEM, impact of magnetic saturation on accurate fault detection, analysis of air gap, vibration, noise, frequency domain method-detection of motor bearing faults, stator faults, rotor faults, eccentricity faults, fault diagnosis using model based approach in induction motor and others motors, Closed-Loop Diagnosis of the Induction Machine, Induction Machine Diagnosis Using Observers, Signal processing techniques for signal analysis.

- **FAULT DIAGNOSIS USING SOFT COMPUTING METHODS** **(10 Hours)**

  Fault Diagnosis using artificial neural networks-Methodology, detection problem, Signature of the stator and rotor faults, Diagnosis, Application of Fuzzy logic and other soft computing techniques.

- **IMPLEMENTATION OF FAULT DIAGNOSIS METHOD** **(07 Hours)**

  Introduction, on board fault diagnosis in electric vehicles, Fault diagnostic techniques applied to voltage source inverter-fed drives, DC–DC converters: Signal-processing-based algorithms and other systems, Wavelet transform.

Total Hours: 42

3. BOOKS RECOMMENDED:

1. Hamid A. Toliyat, Subhasis Nandi,Seungdeog Choi, Homayoun Meshgin-Kelk, Electric Machines: Modeling, Condition Monitoring, and Fault Diagnosis, CRC Press, Boca Raton, 2018.
2. Peter J. Tavner, Li Ran, Jim Penman, Howard Sedding "Condition Monitoring of Rotating Electrical Machines", The Institution of Engineering and Technology, London, 2008.
3. Antonio J. Marques Cardoso, Diagnosis and Fault Tolerance of Electrical Machines, Power Electronics and Drives,The Institution of Engineering and Technology(IET), London.2018.
4. Elias G. Strangas, Guy Clerc, Hubert Razik and Abdenour Soualhi, "Fault Diagnosis, Prognosis, and Reliability for Electrical Machines and Drives," John Wiley & Sons, New Jersey,2022.
5. Jean-Claude Trigeassou, Electrical Machines Diagnosis, John Wiley & Sons, Inc, (Great Britain and the United States by ISTE Ltd), 2011

M. Tech. (Electrical), Semester – II (Core Elective – 4)

EEPE 221: ADVANCED ENERGY STORAGE DEVICES AND APPLICATIONS

L	T	P	C
3	0	0	3

1. COURSE OUTCOMES (COs)

Upon completion of the course, the students will be able to:

CO1	Describe different energy storage technology and compare them based on their performance
CO2	Modelling of various electrochemical storage devices and develop suitable battery management system
CO3	Discuss electrical and magnetic storage systems and describe hydrogen and fuel cells
CO4	Detailed understanding of thermal and mechanical storage and analyze energy savings
CO5	Explain and illustrate hydrogen and fuel cells

2. SYLLABUS

- **INTRODUCTION TO ENERGY STORAGE** **(04 Hours)**

  Relevance and scenario, perspective on development of energy storage systems, energy storage criteria, general concepts, fundamentals and applications, energy storage technologies, future prospect of storage, Ragone plots,.

- **ELECTROCHEMICAL ENERGY STORAGE** **(10 Hours)**

  Battery technologies and different battery chemistry, electrode materials, electrolytes. performance comparison, reaction mechanism, practical parameters, technical characteristics, equivalent circuit. Testing, standards and system sizing, battery storage integration.

- **BATTERY MANAGEMENT SYSTEM (BMS)** **(10 Hours)**

  BMS functionality, requirements; State Estimation: definitions and their estimation methods; SOH estimation: predictive SOH models, aging, capacity estimation, self-discharge detection, parameter estimation, remaining useful life estimation; Cell balancing: causes of imbalancing, balancing strategies, charge transfer balancing-design choices, circuits for balancing; thermal management of battery; case study

- **ELECTRICAL AND MAGNETIC STORAGE SYSTEMS** **(08 Hours)**

  Supercapacitors: basics, technical characteristics, equivalent circuit, electrode material, pseudocapacitive energy storage, energy storage devices, applications and challenges; Magnetic Systems- energy storage in superconducting magnetic systems, superconductive materials, applications.

- **FUEL CELLS AND HYDROGEN STORAGE** **(05 Hours)**

  Fuel cell: working, basic components, principle, thermodynamics of fuel cell, types, challenges; Hydrogen storage-hydrogen as an energy vector and basic principles, hydrogen production, strategies for storing energy in hydrogen, applications.

- **THERMAL AND MECHANICAL STORAGE** **(05 Hours)**

  Basic principle, criteria for TES evaluation, operating characteristics, standards, phase change materials, sensible TES- passive and active systems, design and thermal stratification, energy and exergy analyses, efficiency measures. Mechanical storage: flywheel, pumped hydropower storage and compressed-air energy storage, comparison and application, principle of operation, function and deployments; case study

Total Hours: 42

3. BOOKS RECOMMENDED:

1. Robert A. Huggins, “Energy storage”, Springer Nature, 2nd edition, 2016.
2. Christopher D. Rahn, and Chao-Yang Wang, “Battery systems engineering”, John Wiley & Sons, 2013.
3. Ibrahim Dincer, and Marc A. Rosen, “Thermal energy storage: systems and applications” John Wiley & Sons, 3rd edition, 2021.
4. Gregory L. Plett, “Battery management systems, Volume II: Equivalent-circuit methods”, Artech House, 2015.
5. Phil Weicker, “A systems approach to lithium-ion battery management”, Artech house, 2013.
6. F. Barnes and J. Levine. "Large energy storage systems", CRC press, 2011.

M. Tech. (Electrical), Semester – II (Core Elective – 4)

EEPE 222: INSTRUMENTATION FOR DRIVES

L	T	P	C
3	0	0	3

1. COURSE OUTCOMES (COs)

Upon completion of the course, the students will be able to:

CO1	understand the basic signal conditioning for measurement of electrical quantities.
CO2	study and implement different transducers for electrical motor drives.
CO3	design the digital measurement techniques for motor drives.
CO4	understand the EMI and EMC
CO5	study the protection method for electrical motor drives

2. SYLLABUS

- **TRANSDUCERS FOR DRIVES** **(10 Hours)**

  Current, voltage, speed: incremental and absolute encoders, revolvers, torque sensors

- **DIGITAL MEASUREMENT TECHNIQUES FOR DRIVES** **(12 Hours)**

  Digital techniques of measurement of voltage, current, power, energy, speed and position and direction of rotation

- **SIGNAL CONDITIONING, DATA ACQUISITION AND CONVERSION** **(10 Hours)**

  Instrumentation amplifiers, isolation amplifiers, opto-couplers, sample and hold circuits, V/f and f/V converters, A/D and D/A converters, data acquisition systems

- **EMI AND EMC** **(10 Hours)**

  Introduction, causes of EMI, interference coupling mechanism, basics of circuit layout and grounding, concepts of interfaces, filtering and shielding. Safety: Introduction, electrical hazards, hazardous areas and classification, non-hazardous areas, enclosures – NEMA types, fuses and circuit breakers. Protection methods: Purging, explosion proofing and intrinsic safety

Total Hours: 42

3. BOOKS RECOMMENDED:

1. Helfrick – Cooper, Modern electric instrumentation and measurement technique, PHI 1994.
2. T.S. Rathore, Digital measurement techniques, Narosa publishing House, 1996.
3. Rangan, Sanna, mani, Instrumentation devices & systems, TMH 1997.
4. Golding and Widdis, “Electrical measurements & Measuring instruments”, Wheeler books, 5th edition
5. Doebelin E.O, “Measurement Systems - Application and Design”, Fourth edition, McGraw-Hill, New York, 1992.

M. Tech. (Electrical), Semester – II (Core Elective – 4)

EEPE 223: APPLICATION OF POWER ELECTRONICS TO POWER SYSTEM

L	T	P	C
3	0	0	3

1. COURSE OUTCOMES (COs)

Upon completion of the course, the students will be able to:

CO1	Explain synchronous reference theory, instantaneous reactive power theory and voltage source inverter
CO2	Designing PLL for grid-synchronization
CO3	Explain basics of reactive power compensation
CO4	Analyze and understand various static shunt compensators
CO5	Analyze and understand various static series compensators

2. SYLLABUS

- **INTRODUCTION** **(05 Hours)**

  Voltage source inverter (VSI), Synchronous reference frame theory, Instantaneous reactive power theory, PLL for grid synchronization

- **BASICS OF REACTIVE POWER COMPENSATION** **(09 Hours)**

  Analysis of uncompensated AC line, Passive reactive power compensation, Compensation by a series capacitor connected at the mid-point of the line, Effect on Power Transfer capacity, Compensation by STATCOM and SSSC, Synchronous condenser

- **STATIC VAR COMPENSATORS** **(11 Hours)**

  Configuration of SVC, Thyristor-controlled reactor (TCR), Fixed capacitor-Thyristor controlled reactor (FC-TCR), Thyristor switched capacitor (TSC), Thyristor-switched capacitor-thyristor controlled reactor (TSC-TCR), Advantages of the slope in the SVC Dynamic Characteristic, Influence of the SVC on System Voltage, Design of the SVC Voltage Regulator.

- **STATIC SYNCHRONOUS COMPENSATOR (STATCOM)** **(5 Hours)**

  Principle of operation, Analysis of a three phases six pulse STATCOM, Multi-pulse converters, Applications of STATCOM.

- **THYRISTOR CONTROLLED SERIES CAPACITOR (TCSC) AND STATIC SYNCHRONOUS SERIES COMPENSATOR (SSSC)** **(07 Hours)**

  Principle of operation, Analysis and control, Applications.

- **UNIFIED POWER FLOW CONTROLLER (UPFC)** **(05 Hours)**

  Principle of operation, Analysis and control, Applications

Total Hours: 42

3. BOOKS RECOMMENDED:

1. Mathur R. Mohan & Varma R. K., `` Thyristor based FACTS controller for electrical transmission system'', Wiley Inter-Science, 2002.
2. Padiyar K. R., `` FACTS Controller in power transmission and distribution'', New Age International, 1st edition 2007.
3. N.G. Hingorani, `` Understanding FACTS'', IEEE Press 2001.
4. Vijay K. Sood, "HVDC and FACTS Controllers: Applications of Static Converters in Power Systems", Springer; 1 edition, 2004.
5. T.J.E. Miler, ``Reactive Power Control in Electric Systems'', John Wiley & Sons, 1982.

M. Tech. (Electrical), Semester – II (Core Elective – 4)

EEPE 224: MODEL PREDICTIVE CONTROL FOR POWER ELECTRONICS APPLICATIONS

L	T	P	C
3	0	0	3

1. COURSE OUTCOMES (COs)

Upon completion of the course, the students will be able to:

CO1	understand model predictive control
CO2	apply model predictive control to DC-DC converters and three-phase voltage source converters
CO3	understand working of modular multilevel converters (MMCs) and apply model predictive control to MMCs
CO4	apply model predictive control technique for variable frequency drives.
CO5	understand working of wind energy conversion system (WECS) and apply model predictive control to WECS

2. SYLLABUS

- **REVIEW OF CLASSICAL CONTROL AND INTRODUCTION TO MODEL PREDICTIVE CONTROL (08 Hours)**

  Power electronic converters in energy conversion, control and modulation schemes, classical current control, voltage-oriented control, direct control, fuzzy Logic control, sliding mode control, introduction to model predictive control, classification of model predictive control, main features of finite control set model predictive control, challenges of finite control set model predictive control, comparison of classical control and model predictive control.

- **MODEL PREDICTIVE CONTROL OF DC/DC CONVERTER (04 Hours)**

  Model predictive control of buck converter, model predictive control of boost converter, model predictive control of buck-boost converter, model predictive control of isolated dual active bridge dc/dc converter.

- **MODEL PREDICTIVE CONTROL OF A TWO-LEVEL THREE-PHASE INVERTER (03 Hours)**

  Model predictive control of three-phase inverter in grid connected and islanded modes, control techniques using constant and variable switching frequency model predictive control.

- **MODEL PREDICTIVE CONTROL OF MODULAR MULTILEVEL CONVERTERS (07 Hours)**

  Introduction to modular multilevel Converters (MMCs), classical control of MMCs, direct model predictive control, and indirect model predictive control of MMCs.

- **MODEL PREDICTIVE CONTROL OF MOTOR DRIVES (10 Hours)**

  Introduction to motor drives, dynamic model of an induction machine, model predictive torque control of an induction machine fed by a voltage source inverter, field-oriented control of an induction machine fed by a matrix converter using model predictive current control, permanent magnet synchronous machine equations, discrete-time model of permanent magnet synchronous machine, field-oriented control using model predictive current control of permanent magnet synchronous machine.

- **MODEL PREDICTIVE CONTROL OF WIND ENERGY CONVERSION SYSTEM (10 Hours)**

  Model predictive control of DFIG WECS with voltage source converters, model predictive control of PMSG WECS with back-to-back connected converter, model predictive control of PMSG WECS with passive generator-side converters.

Total Hours: 42

3. BOOKS RECOMMENDED:

1. Jiefeng Hu, Josep Guerrero and Syed Isla, “Model Predictive Control for Microgrids-From power electronic converters to energy management”, The Institution of Engineering and Technology, 1st edition 2021.
2. Jose Rodriguez and Patricio Cortes, “Predictive Control of Power Converters and Electrical Drives”, John Wiley & Sons Ltd , 1st edition 2012.
3. Tobias Geyer, “Model Predictive Control of High Power Converters and Industrial Drives”, Wiley, 1st edition 2017.
4. Venkata Yaramasu and Bin Wu, “Model Predictive Control of Wind Energy conversion Systems” John Wiley & Sons Ltd , 1st edition 2017.

M. Tech. (Electrical), Semester – II (Core Elective – 4)

EEPE 225: ELECTRICAL MACHINES FOR RENEWABLE ENERGY GENERATION

L	T	P	C
3	0	0	3

1. COURSE OUTCOMES (COs)

Upon completion of the course, the students will be able to:

CO1	Explain the fundamental issues and challenges of harvesting Renewable energy
CO2	Analyze the different forms of energy storage by renewable energy sources
CO3	Explain principle and construction, characteristics of electrical machines promising for renewable energy
CO4	Compare existing machines and advanced renewable energy machines
CO5	Identify the design modification of machines for renewable energy
CO6	Select the appropriate electrical machines for harnessing renewable energy

2. SYLLABUS

- **FORMS OF ENERGY STORAGE BY RENEWABLE ENERGY SOURCES (02 Hours)**

  Kinetic energy, Potential Energy, Heat energy.

- **CLASSIFICATION OF ELECTRIC MACHINES (04 Hours)**

  Existing machines – wound filed DC, PMDC, induction machines (wound rotor, DFIG, cage rotor), synchronous machines: wound rotor, PMSG, PM BLDC, PM BLAC, surface mounted PM, surface inset PM, interior radial PM, interior circumferential PM, Advanced machines - stator PM: DSPM (doubly salient), FRPM (flux reversal), FCPM (flux controllable, single magnet, dual magnet DSPM, Direct drive PM machine, Vernier PM machine, Linear Direct drive PM machine, Magnet less machines – switched reluctance machines, doubly salient magnet less machines

- **EXISTING MACHINES FOR RENEWABLE ENERGY (16 Hours)**

  Classifications Principle, construction and characteristics of Synchronous Generator, Induction Generator, Doubly Fed Induction Generator, Permanent Magnet Synchronous Generator, Linear Permanent Magnet Synchronous Generator.

- **ADVANCED RENEWABLE ENERGY MACHINES (20 Hours)**

  Classifications, Principle, construction characteristics and Application of Stator-PM Machines. Direct-drive PM Machines and Magnet less Machines

Total Hours: 42

3. BOOKS RECOMMENDED:

1. K.T. Chau .Electric Machines and Drives for Renewable Energy Harvesting, Energies, special issues, MDPI, 2017
2. D.P. Kotahri, K.C. Singal, Rakesh RanjanRenewable Energy sources and emerging technologies , PHI, 2009
3. Pyrhonen, J.; Jokinen, T.; Hrabovcova, V. Design of Rotating Electrical Machines; Wiley: Chichester, UK, 2007.
4. D.S. Chauhan, S. K. Srivatava, Non- Conventional Energy Resources, New Age international Publishers, Third edition,2014
5. Selected Journal papers on Advanced Electrical machines for Renewable Energy.

M. Tech. (Electrical), Semester – II (Institute Elective – 1)

EEPE 231: ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING

L	T	P	C
3	0	0	3

1. COURSE OUTCOMES (COs)

Upon completion of the course, the students will be able to:

CO1	Explain the fundamental issues and challenges of Artificial Intelligence
CO2	Analyze various Machine learning algorithms
CO3	Compare machine learning/artificial intelligence approaches
CO4	Apply various Machine learning methods
CO5	Develop ANN/FL algorithms and models
CO6	Implement various machine learning algorithms in real-world applications

2. SYLLABUS

- **INTRODUCTION TO MACHINE LEARNING (ML)** **(07 Hours)**

  Identification in the Limit, Oracle Based Learning, Probably Approximately Correct (PAC) Model, Boosting Bayesian Learning: Maximum Likelihood, Estimates, Parameter Estimation. Types of Machine learning – Basic Concepts in Machine Learning - SUPERVISED LEARNING: Linear Models for Classification: Discriminant Functions - Probabilistic Generative Models - Probabilistic Discriminative Models - Bayesian Logistic Regression, linear models, Logistic Regression, Generalized Linear Models, Unsupervised learning, clustering: K-means/Kernel K-means, Dimensionality, Reduction: PCA and kernel PCA, Evaluating Machine Learning algorithms and Model Selection, Ensemble Methods (Boosting, Bagging, Random Forests), Modelling Sequence /Time- Series Data, Deep Learning and Feature Representation, Learning, Scalable Machine Learning (Online and Distributed Learning)

- **INTRODUCTION TO ARTIFICIAL INTELLIGENCE (AI):** **(07 Hours)**

  Computerized reasoning – Artificial Intelligence (AI) – characteristics of an AI problem – Problem representation in AI – State space representation – problem reduction, Concept of small talk programming, Knowledge representation issues, predicate logic- logic programming, semantic nets- frames and
  inheritance, constraint propagation, representing knowledge using rules, rules based deduction systems, Reasoning under uncertainty, review of probability, Baye's probabilistic interferences and Dempster Shafer theory.

- **ARTIFICIAL NEURAL NETWORKS (ANN)** **(11 Hours)**

  Feed forward Network Functions - Error Backpropagation -Regularization in Neural Networks – Mixture Density Networks – Bayesian Neural Networks. Kernel Methods – Dual Representations – Radial Basis Function Networks – Ensemble learning: Boosting – Bagging. Forecasting models using ANN, Trend analysis, Cyclical and Seasonal analysis, smoothing; Moving averages; Box-Jenkins, Holt-winters, Auto-correlation; ARIMA, Examples: Applications of Time Series in financial markets

- **FUZZY LOGIC** **(10 Hours)**

  Reasoning in uncertain environments, Fuzzy logic, fuzzy composition relation, operations on fuzzy sets, fuzzification - defuzzification, fuzzy decision making, fuzzy logic controllers, Fuzzy Classification: Classification by equivalence relations-crisp relations, Fuzzy relations, Cluster analysis, Cluster validity, C-Means clustering, Hard C-Means clustering, Fuzzy C-Means algorithm, Classification metric, Hardening the Fuzzy C-Partition.

- **APPLICATION** **(07 Hours)**

  Examples of Machine Learning Applications – Linear Models for Regression – Linear Basis Function Models – The Bias-Variance Decomposition – Bayesian Linear Regression – Bayesian Model Comparison. Radar for target detection, Deep Learning Automated ECG Noise Detection and Classification, ML in Network for routing, traffic prediction and classification, Application of ML in Cognitive Radio Network (CRN).

Total Hours: 42

3. BOOKS RECOMMENDED:

1. Timothy J.Ross - Fuzzy logic with engineering applications, 3rd edition, Wiley, 2010.
2. George J.KlirBo Yuan - Fuzzy sets and Fuzzy logic theory and Applications, PHI, New Delhi,1995
3. Applied Machine Learning, M. Gopal, McGraw Hill Education
4. Machine Learning March 1997, Thomas M. Mitchell, McGraw-Hill, Inc. 2. Neural Networks: A Comprehensive Foundation, Simon Haykin, Prentice Hall
5. Neural Network Design, M. T. Hagan, H. B. Demuth, Mark Beale, Thomson Learning, Vikash Publishing House
6. Patrick Henry Winston, “Artificial Intelligence”, Addison Wesley, 2000.
7. Luger George F and Stubblefield William A, “Artificial Intelligence: Structures and Strategies for Complex Problem Solving”, Pearson Education, 2002.
8. Christopher Bishop, “Pattern Recognition and Machine Learning” Springer, 2007.
9. Kevin P. Murphy, “Machine Learning: A Probabilistic Perspective”, MIT Press, 2012.
10. Ethem Alpaydin, “Introduction to Machine Learning”, MIT Press, 3rd Edition, 2014
11. Sayed, A.H., 2014. Adaptation, learning, and optimization over networks. Foundations and Trends” in Machine Learning, 7(4-5), pp.311-801.

M. Tech. (Electrical), Semester – II (Institute Elective – 1)

EEPE 232: MODERN INDUSTRIAL DRIVES AND AUTOMATION

L	T	P	C
3	0	0	3

1. COURSE OUTCOMES (COs)

Upon completion of the course, the students will be able to:

CO1	Understand the modern industry drive and its installation and connections
CO2	Apply the various parameter setting
CO3	Explain the need of industrial automations
CO4	Develop the ladder logic for various industrial applications
CO5	Design the scheme to operate dive with PLC

2. SYLLABUS

- **MODERN INDUSTRIAL DRIVES** **(20 Hours)**

  Introduction, Applications of modern industrial drive, specification of Modern Industrial Drives, Installation, connections- control and power terminals, commissioning, parameter setting, open loop and close loop speed control, change of acceleration and de-acceleration time, over speeding, forward/reverse operating with operating two drive in synchronism, sensorless speed control, speed control with encoder, use of digital inputs and outputs of drive.

- **INDUSTRIAL AUTOMATION** **(22 Hours)**

  Need for an industrial automation, PLC definition, overview of PLC systems, input/output modules, power supplies and isolations. General PLC programming procedures, programming on-off inputs/ outputs, Bit logic, data move, timers, counters, compare, convert instructions. Arithmetic instructions. Analog value processing. Generation of Analog output to control drive, control of drive with digital output of PLC. Speed variation of industrial drive with digital and analog output of PLC.

Total Hours: 42

3. BOOKS RECOMMENDED:

1. G.K.Dubey, Fundamentals of Electrical Drives, Narosa- 1995.
2. S.A. Nasar, Boldea, Electrical Drives, Second Edition, CRC Press – 2006.
3. M. A. ElSharkawi, Fundamentals of Electrical Drives, Thomson Learning -2000.
4. John W. Webb and Ronald A. Reis, Programmable Logic Controllers - Principles and Applications, Fourth edition, Prentice Hall Inc., New Jersey, 1998.
5. Frank D. Petruzella, Programmable Logic Controllers, Second edition, McGraw Hill, New York, 1997.

M. Tech. (Electrical), Semester – II (Institute Elective – 1)

EEPE 233: ADVANCED OPTIMIZATION METHODS

L	T	P	C
3	0	0	3

1. COURSE OUTCOMES (COs)

Upon completion of the course, the students will be able to:

CO1	Explain the basic principle of optimization
CO2	Derive the equations and solution through linear programming Method
CO3	Estimate the performance of traditional optimization method
CO4	Analyse the performance of constrained optimization algorithms
CO5	Analyse the Induction of Non-traditional Optimization algorithms.
CO6	Apply the optimization method in real world.

2. SYLLABUS

- **INTRODUCTION** **(04 Hours)**

  Historical Development, Engineering application of Optimization, Formulation of design problems, objective function, design constraints, Classification of optimization problems, local and global maximum and minima, classical optimization methods.

- **LINEAR PROGRAMMING** **(08 Hours)**

  Standard form, Geometry of LP problems, Theorem of Linear programming problems and Relation to convexity, Pivot reduction method, Simplex method, Revised simplex method, Duality in linear programming(LP), Sensitivity analysis, Karmarkar's method, other algorithms for solving LP problems.

- **SINGLE AND MULTI VARIABLE OPTIMIZATION** **(08 Hours)**

  Single variable: Optimality criteria, Bracketing Methods, Region Elimination Method, Gradient Based methods: Newton-Raphson Method, Bisection Method, Secant Method, Multivariable: Optimality criteria, Direct Search Methods, Gradient Based Methods: Steepest Descent Method, Conjugate Gradient Method, Quasi-Newton Method, Variable Metric Method, applications.

- **CONSTRAINED OPTIMIZATION TECHNIQUES** **(06 Hours)**

  Characteristics of a constrained problem, Variable Elimination Method, Lagrange Multiplier, Kuhn-Tucker Conditions, Frank-Wolfe Method, Cutting plane Method, penalty function Methods, application.

- **ADVANCED OPTIMIZATION TECHNIQUES** **(16 Hours)**

  Introduction to Multi objective Optimization: classical method-weighted sum method, ε-constrained method, Benson's method, Genetic Algorithm, Evolution strategies, multi model function, constrained based problems, Swarm intelligences, Teaching Learning Based Optimization, Rao algorithms and other Non-traditional Optimization Algorithms, applications.

Total Hours: 42

3. BOOKS RECOMMENDED:

1. S. S. Rao, 'Engineering "Optimization theory and applications", Fourth Edition, John Wiley and Sons, 2009.
2. Kalyanmoy Deb, "Optimization for Engineering Design: Algorithms and Examples" Prentice-Hall of India Pvt.Ltd.,2005.
3. M.S. Bazaraa, H.D. Sheraliand C. Shetty, "Nonlinear Programming, Theory and Algorithms", John Wiley and Sons, New York, 1993.
4. Ke-Lin Du and M.N.S. Swamy, "Search and Optimization by Metaheuristics Techniques and Algorithms Inspired by Nature," Springer International Publishing Switzerland, 2016.

5. R. Venkata Rao, Teaching Learning Based Optimization Algorithm and Its Engineering Applications, Springer International Publishing Switzerland, 2016.
6. Kwang Y. Lee and Mohamed and A. El-Sharkawi, Modern Heuristic Optimization Techniques Theory And Applications To Power Systems, John Wiley & Sons, Inc., Hoboken, New Jersey, 2008.
7. Gang Lei, Jianguo Zhu and Youguang Guo, “Multidisciplinary Design Optimization Methods for Electrical Machines and Drive Systems,” Springer-Verlag Berlin Heidelberg 2016.
8. Rangrajan K. Sundaram,”A First Course in Optimization Theory”, Cambridge UniversityPress,1996
9. A.Ravindran, K.M. Ragsdell, G.V.Reklaitis,” Engineering Optimization Methods and Applications’, Wiley India Pvt.Ltd., 2006.
10. E.S. Gopi, “Algorithm Collections for Digital Signal Processing Applications Using MATLAB,” Springer, Dordrecht, The Netherlands,2007

M. Tech. (Electrical), Semester – II (Institute Elective – 1)

EEPE 234: SMART GRID TECHNOLOGY

L	T	P	C
3	0	0	3

1. COURSE OUTCOMES (COs)

Upon completion of the course, the students will be able to:

CO1	To explain the basic understanding of smart grid
CO2	To explain integration of renewable energy with smart grid
CO3	To analyze communication performance of smart grid
CO4	To analyze the performance of design system
CO5	To analyze stability of the system
CO6	To explain quality of the developed system

2. SYLLABUS

- **SMART GRID ARCHITECTURAL DESIGNS** **(08 Hours)**

  Today's Grid versus the Smart, General View of the Smart Grid Market Drivers, Stakeholder Roles and Function, Utilities, Working Definition of the Smart Grid Based on Performance Measures, Functions of Smart Grid Components, Smart Devices Interface Component, Storage Component, Monitoring and Control Technology Component , Demand Side Management Component.

- **RENEWABLE ENERGY SYSTEM AND STORAGE** **(07 Hours)**

  Sustainable Energy Options for the Smart Grid- solar power, wind system, biomass, small hydropower system, Geothermal, Tidal energy, Environmental Implications, Electric Vehicles and Plug-in Hybrids, Opportunities and Challenges, Application of smart system, Demand response issues, Storage technologies.

- **SMART GRID COMMUNICATIONS AND MEASUREMENT TECHNOLOGY** **(07 Hours)**

  Monitoring, PMU, Smart Meters, and Measurements Technologies, Wide Area Monitoring Systems (WAMS), Phasor Measurement Units (PMU), Smart Meters, Smart Appliances, Advanced Metering Infrastructure (AMI), Multiagent Systems (MAS) Technology, Multiagent Systems for Smart Grid Implementation.

- **PERFORMANCE ANALYSIS TOOLS FOR SMART GRID DESIGN** **(8 Hours)**

  Introduction to Load Flow Studies, Challenges to Load Flow in Smart Grid and Weaknesses of the present Load Flow Methods, Load Flow State of the Art: Classical, Extended Formulations, and Algorithms, Distribution Load Flow Methods, Congestion Management Effect, Load Flow for Smart Grid Design, the Development of Stochastic Dynamic Optimal Power Flow (DSOPF), DSOPF Application to the Smart Grid, Static Security Assessment (SSA) and Contingencies, Contingency Studies for the Smart Grid, application of smart grid

- **STABILITY ANALYSIS TOOLS FOR SMART GRID** **(06 Hours)**

  Introduction to Stability, Voltage Stability Assessment, Voltage Stability and Voltage Collapse, Classification of Voltage Stability, Static Stability (Type I Instability), Dynamic Stability (Type II Instability) , Angle Stability Assessment, Transient Stability , State Estimation

- **POWER QUALITY MANAGEMENT IN SMART GRID** **(06 Hours)**

  EMC in smart grid, equipment required for grid connected systems, grid connection requirements from power provider, addressing safety and power quality for grid connection, metering and rate arrangement for grid connected systems, Web based power quality monitoring.

Total Hours: 42

3. BOOKS RECOMMENDED:

1. James Momoh, “Smart grid: fundamentals and design”, John Wiley & Sons, New Jersey 2012,
2. Bharat Modi, Anu Prakash, Yogesh Kumar, “Fundamentals of smart grid technology”, S.K.Kataria & sons, Delhi, 2019
3. A. Keyhani, “Smart Power Grid Renewable Energy Systems”, John Wiley & Sons, New Jersey 2011.
4. Shady S. Refaat, Omar Ellabban, Sertac Bayhan,Haitham Abu-Rub, Frede Blaabjerg and Miroslav M. Begovic, Smart Grid and Enabling Technologies, IEEE Press, John Wiley & Sons Ltd, 2021.
5. Janaka Ekanayake, Kithsiri Liyanage, Jianzhong Wu, Akihiko Yokoyama and Nick Jenkins, Smart Grid Technology and Applications, John Wiley & Sons,2012
6. I.S. Jha, Subir Sen, Rajesh Kumar and D.P. Kothari, “Smart Grid: Fundamentals & Applications, New Age International publishers, New Delhi, 2019.

M. Tech. (Electrical), Semester – II

EEPE204: REAL TIME SIMULATION OF POWER ELECTRONIC CONVERTER APPLICATIONS

L	T	P	C
0	0	2	1

1. COURSE OUTCOMES (COs)

Upon completion of the course, the students will be able to:

CO1	Understand HIL and SiL operations with real time simulators
CO2	Implement power converters for various applications in the SiL mode
CO3	Implement power converters for various applications in the HiL mode

2. SYLLABUS

LIST OF EXPERIMENTS

1. Implementation of three-phase fully controlled rectifier MATLAB model on real time.
2. Implementation of 2-level inverter model on real time by using SPWM in HiL mode.
3. Demonstration of Speed control of 2-level voltage source inverter fed 3-phase induction motor drive using Open-loop v/f control on real time.
4. Implementation of SHE based CHB-MLI model on real time.
5. Implementation of SVM based VSI on real time.
6. Demonstration of DVR on real time.
7. Demonstration of Active Filter on real time.
8. Demonstration of Grid connected system on real time.
9. Demonstration of Micro Grid Network on real time.
10. Demonstration of Slip compensation technique for 2-level VSI fed 3-phase induction motor drive on real time.

Total Hours: 24

3. REFERENECS:

1.https://www.opal-rt.com/power-electronics-overview/
2.https://www.typhoon-hil.com/documentation/typhoon-hil-application-notes
3.https://www.ni.com/en-in/innovations/white-papers/09/hardware-in-the-loop--hil--test-system-architectures.html