Under Graduate Programme

B. Tech.
in
Electrical Engineering

Curriculum of 4th Year

(as per NEP with effect from batch 2023-24)

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

SARDAR VALLABHBHAI NATIONAL INSTITUTE OF TECHNOLOGY, SURAT
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Course Structure and Scheme of Evaluation (Semester wise)
B. Tech. Electrical Engineering (4th Year Scheme)

Sr. No.	Subjects	Code	Scheme L-T-P	Credits (Min.)	Notional hours of Learning (Approx.)
Seventh Semester (4th year of UG)					
1.	Innovation, Incubation and Entrepreneurship	MG110	3-1-0	4	70
2.	Elective	EE4AA	3-0-0	3	55
3.	Elective	EE4BB	3-0-0	3	55
4.	Elective	EE4CC	3-0-0	3	55
5.	Elective	EE4DD	3-0-0	3	55
6.	Project	EE480	0-0-8	4	120
			Total	**20**	**410**
6.	Minor/Honor (M/H#4)	EE4EE	3-X-X	4	70/85
7.	Mini Project (Minor/Honor)	EE481	0-0-4	2	60
Eight Semester (4th year of UG)					
1.	Industrial Internship/ Professional Experience (Mandatory)	EEP08	0-0-40	20	800 (20 x 40)
				20	**800**

Sr. No.	**Electives**	Code	Scheme L-T-P
B. Tech. IV year, VII semester (Any four courses) (EE4AA, EE4BB, EE4CC, EE4DD)			
1.	Advanced Micro-controller	EE451	3-0-0
2.	Power Quality Disturbances and Mitigation	EE452	3-0-0
3.	Advanced Electrical Drives	EE453	3-0-0
4.	High Voltage Engineering	EE454	3-0-0
5.	HVDC Transmission	EE455	3-0-0
6.	Nonlinear Control	EE456	3-0-0
7.	Advanced Optimization Methods	EE457	3-0-0
8.	Electric Vehicles	EE458	3-0-0
9.	Switched Mode Power Supply	EE459	3-0-0
10.	Power Filter Technology	EE460	3-0-0
11.	EHV AC Transmission	EE461	3-0-0
12.	Distributed Power Generation and Micro-grid	EE462	3-0-0
13.	Smart Grid Technologies	EE463	3-0-0
14.	FPGA based control of Power Electronic Converters	EE464	3-0-0

Sr. No.	**for B.Tech. (CE, ME, ChE, InsChe, MaC) students (Minor in Electrical Engineering)**	Code	Scheme L-T-P
1.	Electrical and Electronic Measurements (VII semester)	EE481	3-0-2

Sr. No.	**for B.Tech. (AI, CSE, ECE, ECVLSI, EnggPhy) students (Minor in Electrical Engineering)**	Code	Scheme L-T-P
1.	Electrical and Electronic Measurements (VII semester)	EE481	3-0-2

Sr. No.	**B.Tech. in Electrical Engineering with Honors** (Any one subject)	Code	Scheme L-T-P
1.	Advanced Power Electronics (VII semester)	EE491	3-1-0
2.	Power System Transients (VII semester)	EE492	3-1-0
3.	Advanced Industrial Instrumentation (VII semester)	EE493	3-1-0

Note: Throughout this scheme structure, the notations L, T, P, C denote lecture, tutorial, practical and credit respectively for the related subject.

B. Tech. IV year(Electrical), Semester- VII

Innovation, Incubation and Entrepreneurship

L	T	P	CREDIT
3	1	0	04

MG110 Scheme

1. Course Outcomes (Cos):

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

CO1	Explain the concepts of Entrepreneurship
CO2	Develop skills related to various functional areas of management (Marketing Management, Financial Management, Operations Management, Personnel Management etc.)
CO3	Develop skills related to Project Planning and Business Plan development
CO4	Demonstrate the concept of Innovation, Intellectual Property Rights (IPR) and Technology Business incubation
CO5	Build knowledge about Sources of Information and Support for Entrepreneurship

2. Syllabus:

- **CONCEPTS OF ENTREPRENEURSHIP** **(08 Hours)**

Scope of Entrepreneurship, Definitions of Entrepreneurship and Entrepreneur, Entrepreneural Traits, Characteristics and Skills, Entrepreneurial Development models and Theories, Entrepreneurs Vs Managers, Classification of Entrepreneurs; Major types of Entrepreneurship – Techno Entrepreneurship, Women Entrepreneurship, Social Entrepreneurship, Intrapreneurship (Corporate entrepreneurship), Rural Entrepreneurship, Family Business etc.; Problems for Small Scale Enterprises and Industrial Sickness; Entrepreneurial Environment – Political, Legal, Technological, Natural, Economic, Socio – Cultural etc.

- **FUNCTIONAL MANAGEMENT AREA IN ENTREPRENEURSHIP** **(15 hours)**

Marketing Management: Basic concepts of Marketing, Development of Marketing Strategy and Marketing plan
Operations Management: Basic concepts of Operations management, Location problem, Development of Operations strategy and plan
Personnel Management:Main operative functions of a Personnel Manager, Development of H R strategy and plan
Financial Management: Basics of Financial Management, Ratio Analysis, Investment Decisions, Capital Budgeting and Risk Analysis, Cash Flow Statement, Break Even Analysis

- **PROJECT PLANNING** **(09 hours)**

Search for Business Idea, Product Innovations, New Product Development – Stages in Product Development; Sequential stages of Project Formulation; Feasibility analysis – Technical, Market, Economic, Financial etc.; Project report; Project appraisal; Setting up an Industrial unit – procedure and formalities in setting up an Industrial unit; Business Plan Development

- **PROTECTION OF INNOVATION THROUGH IPR** **(03 hours)**

Introduction to Intellectual Property Rights – IPR, Patents, Trademarks, Copy Rights

- **INNOVATION AND INCUBATION** **(06 hours)**

Innovation and Entrepreneurship, Creativity, Green Technology Innovations, Grassroots Innovations, Issues and Challenges in Commercialization of Technology Innovations, Introduction to Technology Business Incubations, Process of Technology Business Incubation

- **SOURCES OF INFORMATION AND SUPPORT FOR ENTREPRENEURSHIP** **(04 hours)**

State level Institutions, Central Level institutions and other agencies

Tutorials will be conducted separately for 15 hours **Total Hours: 45**

3. **Books Recommended:**

1. Desai Vasant, Dynamics of Entrepreneurial Development and Management, Himalaya Publishing House, India, 6^{th} Revised Edition, 2020
2. Charantimath P. M., Entrepreneurial Development and Small Business Enterprises, Pearson Education, 3^{rd} Edition, 2018
3. Holt David H., Entrepreneurship: New Venture Creation, Pearson Education, 2016
4. Chandra P., Projects: Planning, Analysis, Selection, Financing, Implementation and Review, Tata McGraw Hill, 9^{th} Edition, 2019
5. Banga T. R. &Shrama S.C., Industrial Organisation & Engineering Economics, Khanna Publishers, 25^{th} Edition, 2015

Further Reading:

1. Prasad L.M., Principles & Practice Of Management, Sultan Chand & Sons, 8^{th} Edition,2015
2. Everett E. Adam, Ronald J. Ebert, Production and Operations Management , Prentice Hall of India, 5th edition, 2012
3. Kotler P., Keller K. L, Koshi A.& Jha M., Marketing Management – A South Asian Perspective, Pearson, 14^{th} Edition, 2014
4. Tripathi P.C. , Personnel Management & Industrial Relations, Sultan Chand & sons, 21^{st} Edition, 2013
5. Chandra P., Financial Management, Tata McGraw Hill, 9^{th} Edition, 2015

B. Tech. IV year(Electrical), Semester- VII	**L**	**T**	**P**	**CREDIT**
Advanced Micro-Controller	**3**	**0**	**0**	**03**

EE451 **Scheme**

1. Course Outcomes (Cos):

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

CO1	Explain the basics of 32-bit ARM cortex M-series (RISC) architecture and STM32F4xx MCU architecture
CO2	Explore advanced concepts of Embedded C Programming.
CO3	Illustrate STM32 peripherals with practice of code examples.
CO4	Discuss and analyze interfacing circuits with STM32
CO5	Design and develop hardware and embedded software for real life systems.

2. Syllabus:

- **INTRODUCTION TO ARM CORTEX-M ARCHITECTURE** **(04 Hours)**

  Von Neumann and Harvard CPU architecture, Overview of cortex M0and M4 cores, Thum-2 ISA, Registers, Operating Modes, Core buses, MPU, NVIC, System Tick Timer, Memory Map.
- **INTRODUCTION TO STM32F4XX MCU ARCHITECTURE** **(04 hours)**

  Memory and Bus Architecture, Power controller, Reset and Clock control.
- **INTRODUCTION TO PROGRAMMING OF STM32 CONTROLLER** **(04 hours)**

  Thumb-2 Instruction Set, Pointers, structure, Union, Pointer to Structure, Points to Function, enumeration, Introduction to IDE Debugging Techniques, Programming methods and addressing mechanism for Memory Mapped peripheral registers.
- **HARDWARE CONCEPT AND PROGRAMMING OF STM32 PERIPHERALS** **(20 hours)**

  GPIO, General purpose timers, Advanced control timers, ADC, DAC, USART, SPI, I2C.
- **INTERFACING AND PROGRAMMING OF STM32 WITH INPUT/OUTPUT SYTEMS** **(09 hours)**

  Pushbutton keys, Matrix keyboard, LCD display, External interrupt, Relay, ZCD circuit, Thyrisor and TRIAC Firing, encoder interface, PWM generation for buck and boost converter.
- **INTRODUCTION TO STM32 H7 MCU** **(04 hours)**

  6 stage pipeline with dual instruction issue, instruction cache, data cache, 64 bit AXI bus interface, instruction TCM and data TCM.

Total Hours: 45

3. Books Recommended:

1. Georey Brown, Discovering the STM32 Microcontroller, Creative Common Attribution.
2. Donald Norris, The Insider's Guide to STM32 Microcontrollers, Hitex (UK) Ltd., 1st Edition, 2018.
3. Joseph Yiu, The Definite Guide to Cortex –M3, Elsevier Publication, 2007.
4. Andrew & Sloss, ARM System Development Guide, Elsevier publication, 2007.
5. Data Sheets and User Reference Manuals of STM32f4xx, STM32h7xx.

B. Tech. IV year(Electrical), Semester- VII

Power Quality Disturbances and Mitigation

L	T	P	CREDIT
3	0	0	03

EE452 **Scheme**

1. Course Outcomes (Cos):

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

CO1	Identify the power quality events and problems
CO2	Analyze of stationary/Non-stationary signals
CO3	Assess the power quality events.
CO4	Design and analyze of power filters
CO5	Design the controllers for power filters

2. Syllabus:

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

  Signal processing and power quality, Origin of power quality variation and events, power quality indices, causes and effects of power quality disturbances, Power quality standards, Power quality measuring instruments, Analysis of Power outages, unbalance, distortions, voltage sag, flickers and load balancing.

- **PROCESSING OF STATIONARY & NON-STATIONARY SIGNALS** **(12 Hours)**

  Stationary signals: Overview of analysis methods, frequency domain analysis and signal transformation, estimation of harmonics and inter-harmonics.
  Non –stationary signals: Power quality data analysis methods, discrete STFT for analyzing time – evolving signal components, discrete wavelet transform for time scale analysis disturbances, block– based modeling.

- **CHARACTERIZATION OF POWER QUALITY EVENTS** **(09 Hours)**

  Voltage magnitude, phase angle and three characteristics versus time, event indices, transient.

- **EVENT CLASSIFICATION** **(08 Hours)**

  Overview of event classification method, step used for event classification, learning and classification using artificial neural network.

- **POWER FACTOR CORRECTION & MITIGATION OF POWER QUALITY PROBLEMS** **(08 Hours)**

  Power factor improvement techniques, Passive Compensation, Passive filter: Design and operation, Active filter: Design of shunt and series active filter and Control algorithms.

Total Hours: 45

3. Books Recommended:

1. Hirofumi Akagi, Edson Hirokazu Watanabe and Mauricio Aredes, Instantaneous Power Theory and Applications to Power Conditioning, Wiley Interscience, New Jersey, 2007.
2. Bollen Math, H. J. GU and Y. H. Irene, Signal Processing of Power Quality Disturbances, Wiley Interscience Publication (IEEE Press), 2006.
3. J. Wakileh George, Power System Harmonics: Fundamentals, analysis and filter Design, Springer, (first Indian reprint) 2007.
4. E. F. Fuchs, A. S. Masoum Mohammad, Power Quality in Power Systems and Electrical Machines, Elsevier Academic Press, 2008.
5. A. Ghosh and G. Ledwich, Power Quality Enhancement Using Custom Power Devices, Springer International Edition, Delhi, 2009.

B. Tech. IV year(Electrical), Semester- VII

Advanced Electrical Drives

L	T	P	CREDIT
3	0	0	03

EE453 **Scheme**

1. Course Outcomes (Cos):

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

CO1	Explain the basic principle of operation of conventional and modern electric drives
CO2	Apply the concept of reference frame theory and space vector concept for AC drives.
CO3	Develop various control strategies for modern electric drives
CO4	Apply the soft computing techniques for electric drives.
CO5	Compare various soft computing techniques in terms of dynamic and steady state response.

2. Syllabus:

- **REVIEW OF FUNDAMENTALS OF AC DRIVE** **(06 Hours)**

  Reference frame theory, concept of space vector, state space model.

- **INDUCTION MOTOR DRIVES** **(14 Hours)**

  Introduction, Review of three phase I.M. analysis and performance, Analysis of I.M. fed from Non-sinusoidal supply voltage, PWM and SVPWM method, rotating field, dynamic d-q model, Stator voltage control, V/f controlled induction motors, DC drive analogy, field oriented control, sensor less control, doubly fed induction machine, direct torque and flux control, CSI fed induction motor drives, Applications.

- **SYNCHRONOUS MOTOR DRIVES** **(12 Hours)**

  Introduction, Sinusoidal SPM machine drives, synchronous reluctance machine drives, Trapezoidal SPM machine drive, wound field synchronous motor drive, Load-commutated Synchronous Motor Drives, Model of PMSM, Vector controlled PMSM drive, UPF control, torque angle control, optimum torque per ampere control.

- **SOFT COMPUTING FOR ELECTRICAL DRIVES** **(13 Hours)**

  PI tuning methods, speed control using fuzzy logic controllers and adaptive controllers, Application of neural network for control of electrical drives, identification and parameter estimation.

Total Hours: 45

3. Books Recommended:

1. B.K. Bose, Modern Power Electronics & AC Drives, Pearson, 1st Edition, 2005.
2. R. Krishnan, Electric Motor Drives: Modeling, Analysis and Control, Prentice Hall, 1st Edition, 20
3. Peter Vas, Vector Control of Electric Drives, Oxford Publishers, 1998.
4. S. Dewan, B. Slemon, A. G. R. Straughen, Power Semiconductor drives, John Wiley and Sons, NewYork 2009.
5. G. K. Dubey, Fundamentals of Electrical Drives, Narosa Publishing House, 2nd Edition, 2001.

B. Tech. IV year(Electrical), Semester- VII

High Voltage Engineering

L	T	P	CREDIT
3	0	0	03

EE454 **Scheme**

1. Course Outcomes (Cos):

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

CO1	Illustrate different methods of generating various high voltages and currents
CO2	Explain various methods of measuring various high voltages and currents
CO3	Analyze various breakdown phenomena occurring in gaseous, liquid and solid dielectrics
CO4	Apply appropriate testing method(s) for various high voltage apparatus
CO5	Estimate the testing source requirement for any high voltage testing
CO6	Plan the high voltage laboratory

2. Syllabus:

- **GENERATION OF VARIOUS TYPES OF HIGH VOLTAGES** **(15 Hours)**

  Generation of High DC Voltages: Half Wave and full wave circuits –Ripple voltages in HW and FW rectifiers. Voltage doubler circuits – Simple voltage doubler, cascade voltage doubler. Voltage multiplier circuits – Crockroft Walton voltage multiplier circuits. Ripple and regulation. Electrostatic machines – principles – Van de Graff generator.

  Generation of high AC voltages: Cascade transformers, resonant transformers – parallel and series resonant test systems. Generation of high frequency high voltages – Tesla coil.

  Generation of impulse voltages – Standard impulse wave shape Basic circuits for producing impulse waves – Analysis of commercial impulse generator circuits – Wave shape control, multi-stage impulse generators – Marx circuit – modified Marx impulse generator circuit – Components of multi stage impulse generator. Generation of Switching surges. Generation of impulse current. Definition of impulse current waveform – Circuit for producing impulse current waves.

- **MEASUREMENTS OF HIGH VOLTAGES & CURRENTS** **(06 Hours)**

  Measurement of high voltages and currents-DC,AC and impulse voltages and currents-DSO, electrostatic and peak voltmeters, sphere gaps-factors affecting measurements, potential dividers(capacitive and resistive)-series impedance ammeters, Rogowski coils, hall effect generators.

- **ELECTRICAL BREAKDOWN IN GASES, LIQUIDS & SOLID DIELECTRICS** **(10 Hours)**

  Introduction to Insulation materials. Breakdown in gas and gas mixtures-breakdown in uniform and non-uniform fields, Paschen’s law, Townsends criterion, streamer mechanism, corona discharge, breakdown in electro negative gases, Breakdown in liquid dielectrics-suspended particle mechanism, Breakdown in solid dielectrics-intrinsic, streamer, thermal breakdown.

- **DESIGN, PLANNING AND LAYOUT OF HV LABORATORY** **(04 Hours)**

  Test Facilities, Activities & Studies in HV lab, Classification of HV lab, Size & rating of HV lab, grounding of impulse testing laboratories.

- **HV TESTING OF ELECTRICAL APPRATUS** **(10 Hours)**

  Non-destructive testing of dielectric materials – measurement dielectric constant and loss factor. Testing of Insulators, Bushings, Isolators, Circuit breakers, Cables, Transformers, Surge diverters, RI Measurement.

Total Hours: 45

3. <u>Books Recommended:</u>

1. E. Kuffel, W. S. Zaengl and J. Kuffel, _High voltage Engineering Fundamentals,_Newnes, 2nd Edition, 2002.
2. M. S. Naidu, V. Kamaraju, High Voltage Engineering,_Tata Mcgraw Hill, 2nd Edition, 2001.
3. L. L. Alston, High voltage Technology,_BS Publications, 2008.
4. Nils Hylten-Cacallius, High voltage Laboratory Planning, High voltage test system, Asea Haefely.
5. Standard Techniques for High Voltage Testing,_IEEE Publication, 1978.
6. Relevant IS standards and IEC standards.

B. Tech. IV year(Electrical), Semester- VII

HVDC Transmission

L	T	P	CREDIT
3	0	0	03

EE455 **Scheme**

1. Course Outcomes (Cos):

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

CO1	Describe the basic concepts of HVDC transmission system
CO2	Analyze the convertor for HVDC transmission applications
CO3	Choose between AC and DC transmission systems for an application
CO4	Explain the various control methods for HVDC power flow
CO5	Select the suitable protection method for various converter faults
CO6	Decide the converter configuration for harmonic mitigation on both AC and DC sides

2. Syllabus:

- **INTRODUCTION** **(06 Hours)**

  Introduction to AC and DC Transmission - application of DC Transmission - description of DC transmission - DC system components and their functions - modern trends in DC Transmission.

- **CONVERTER** **(11 Hours)**

  Pulse Number - Converter configuration - analysis of Graetz circuit - converter bridge characteristics - characteristics of 12 Pulse converters.

- **HVDC CONTROLLERS** **(12 Hours)**

  General principle of DC link control - converter control characteristics - system control hierarchy - firing angle control - current and extinction angle control - Dc link power control - high level controllers.

- **FILTERS** **(08 Hours)**

  Introduction to harmonics - generation of harmonics - design of AC filters - DC filters - carrier frequency and RI noise.

- **PROTECTION** **(08 Hours)**

  Basics of protection - DC reactors - voltage and current oscillations - circuit breakers - over voltage protection - switching surges - lightning surges - lightning arresters for DC systems.

Total Hours: 45

3. Books Recommended:

1. Kimbark, Direct Current Transmission - Vol. 1, John Wiley and Sons Inc., New York, 1st Edition, 1971.
2. K. R. Padiyar, HVDC Power Transmission Systems, Wiley Eastern Limited, New Delhi, 2nd Edition, 2017.
3. J. Arrillaga, High Voltage Direct Current Transmission, Peter Peregrines, London, 2nd Edition, 1998.
4. Vijay K. Sood, HVDC and FACTS Controllers: Applications of Static Converters in Power Systems, Springer; 1st Edition, 2004.
5. Chan-Ki Kim, Vijay K. Sood, Gil-Soo Jang, Seong-Joo Lim, and Seok-Jin Lee, HVDC Transmission, Wiley-Blackwell, 2009.

B. Tech. IV year(Electrical), Semester- VII

Nonlinear Control

L	T	P	CREDIT
3	0	0	03

EE456 **Scheme**

1. Course Outcomes (Cos):

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

CO1	Classify nonlinearity in control systems design point of view
CO2	Analyze nonlinear systems based on describing functions
CO3	Evaluate the stability of nonlinear systems by analyzing limit cycles
CO4	Visualize and understand the response of second order nonlinear control systems using various phase-plane methods
CO5	Impart the basic idea of optimal control strategies and their implementation

2. Syllabus:

- **INTRODUCTION TO NONLINEARITY:** **(12 Hours)**

Introduction to nonlinear components and systems, inherent and intentional nonlinearity, specific example of nonlinear spring for introducing non linearity like jump resonance and variation of resonant frequency with amplitude of input, linearization of non-linear state equations, non-linear measurement systems, input-output Volterra models, variational equation approach for solving non-linear systems.

- **DESCRIBING FUNCTION ANALYSIS OF NONLINEAR CONTROL SYSTEM:** **(13 Hours)**

Introduction to Nonlinear Systems Describing Functions for Common Types of Nonlinearities Describing Function Analysis, Stability and Limit Cycles.

- **PHASE-PLANE ANALYSIS:** **(20 Hours)**

Introduction, Analytical Methods for constructing Trajectories, Graphical Methods for constructing Trajectories, Isocline Method, Delta Method, Pell's Method, Lienard's Method, Classification of Singular Points, Limit Cycles, Phase-Plane Analysis of Linear control systems, Phase-Plane Analysis of' Non-linear control systems, Minimum Time Trajectory, Optimum Switching Curve.

Total Hours: 45

3. Books Recommended:

1. H. K. Khalil, Nonlinear Systems, Pearson 3rd Edition, 2001.
2. J.E. Slotine and W. Li, Applied Nonlinear Control, Prentice Hall, New Jersey, 1991.
3. D.E. Kirk, Optimal Control Theory: An Introduction, Dover Publications, Inc., 1st Edition, 2004.
4. B.D.O. Anderson & J. B. Moore, Optimal Control: Linear Quadratic Methods, Dover Publication,
5. R. C. Dorf & R. H. Bishop, Modern control system, Pearson Education Asia. 8th Edition, 2004.

B. Tech. IV year(Electrical), Semester- VII

Advanced Optimization Methods

L	T	P	CREDIT
3	0	0	03

EE457 Scheme

1. Course Outcomes (Cos):

At the end of the course 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, Classification of optimization problems.

- **LINEAR PROGRAMMING (08 Hours)**

  Theorem of Linear programming problems and Relation to convexity, Simplex method, Revised simplex method, Duality in linear programming(LP), Sensitivity analysis, other algorithms for solving LP problems.

- **SINGLE AND MULTIVARIABLE OPTIMIZATION (10 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 (10 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, Swarm intelligences, Genetic Algorithm, Teaching Learning Based Optimization, Rao algorithms and other Non-traditional Optimization Algorithms, applications.

Total Hours: 45

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

B. Tech. IV year(Electrical), Semester- VII

L	T	P	CREDIT
3	0	0	03

Electric Vehicles

EE458 Scheme

1. Course Outcomes (Cos):

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

CO1	Explain various terminologies related to electric vehicle.
CO2	Explain the concepts and drivetrain configurations of electric vehicles
CO3	Develop different electric motors drive systems and energy storage system for EV.
CO4	Construct different battery charger topologies for electric vehicles
CO5	Design the complete electric propulsion system for EV/HEV.

2. Syllabus:

- **DESIGN OF ELECTRIC VEHICLE: (12 Hours)**

  Basics of vehicle dynamics, Traction Effort, Modeling of vehicle acceleration and range, Concept and role of different drive cycle for vehicle performance analysis. Sizing of propulsion motor, internal combustion engine (ICE) and power electronics; sizing of the energy storage system, Electronic Control Units, In-vehicle Communications between Electronic Control and Supporting subsystems.

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

  Introduction to Energy Storage Requirements in Hybrid and Electric Vehicles, Terminologies related to Energy storage system, Battery, Fuel Cell, Ultra Capacitor and Flywheel based energy storage and its analysis, Hybridization of different energy storage devices, design of power source for different types of vehicle, Energy Management system - Charge Balancing circuits for the Energy storage system.

- **ELECTRIC PROPULSION DRIVE AND CONTROLLER: (10 Hours)**

  Selection of Motor drive based on vehicle torque and speed characteristics, Electric Motors in EV, Configuration and control of BLDC Motor drives, Induction Motor drives, Permanent Magnet Motor drives, and Switch Reluctance Motor drives, controllers, drive system efficiency.

- **ENERGY MANAGEMENT STRATEGIES FOR EV: (05 Hours)**

  Introduction to energy management strategies used in hybrid and electric vehicles, classification of different energy management strategies, comparison of different energy management strategies, implementation issues of energy management strategies.

- **ENERGY MANAGEMENT STRATEGIES FOR EV: (04 Hours)**

  Introduction to energy management strategies used in hybrid and electric vehicles, classification of different energy management strategies, comparison of different energy management strategies, implementation issues of energy management strategies.

Total Hours: 45

3. Books Recommended:

1. Iqbal Hussain, Electric & Hybrid Vehicles – Design Fundamentals, 2nd Edition, CRC Press, 2011.
2. James Larminie, Electric Vehicle Technology Explained, John Wiley & Sons, 2nd Edition, 2012.
3. Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay, Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press, 2nd Edition, 2009.
4. Chris Mi, Dearborn, M. Abul Masrur, David Wenzhong Gao, Hybrid electric Vehicles Principles and applications with practical perspectives, A John Wiley & Sons, Ltd., 2011.
5. Iqbal Hussain, Electric & Hybrid Vehicles – Design Fundamentals, 2nd Edition, CRC Press, 2011.

B. Tech. IV year(Electrical), Semester- VII

Switched Mode Power Supply

L	T	P	CREDIT
3	0	0	03

EE459 **Scheme**

1. Course Outcomes (Cos):

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

CO1	Explain the principle of switched-mode dc-dc power conversion.
CO2	Design of reactive components for SMPS
CO3	Analyze CCM and DDM operations of switched-mode power conversion.
CO4	Modelling of switch mode power converters
CO5	Design the controller for closed loop operation of the SMPS system

2. Syllabus:

- **THE PRINCIPLES OF SWITCHING POWER CONVERSION** **(08 Hours)**

  Introduction, evolution of switching topologies, switching devices - ideal and real characteristics, control, drive and protection.

- **REACTIVE COMPONENT DESIGNING** **(12 Hours)**

  Inductor, Transformer, Capacitor, Issues related to switches, Energy storage, their selection and design.

- **SWITCHING POWER CONVERTERS** **(15 Hours)**

  Switching power converters - circuit topology, operation, steady-state model, dynamic model.
  Analysis, modeling and performance functions of switching power converters.
  Non-isolated converters, Isolated converters, CCM and DCM operation of converters, Modeling of converters.

- **CONTROLLER DESIGNING** **(10 Hours)**

  Review of linear control theory, Closed-loop control of switching power converters, Sample designs and construction projects.

Total Hours: 45

3. Books Recommended:

1. Fang Lin Luo and Hong Ye. ‗Power Electronics: Advanced Conversion Technologies' CRC Press, Taylor & Francis Group, Boca Raton London New York, 2nd Edition, 2018.
2. Middlebrook, Robert David and Slobodan Cuk, Advances in Switched-Mode Power Conversion' Volumes 1 and 2, 2nd Edition, TESLA co., 1983.
3. Erickson, W. Robert, Fundamentals of Power Electronics' Chapman & Hall, 2nd Edition, 1997.
4. A.Pressman, Switching Power Supply Design' McGraw-Hill, 3rd Edition, 2009.
5. V. Ramanarayanan, Course Material on Switched Mode Power Conversion' Department of Electrical Engineering, IISc, Bangalore 560012
   http://minchu.ee.iisc.ernet.in/new/people/faculty/vr/book.pdf

B. Tech. IV year(Electrical), Semester- VII

Power Filter Technology

L	T	P	CREDIT
3	0	0	03

EE460 Scheme

1. Course Outcomes (Cos):

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

CO1	Describe the linear, nonlinear loads and identify the sources of power quality disturbances in the distribution system
CO2	Classify and explain the functions of passive, active and hybrid power filters
CO3	Develop different control techniques to mitigate the power quality disturbances
CO4	Analyze and compare the merits and demerits of several power quality control techniques
CO5	Design the controller for integration of the renewable energy sources to the grid through power filter technology

2. Syllabus:

- **ELECTRICAL POWER QUALITY** **(06 Hours)**

  Definitions, power quality standards, Classification of power system disturbances, power quality problems, formulations and measures used for power quality, effect of poor power quality on power system devices, non-ideal supply source, power factor correction and voltage regulation mode.

- **POWER QUALITY PROBLEM CREATING LOADS AND PASSIVE COMPENSATION** **(06 Hours)**

  Definition of linear and nonlinear loads, power electronics and electrical machine based nonlinear loads, current fed and voltage fed type nonlinear loads, mixed loads, grounding and banding, passive shunt and series compensator: operation and design methods.

- **PASSIVE POWER FILTER** **(06 Hours)**

  Classification of passive filters, application potentials and limitation of passive filter, basic principle, hybrid passive filters, design methods.

- **ACTIVE POWER FILTER** **(12 Hours)**

  Classification of active filters, application potential and advantages, basic principle, design of power circuit components, time domain control techniques: IRPT, PQ theory and SRF theory, real time implementation issues, voltage sensor and current sensors used in active filters, various topologies of active filters in three wire and four systems. Custom power devices: introduction, load compensation using DSTATCOM, DVR: structure and control, UPQC: configuration, structure and control techniques.

- **HYBRID POWER FILTER** **(09 Hours)**

  Classification of hybrid filters, applications potentials and limitation of hybrid filter, basic principle, hybrid filters, advantages, design and control techniques.

- **CUSTOM POWER DEVICES IN DISTRIBUTED GENERATION** **(06 Hours)**

  Distributed energy source: wind, hydro and solar based system, application of custom power devices for reactive power compensation, harmonic suppression and load balancing, Design problems.

Total Hours: 45

3. Books Recommended:

1. E. F. Fuchs, Masoum, A. S. Mohammad, Power Quality in Power Systems and Electrical Machines, Elsevier Academic Press, 1st Edition, 2008.
2. Ghosh and G. Ledwich, Power Quality Enhancement Using Custom Power Devices, Springer International Edition, Delhi, reprint 1st Edition, 2012.
3. Hirofumi Akagi, Edson Hirokazu Watanabe and Mauricio Aredes, Instantaneous Power Theory and Applications to Power Conditioning, Willey Interscience, New Jersey, 2nd Edition, 2017.
4. Antonio Moreno Munoz, Power Quality:Mitigation Technologies in a Distributed Environment, Springer-Verlag, London, reprint 1st Edition, 2010.
5. Sankaran, Power Quality, CRC Press, New York, 2001.

B. Tech. IV year(Electrical), Semester- VII

EHV AC Transmission

L	T	P	CREDIT
3	0	0	03

EE461 Scheme

1. Course Outcomes (Cos):

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

CO1	Enumerate the requirements of EHVAC transmission systems
CO2	Calculate the line and ground parameters as well as voltage gradients of EHVAC transmission
CO3	Analyze the corona effects for audible noise, power loss and radio interference
CO4	Interpret the effect of electrostatic field
CO5	Estimate the reactive power requirement and compensation of EHVAC transmission
CO6	Design EHV transmission lines for a given specifications

2. Syllabus:

- **INTRODUCTION TO EHV AC TRANSMISSION (04 Hours)**

  Role of EHV AC transmission, standard transmission voltages, Average values of line parameters, power handling capacity and Line loss, surge impedance loading.

- **CALCULATION OF LINE AND GROUND PARAMETERS (06 Hours)**

  Resistance of conductors, Properties of bundle conductors, Inductance of EHV line configuration, Line capacitance calculation, Sequence inductance and capacitance, line parameters for Modes of propagation.

- **VOLTAGE GRADIENTS OF CONDUCTORS (06 Hours)**

  Field of sphere gap & line charges and their properties, charge potential relations for multi conductor lines, surface voltage gradient on conductors, gradient factors and their use, distribution of voltage gradient on sub conductors of bundle.

- **CORONA AND ITS EFFECTS (06 Hours)**

  Coronal loss formulas, charge- voltage diagram and corona loss, Audible noise, limits for audible noise, AN measurement and meters, formula for audible noise and use in design, radio interference, limits of radio interference fields, CIGRE formula, measurement of RI, RIV and excitation function.

- **ELECTROSTATIC FIELD OF EHV LINES (05 Hours)**

  Calculation of Electrostatic filed of AC Lines, Effect of High Electrostatic filed on Humans, Animals and plants, Measurement of Electrostatic filed.

- **POWER FREQUENCY VOLTAGE CONTROL AND OVER VOLTAGES (12 Hours)**

  Problems at Power frequency, Generalized constants, No-load voltage conditions and charging current, The power circle diagram and it use, Voltage control using synchronous condensers, Cascade connection of components- Shunt and Series Compensation, Sub synchronous resonance in series capacitor compensated line.

- **DESIGN OF EHV LINES (06 Hours)**

  Design factors under steady state, Line insulation design based upon transient over voltages.

Total Hours: 45

3. Books Recommended:

1. Begamudre, EHV AC Transmission Engineering, Wiley Easter Ltd. 4th Edition, 2011.
2. EPRI, Palo Alto, Transmission line Reference Book 345 KV & above".
3. W. D. Stevenson, Element of Power System Analysis, Mc Graw Hill, 4th Edition, 2017.
4. Nagrath& Kothari, Power System Engineering, 4th Edition, Tata Mcgraw Hill publishing Company Ltd, 2014.
5. A. Chakrabarti, M. L. Soni, P. V. Gupta, & U. S. Bhatnagar, A Text Book on Power System Engineering, Dhanpat Rai & Co., 2016.

B. Tech. IV year(Electrical), Semester- VII

Distributed Power Generation and Micro-grid

L	T	P	CREDIT
3	0	0	03

EE462 **Scheme**

1. Course Outcomes (Cos):

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

CO1	Explain the concept of conventional grid and micro-grids
CO2	Appraise the need of distributed renewable energy resources
CO3	Describe the extraction and conversion of solar and wind energy.
CO4	Evaluate the response and protection of micro-grids.
CO5	Recognize the need of smart meters, electricity tariff and other smart devices.

2. Syllabus:

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

  The basic concepts of power grid, the electric grid vs micro-grids: technical and historic perspective, concept of micro-grid, typical configuration of micro-grid, AC and DC micro-grids, interconnection of micro-grids, technical and economic advantages of micro-grid, challenges and disadvantages of micro-grids, Islanding, need and benefits, different methods of islanding detection, modelling a micro-grid system

- **DISTRIBUTED ENERGY RESOURCES:** **(08 Hours)**

  Introduction - Combined heat and power (CHP) systems - Solar photovoltaic (PV) systems – Wind energy conversion systems (WECS) - Small-scale hydroelectric power generation - Storage devices: Batteries: Lead acid, nickel metal hydrate, and lithium ion batteries , ultra-capacitors, flywheels, Advantages and disadvantages of DG.

- **MICRO-GRID SOLAR ENERGY SYSTEM:** **(08 Hours)**

  the solar energy conversion process, photovoltaic power conversion, photovoltaic material, photovoltaic characteristic, photovoltaic efficiency, design of photovoltaic system, MPPT, storage system based on a single cell battery, the energy yield of a photovoltaic module and the angle of incident, Application of power electronics in solar system

- **MICRO-GRID WIND ENERGY SYSTEM:** **(08 Hours)**

  Wind power, wind turbine generators, power flow analysis of an induction machine, the operation of an induction generator, Permanent magnet synchronous generators, reluctance generators and Application of power electronics in wind farms.

- **PROTECTION ISSUES FOR MICROGRIDS:** **(06 Hours)**

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

- **INTRODUCTION TO SMART METERS, ELECTRICITY TARIFF:** **(07 Hours)**

  One Part Tariff, Two Part 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: 45

3. Books Recommended:

1. Ali Keyhani, Mohammad Marwali and Min Dai, Integration and Control of Renewable Energy in Electric Power System John Wiley publishing company, 2009.
2. S. Chowdhury, S. P. Chowdhury, P. Crossley, Micro-grids and Active Distribution Networks, IET Power Electronics Series, 2012.
3. Ali Keyhani, Design of Smart Power Grid Renewable Energy Systems, Wiley, 2nd Edition, 2016.
4. James Momoh, Smart Grid: Fundamentals of Design and Analysis, Wiley, 1st Edition, 2012.
5. R. C. Durgan, M. F. Me Granaghen, H. W. Beaty, Electrical Power System Quality, McGraw-Hill, 3rd Edition, 2017.

B. Tech. IV year(Electrical), Semester- VII

Smart Grid Technologies

L	T	P	CREDIT
3	0	0	03

EE463 Scheme

1. Course Outcomes (Cos):

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

CO1	Identify the background for smart Grid and have knowledge of smart grid in the context of Indian grid.
CO2	Classify smart grid architectures and understand the role of automation in transmission and distribution.
CO3	Apply PMUs, PDCs, WAMs. Technology for smart grid
CO4	Identify and apply a suitable evolutionary algorithm for the given smart grid application.
CO5	Use performance analysis tools for smart grid
CO6	Analyze and perform basic design of smart grid electric power systems, with emphasis on micro-grids.

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.

- **DISTRIBUTED ENERGY RESOURCES (08 Hours)**

Introduction - Combined heat and power (CHP) systems - Solar photovoltaic (PV) systems – Wind energy conversion systems (WECS) - Small-scale hydroelectric power generation - Storage devices: Penetration and Variability Issues Associated with Sustainable Energy Technology, Demand Response Issues, Electric Vehicles and Plug-in Hybrids.

- **SMART GRID COMMUNICATIONS AND MEASUREMENT TECHNOLOGY (08 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), Multi-agent Systems (MAS) Technology, Multi-agent Systems for Smart Grid Implementation.

- **PERFORMANCE ANALYSIS TOOLS FOR SMART GRID DESIGN (08 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.

- **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** **(07 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: 45

3. Books Recommended:

1. James Momoh, Smart Grid Fundamentals of Design and Analysis, A. John Wiley & Sons, 1st Edition, 2012.
2. Bharat Modi, Anu Prakash, Yogesh Kumar, Fundamentals of smart grid technology, S. K. Kataria & Sons, 2015
3. A. Keyhani, Smart Power Grid Renewable Energy Systems, Wiley 2nd Edition, 2016.
4. I.S. Jha, Subirata Sen, Rajesh Kumar and D.P. Kothari, Smart grid: Fundamental & applications, New Age international, New Delhi, 2019.
5. Gilbert N Sorebo and Michael C. Echols, Smart grid Security, CRC press, 1st Edition, 2012.

B. Tech. IV year(Electrical), Semester- VII

FPGA based control of Power Electronics Converters

L	T	P	CREDIT
3	0	0	03

EE464 **Scheme**

1. Course Outcomes (Cos):

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

CO1	Write programs using Verilog HDL code.
CO2	Simulate the programs using integrated development environment (IDE).
CO3	Interface the FPGA with external hardware using ADC/DAC and GPIO port.
CO4	Generate gate pulses to control various power electronic converters.
CO5	Develop a laboratory prototype of FPGA based controller for PE converters.

2. Syllabus:

- **INTRODUCTIN** **(05 Hours)**

  Review of digital logic circuits, Different kinds of programmable logic devices: Field Programmable Gate Array (FPGA), Programmable Logic Device (PLD), FPGA manufacturers (Xilinx, Altera, Actel, Lattice Semiconductor, Atmel). FPGA applications. Adjoining devices. Instruments and software.

- **THE STRUCTURE OF FPGA** **(05 Hours)**

  FPGA general description. Different kinds of FPGA packages. FPGA architecture. Internal hard modules of FPGA (CLB, Block RAM, DCM), their meanings and usage. Different kinds of I/O modules, their usage and configuration

- **HARDWARE DESCRIPTION LANGUAGE** **(15 Hours)**

  Introduction to Verilog HDL, Overview of Digital Design with Verilog HDL, Hierarchical Modeling Concepts, Basic Concepts, Modules and Ports, Gate-Level Modeling, Dataflow Modeling, Behavioural Modeling, Tasks and Functions, Useful Modeling Techniques, Timing and Delays, Switch-Level Modeling, User-Defined Primitives, Programming Language Interface, Logic Synthesis with Verilog HDL

- **FPGA DESIGN FLOW** **(10 Hours)**

  Architecture design, Project design using Verilog Hardware Description Language (HDL), Defining testing methodology and test bench design, RTL simulation, synthesizing, implementation, gate level simulation of design, Reusing of internal hard modules during design and implementation.

- **FPGA Configuration and Testing Methodology** **(10 Hours)**

  Introduction to integrated development environment (IDE) for system Verilog, Different types of FPGA configuration files, Generation of configuration file and its loading into FPGA. Functional and gate level testing. SDF file description and usage.

Total Hours: 45

3. List of Experiments:

1. Getting acquainted with Verilog programming and IDE
2. (i)Full adder, (ii) Up-down counter (iii) LED blink
3. Generation of Arbitrary waveforms using Look up table (LUT)
4. Interfacing using GPIO pins
5. ADC/DAC interfacing
6. Open-loop control of DC-DC converter
7. Square wave operation of Single-phase inverter
8. Generation of gating pulses with PWM techniques (i) DC modulation (ii) SPWM

3. Books Recommended:

1. Samir Palnitkar, “Verilog HDL - A guide to Digital Design and Synthesis”, SunSoft Press 1996.
2. P. Chu Pong, “FPGA Prototyping by Verilog Examples”, Xilinx Spartan, 3rd version, 2008
3. DE1-SoC Getting started Guide for ALTERA Cyclone V GX, https://www.terasic.com.tw/cgibin/page/archive.pl?Language=English&CategoryNo=165&No=836&PartNo=4#contents
4. NPTEL video Lectures on “Hardware modelling using Verilog by Prof. Indaranil Sengupta, IIT Kharagpur”.
5. NPTEL video Lectures on “Control and tunning methods in switched mode power converters by Prof. Santanu Kapat, IIT Khargpur”.
6. NPTEL video Lectures on “Digital control of switched mode power converters and FPGA based prototyping by Prof. Santanu Kapat, IIT Khargpur”.

B. Tech. IV year (CE, ME, ChE, IndChe, MaC), (Minor in Electrical Engineering) Semester- VII

L	T	P	CREDIT
3	0	2	04

Electrical and Electronics Measurements

EE481 Scheme

1. Course Outcomes (Cos):

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

CO1	Identify different standards and explain measurement techniques of resistance, inductance and capacitance.
CO2	Explain magnetic measurement techniques, discuss and analyze utilization of CT and PT.
CO3	Classify different indicating instrument.
CO4	Operate electronic meters and oscilloscope
CO5	Illustrate calibration and traceability of test equipment

2. Syllabus:

- **STANDARDS** **(03 Hours)**

  Standards and their classification. Electrical Standards: EMF, current, resistance and capacitance standards
- **MEASUREMENT of RESISTANCE, INDUCTANCE AND CAPACITANCE** **(08 Hours)**

  Concept of four arm bridge network, Kelvin's double bridge, Anderson bridge, Schering bridge, Wagner earthling device, Localization of cable fault using loop methods
- **MAGNETIC MEASUREMENTS** **(06 Hours)**

  Measurement of flux: ballistic galvanometer, Grassot flux meter, Hall effect devices for measurement of flux, measurement of iron loss by wattmeter method, Hibbert magnetic standard.
- **INSTRUMENT TRANSFORMERS** **(07 Hours)**

  Theory of current and voltage transformer, ratio error and phase angle, burden, turns compensation performance characteristics, testing of CT and PT and applications of CT and PT in measurement of power.
- **INDICATING INSTRUMENTS** **(07 Hours)**

  Classification, operating principles, general construction details of indicating instruments, balancing, control and damping method, theory and construction of PMMC, moving iron and electrostatic instruments, electrodynamics wattmeter.
- **ELECTRONIC METERS AND OSCILLOSCOPE** **(08 Hours)**

  DC amplifier voltmeter, AC voltmeter using rectifiers, true RMS responding voltmeter, Oscilloscope block diagram, CRT and its circuits, vertical deflection systems, delay line, multiple trace, horizontal deflection system, oscilloscope probes, Function generator.
- **CALIBRATION AND MEASUREMENT** **(06 Hours)**

  calibration and traceability of instruments, Calibration of indicating instruments using DC potentiometer, High voltage oil testing equipment, H.V. breakdown tester, Insulation resistance measurement techniques, calibration of energy meter

Total Hours: 45

3. List of Experiments:

1. To measure unknown resistance using Kelvin's Double Bridge.
2. To measure unknown inductance using Anderson Bridge
3. To calibrate voltmeter using Potentiometer.
4. To measure unknown capacitance using Schering Bridge
5. Calibration of single phase energy meter.
6. Testing of Current Transformer using Biffi's method.
7. To find out iron loss and flux density in a given sample of laminated steel core. (Lloyd fisher square)
8. To perform the operation of HV oil testing.
9. To study operation of oscilloscope and function generator.

4. Books Recommended:

1. Golding and Widdis, Electrical measurements and Measuring instruments, Wheeler books, 5th Edition.
2. A. K. Sawhney, Electrical and electronic Measurements and Instrumentation, Dhanpat Rai & Co., 17th Edition.
3. A. D. Helfrick and W. D. Cooper, Modern electronic Instrumentation and Measurement techniques, PHI, 2nd Edition, 2009.
4. D. A. Bell, Electronic Instrumentation and Measurement, Oxford Uni. Press, 3rd Edition, 2013.
5. P. Purkait, B. Biswas, S. Das and C. Koley Electrical and Electronics Measurement and Instrumentation, McGraw Hill Education, 1st Edition, 2013.

B. Tech. IV year (AI,CSE,ECE, ECVLSI, EnggPhy),

(Minor in Electrical Engineering) Semester- VII

Electrical and Electronics Measurements

L	T	P	CREDIT
3	0	2	04

EE481 **Scheme**

1. Course Outcomes (Cos):

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

CO1	Identify different standards and explain measurement techniques of resistance, inductance and capacitance.
CO2	Explain magnetic measurement techniques, discuss and analyze utilization of CT and PT.
CO3	Classify different indicating instrument.
CO4	Operate electronic meters and oscilloscope
CO5	Illustrate calibration and traceability of test equipment

2. Syllabus:

- **STANDARDS** **(03 Hours)**

  Standards and their classification. Electrical Standards: EMF, current, resistance and capacitance standards

- **MEASUREMENT of RESISTANCE, INDUCTANCE AND CAPACITANCE** **(07 Hours)**

  Concept of four arm bridge network, Kelvin's double bridge, Anderson bridge, Schering bridge, Wagner earthling device, Localization of cable fault using loop methods

- **MAGNETIC MEASUREMENTS** **(06 Hours)**

  Measurement of flux: ballistic galvanometer, Grassot flux meter, Hall effect devices for measurement of flux, measurement of iron loss by wattmeter method, Hibbert magnetic standard.

- **INSTRUMENT TRANSFORMERS** **(06 Hours)**

  Theory of current and voltage transformer, ratio error and phase angle, burden, turns compensation performance characteristics, testing of CT and PT and applications of CT and PT in measurement of power.

- **INDICATING INSTRUMENTS** **(08 Hours)**

  Classification, operating principles, general construction details of indicating instruments, balancing, control and damping method, theory and construction of PMMC, moving iron and electrostatic instruments, electrodynamics wattmeter.

- **ELECTRONIC METERS AND OSCILLOSCOPE** **(08 Hours)**

  DC amplifier voltmeter, AC voltmeter using rectifiers, true RMS responding voltmeter, Oscilloscope block diagram, CRT and its circuits, vertical deflection systems, delay line, multiple trace, horizontal deflection system, oscilloscope probes, Function generator.

- **CALIBRATION AND MEASUREMENT** **(07 Hours)**

  calibration and traceability of instruments, Calibration of indicating instruments using DC potentiometer, High voltage oil testing equipment, H.V. breakdown tester, Insulation resistance measurement techniques, calibration of energy meter

Total Hours: 45

3. List of Experiments:

1. To measure unknown resistance using Kelvin's Double Bridge.
2. To measure unknown inductance using Anderson Bridge
3. To calibrate voltmeter using Potentiometer.
4. To measure unknown capacitance using Schering Bridge
5. Calibration of single phase energy meter.
6. Testing of Current Transformer using Biffi's method.
7. To find out iron loss and flux density in a given sample of laminated steel core. (Lloyd fisher square)
8. To perform the operation of HV oil testing.
9. To study operation of oscilloscope and function generator.

4. Books Recommended:

1. Golding and Widdis, Electrical measurements and Measuring instruments, Wheeler books, 5th Edition.
2. A. K. Sawhney, Electrical and electronic Measurements and Instrumentation, Dhanpat Rai & Co., 17th Edition.
3. A. D. Helfrick and W. D. Cooper, Modern electronic Instrumentation and Measurement techniques, PHI, 2nd Edition, 2009.
4. D. A. Bell, Electronic Instrumentation and Measurement, Oxford Uni. Press, 3rd Edition, 2013.
5. P. Purkait, B. Biswas, S. Das and C. Koley Electrical and Electronics Measurement and Instrumentation, McGraw Hill Education, 1st Edition, 2013.

B. Tech. IV year(Electrical Engineering with Honors), Semester- VII	L	T	P	CREDIT
Advanced Power Electronics	3	1	0	04

EE491 Scheme

1. Course Outcomes (Cos):

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

CO1	Distinguish the power devices and their driver circuits
CO2	Analyze the CCM and DCM operation switched-mode dc-dc converters
CO3	Estimate the power quality indices and improve it using power electronics
CO4	Apply power electronics for field applications
CO5	Use simulation tools like PSIM and MATLAB

2. Syllabus:

- **MODERN SEMICONDUCTOR DEVICES** **(04 Hours)**

  Power Diodes, Power BJT, Power MOSFETs, Thyristor, GTOs, IGBT, MCT – Basic characteristics and controlling, Emerging devices and circuits, Power Integrated Circuits.

- **PRACTICAL DESIGN CONSIDERATION** **(06 Hours)**

  Gate and Base drive circuits – Design Consideration for different Devices, DC-Coupled Circuits, Isolated Drive Circuits, and Protection in Drive Circuits. Snubber circuits Designing, Temperature control and Heat sink design consideration, Design of Magnetic Components.

- **DC-DC SWITCHED MODE CONVERTERS** **(08 Hours)**

  Introduction, Step-Down (Buck) Converter, Step-Up (Boost) Converter, Buck-Boost Converter, Cuk Converter, Control Principles, Applications of DC-DC Converters.

- **SWITCHING DC POWER SUPPLIES** **(08 Hours)**

  Introduction, Linear Power Supplies, Switching Power Supplies, DC-DC Converter with isolation – Fly-back converters, Half Bridge Converters, Full Bridge converters, Forward Converter, Push-pull converter, Protection, Isolation and Design criteria for SMPS.

- **STATIC POWER ELECTRONICS APPLICATIONS** **(06 Hours)**

  Electronic Ballasts, UPSs, Power Electronics in Capacitor Charging Applications, Power Electronics for Renewable Energy Sources HVDC Transmission, Automotive Applications of Power Electronics.

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

  Power Quality, Reactive Power and Harmonic Compensation, IEEE Standards, Static VAR Compensator, Thyristor Controlled Reactor (TCR), Thyristor Switched Capacitors (TSC), Principle of Active Filters, Types of Active Power Filters, Shunt Active Power Filters, Series Active Power Filters.

- **SIMULATION OF POWER ELECTRONIC CONVERTERS AND VARIOUS CONTROL STRATEGIES USING PSIM SOFTWARE** **(05 Hours)**

  Introduction, Use of Simulation Tools for Design and Analysis, Simulation of Power Electronics Circuits with , PSIM, State-Space Averaged Models and their simulation using PSIM software.

Tutorials will be conducted separately for 15 hours **Total Hours: 45**

3. Books Recommended:

1. Rashid, M. H., Power Electronics Handbook, Elsevier Academic Press, 2nd revised Edition, 2006.
2. Ned Mohan, Tore M. Undeland and William P. Robbins, Power Electronics Converters, Applicati and Design, John Willey & Sons, Inc., 2nd Edition, 1995.
3. Agrawal, J. P., Power electronic systems: Theory and design, Addison Wesley Longman (Singapo Pte. Ltd. New Delhi, 2001.
4. Robert W. Erickson and Dragan Maksimovic, Fundamentals of Power Electronics, Springer international Edition.
5. L. Umanand, Power Electronics – Essentials & Applications, Wiley India Pvt. Ltd, 2009.

B. Tech. IV year(Electrical Engineering with Honors), Semester- VII

Power System Transients

L	T	P	CREDIT
3	1	0	04

EE492 **Scheme**

1. Course Outcomes (Cos):

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

CO1	Recall the fundamentals of transient analysis of RLC circuit and circuit breaker operation
CO2	Identify the source and characteristics of lightning, switching, and temporary over voltages
CO3	Interpret the concept of travelling wave propagation on transmission lines
CO4	Analyze switching transients in electric equipment like transformer, generator and motor
CO5	Evaluate different protection schemes for power system equipment against travelling wave

2. Syllabus:

- **OVERVOLTAGES IN POWER SYSTEMS** **(13 Hours)**

Transient over voltages due to lightning, Theory of ground wires, Direct stroke to a tower, Effect of reflection up and down the tower, Tower grounding and counterpoises, Switching transients, Single and double frequency transients, Abnormal switching transients, Capacitance switching, Kilometric fault, Line dropping and load ejection, Closing and reclosing of lines, High charging currents, Over voltages induced by faults, Ferro-resonance, Switching transients in integrated systems, Peaking switching over voltages in EHV lines and cables.

- **TRAVELLING WAVES IN TRANSMISSION LINES** **(13 Hours)**

Origin and nature of power system transients, Traveling waves on transmission lines, General wave equation, Attenuation and distortion of waves, Reflection and refraction of traveling waves at different line terminations, Bewley Lattice Diagram, Traveling waves in multi-conductor systems, Transition points on multi-conductor circuits.

- **PROTECTION AGAINST TRAVELLING WAVES** **(06 Hours)**

Rod gap, Arcing Horn, Lightning Arresters, Surge Absorber, Insulation Coordination.

- **TRANSIENT IN TRANSFORMERS AND ROTATING ELECTRICAL MACHINES** **(13 Hours)**

High frequency transients and voltage distribution in windings of transformer and rotating electrical machines, Surge impedance.

Tutorials will be conducted separately for 15 hours **Total Hours: 45**

3. Books Recommended:

1. I.V. Begley, Traveling waves in Transmission Systems, John Wiley (1933, 51), Dover.
2. R. Rudenberg., Electric Stroke waves in Power System, Harvard Unive rsity Press and Cambridge, Massachusetts.
3. Allan Greenwood, Electric Transients in Power Systems, Wiley Inter science 2nd Edition, 2010.
4. C.S. Indulkar and D.P. Kothari, Power System Transients, A Statistical Approach, Prentice Hall of India Pvt. Ltd., New Delhi. 110001, 2nd Edition, 2010.
5. V.A. Venikov, Transient phenomena in Electrical Power Systems, Pergamon Press, London, 2014.

B. Tech. IV year(Electrical Engineering with Honors), Semester- VII

Advanced Industrial Instrumentation

L	T	P	CREDIT
3	1	0	04

EE493 **Scheme**

1. Course Outcomes (Cos):

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

CO1	Classify Various types of Digital Measurement techniques and explain working principle of various types of digital instruments
CO2	Explain working principle of various sensors used in industrial applications
CO3	Understand the working principle of various types of Instrumentation amplifiers, multiplexers, demultiplexers, converters and data acquisition systems
CO4	Understand the basic architecture of PLC and its functionalities
CO5	Develop Ladder logic diagrams/ programs for PLC for various industrial applications

2. Syllabus:

- **DIGITAL MEASUREMENT TECHNIQUES** **(10 Hours)**

  Digital measurement techniques for voltage, current, power, energy, resistance, capacitance and loss angle (TAN ∂), impedance and quality factor, Frequency counter, period duration meter, pulse width meter, frequency ratio meter, error in digital instruments

- **SENSORS** **(10 Hours)**

  Principle and applications of photosensitive, fiber optic sensors, Ultrasonic Sensors, Synchro, Oxygen Sensors and Smart Sensors.

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

  Instrumentation amplifiers, isolation techniques, sample and hold circuits, multiplexers and demultiplexers, digital to analog converters, data acquisition systems, encoders, grounding and shielding techniques.

- **AN OVER VIEW OF PLC** **(06 Hours)**

  Introduction, definitions and history of PLC, manufacturing and assembly processes, PLC advantages and disadvantages, overall PLC system, CPU, PLC, input and output modules, program recording devices

- **PROGRAMMING OF PLC** **(09 Hours)**

  Ladder diagrams, programming ON/OFF inputs to produce ON/OFF outputs, digital gate logic and contact coil logic, creating ladder diagrams from process control descriptions ,register, timer function, counter function, arithmetic functions, comparison functions

Tutorials will be conducted separately for 15 hours **Total Hours: 45**

3. **Books Recommended:**

1. Helfrick A D; Cooper W. D. , “Modern electronic Instrumentation and Measurement techniques”, PHI ,Edition 1997
2. Rangan; Sarma; Mani , “Instrumentation devices and systems”, TMH , 2nd edition
3. Doebelin E.O, “Measurement Systems - Application and Design”, Fourth edition, McGraw-Hill, New York, 1992.
4. T.S Rathore, “Digital Measurement Technique”, Narosa publishing house, 2nd edition
5. Curtis Johnson, “Process control instrumentation technology”, PHI, 6th edition
6. John. W .Webb Ronald A Reis , “Programmable Logic Controllers - Principles and Applications”, Fourth edition, Prentice Hall Inc., New Jersey, 1998.
7. D. Patranabis, “Principle of Industrial Instrumentation”, Tata McGraw Hill, 2nd Edition.
8. Petruzella, “Industrial Electronics”, McGraw-Hill, ISE Editions