PRAKASAM ENGINEERING COLLEGE
(AUTONOMOUS)
Approved by AICTE, Affiliated to JNTUK and Accredited by NAAC 'A'

R23 III Year ELECTRICAL AND ELECTRONICS ENGINEERING

B.Tech. III Year-I Semester

S.No.	Category	Title	L	T	P	C
1	Professional Core	Power Electronics	3	0	0	3
2	Professional Core	Digital Circuits	3	0	0	3
3	Professional Core	Power Systems-II	3	0	0	3
4	Professional Elective- I	Computer Architecture and Organization	3	0	0	3
5	Open Elective-I	Principles of Operating Systems	3	0	0	3
6	Professional Core	Power Electronics Lab	0	0	3	1.5
7	Professional Core	Analog and Digital Circuits Lab	0	0	3	1.5
8	Skill Enhancement course	Soft skills	0	1	2	2
9	Engineering Science	Tinkering Lab	0	0	2	1
10	Evaluation of Community Service Internship		-	-	-	2
		Total	**15**	**1**	**10**	**23**
MC	Minor Course (Student may select from the same specialized minors pool)		3	0	3	4.5
MC	Minor Course through SWAYAM / NPTEL (Minimum 12 Week, 3 credit course)		3	0	0	3
HC	Honors Course (Student may select from the same Honors pool)		3	0	0	3
HC	Honors Course (Student may select from the same Honors Pool)		3	0	0	3

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B.Tech. III Year-II Semester

S.No.	Category	Title	L	T	P	C
1	Professional Core	Electrical Measurements and Instrumentation	3	0	0	3
2	Professional Core	Microprocessors and Microcontrollers	3	0	0	3
3	Professional Core	Power System Analysis	3	0	0	3
4	Professional Elective-II	1. Switchgear and Protection 2. Advanced Control Systems 3. Renewable and Distributed Energy Technologies	3	0	0	3
5	Professional Elective-III	1. Electric Drives 2. Digital Signal Processing 3. High Voltage Engineering	3	0	0	3
6	Open Elective - II		3	0	0	3
7	Professional Core	Electrical Measurements and Instrumentation Lab	0	0	3	1.5
8	Professional Core	Microprocessors and Microcontrollers Lab	0	0	3	1.5
9	Skill Enhancement course	IoT Applications of Electrical Engineering Lab	0	1	2	2
10	Audit Course	Research Methodology	2	0	0	-
		Total	**20**	**1**	**08**	**23**

		L	T	P	C
MC	Student may select from the same minor's pool	3	0	3	4.5
MC	Minor Course (Student may select from the same specialized minors pool)	3	0	0	3
HC	Student may select from the same honors pool	3	0	0	3
HC	Honors Course (Student may select from the honors pool)	3	0	0	3

OPEN ELECTIVES

S.No.	Category	Title	L	T	P	C
1	Open Elective-I (III-I)	1. Renewable Energy Sources 2. Concepts of Energy Auditing & Management	3	0	0	3
2	Open Elective – II (III-II)	1. Fundamentals of Electric Vehicles 2. Electrical Wiring Estimation and Costing	3	0	0	3
3	Open Elective – III (IV-I)	1. Battery Management Systems and Charging Stations 2. Concepts of Smart Grid Technologies	3	0	0	3
4	Open Elective-IV (IV-I)	1. Concepts of Power Quality 2. Intelligent Control Systems	3	0	0	3

***Minor Engineering Courses offered by EEE Department for Other Branches (Except EEE Branch)**

S.No.	Course	Title	L	T	P	C
1	I	Concepts of Control Systems	3	0	0	3
2	II	Fundamentals of Electrical Measurements and Instrumentation	3	0	0	3
3	III	Concepts of Power System Engineering	3	0	0	3
4	IV	Fundamentals of Power Electronics	3	0	0	3
5	V	Basics of Electric Drives and applications	3	0	0	3
6	VI	Fundamentals of utilization of Electrical Energy	3	0	0	3
		Total	**18**	**0**	**0**	**18**

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*Honors Engineering Courses offered EEE Branch students Need to Acquire 18 credits

Power Systems

S.No.	Course	Title	L	T	P	C
1	I	Electric Power Quality	3	0	0	3
2	II	Smart Grid Technologies	3	0	0	3
3	III	Power System Deregulation	3	0	0	3
4	IV	Real Time Control of Power Systems	3	0	0	3
5	V	Advanced Power Systems Protection	3	0	0	3
6	VI	Flexible ACTransmission Systems	3	0	0	3
7	VII	AI applications in Power Systems	3	0	0	3
8	VIII	Power Systems Lab	0	0	3	1.5
9	IX	Advanced Power Systems Simulation Lab	0	0	3	1.5

Power Electronics

S.No.	Course	Title	L	T	P	C
1	I	Special Electrical Machines	3	0	0	3
2	II	Machine Modeling and Analysis	3	0	0	3
3	III	Power Electronic Converters	3	0	0	3
4	IV	Power Quality and Custom Power Devices	3	0	0	3
5	V	Power Electronics for Renewable Energy systems	3	0	0	3
6	VI	Industrial Applications of Power Electronic Converters	3	0	0	3
7	VII	Advanced Electrical Drives	3	0	0	3
8	VIII	FACTS Controllers	3	0	0	3
9	IX	Power Converters Laboratory	0	0	3	1.5
10	X	Electric Drives Laboratory	0	0	3	1.5
11	XI	Renewable Technologies Laboratory	0	0	3	1.5
12	XII	Electric Vehicles Laboratory	0	0	3	1.5

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		L	T	P	C
III Year –I Semester	**PROFESSIONAL CORE POWER ELECTRONICS**	**3**	**0**	**0**	**3**

Pre-requisite:

Electrical Circuit Analysis, Semiconductor Physics, Control Systems

Course Objectives:

- To know the characteristics of various power semiconductor devices.
- To learn the operation of single phase controlled converters and perform harmonic
- analysis of input current.
- To learn the operation of three phase controlled converters and AC/AC converters.
- To learn the operation of different types of DC-DC converters and control techniques.
- To learn the operation of PWM inverters for voltage control and harmonic mitigation.

Course Outcomes:

After the completion of the course the student should be able to:

CO1: Illustrate the static and dynamic characteristics of SCR, Power-MOSFET and Power-IGBT.

CO2: Analyse the operation of phase-controlled rectifiers.

CO3: Analyse the operation of three-phase full–wave converters, AC Voltage Controllers and Cyclo converters.

CO4: Examine the operation and design of different types of DC-DC converters.

CO5: Analyse the operation of Square wave inverters and PWM inverters for voltage control.

UNIT – I

Power Semi-Conductor Devices

Silicon controlled rectifier (SCR) – Two transistor analogy - Static and Dynamic characteristics – Turn on and Turn off Methods - Triggering Methods (R, RC and UJT) – Snubber circuit design.

Static and Dynamic Characteristics of Power MOSFET and Power IGBT-Numerical problems.

UNIT – II

Single-phase AC-DC Converters

Single-phase half-wave controlled rectifiers - R and RL loads with and without freewheeling diode - Single-phase fully controlled mid-point and bridge converter with R load, RL load and RLE load - Continuous and Discontinuous conduction - Effect of source inductance in Single-phase fully controlled bridge rectifier – Expression for output voltages – Single-phase Semi-Converter with R load-RL load and RLE load – Continuous and Discontinuous conduction - Dual converter and its mode of operation - Numerical Problems.

UNIT – III
Three-phase AC-DC Converters & AC – AC Converters
Three-phase half-wave Rectifier with R and RL load - Three-phase fully controlled rectifier with R and RL load - Three-phase semi converter with R and RL load - Expression for Output Voltage - Numerical Problems.
Single-phase AC-AC power control by phase control with R and RL loads - Expression for rms output voltage – Single-phase step down and step up Cycloconverter - Numerical Problems.

UNIT – IV
DC–DC Converters
Operation of Basic Chopper – Analysis of Buck, Boost and Buck-Boost converters in Continuous Conduction Mode (CCM) and Discontinuous Conduction Modes (DCM) - Output voltage equations using volt-sec balance in CCM & DCM – Expressions for output voltage ripple and inductor current ripple – control techniques – Introduction to PWM control -Numerical Problems.

UNIT – V
DC–AC Converters
Introduction - Single-phase half-bridge and full-bridge inverters with R and RL loads – Phase Displacement Control – PWM with bipolar voltage switching, PWM with unipolar voltage switching - Three-phase square wave inverters - 120^0 conduction and 180^0 conduction modes of operation - Sinusoidal Pulse Width Modulation - Current Source Inverter (CSI) - Numerical Problems.

Text Books:

1. Power Electronics: Converters, Applications and Design by Ned Mohan, Tore M Undeland, William P Robbins, John Wiley & Sons, 2002.
2. Power Electronics: Circuits, Devices and Applications – by M. H. Rashid, Prentice Hall of India, 2nd edition, 2017.
3. Power Electronics: Essentials & Applications by L.Umanand, Wiley, Pvt. Limited, India, 2009.

Reference Books:

1. Elements of Power Electronics–Philip T.Krein. Oxford University Press; Second edition, 2014.
2. Power Electronics – by P.S.Bhimbra, Khanna Publishers.
3. Thyristorised Power Controllers – by G. K. Dubey, S. R. Doradla, A. Joshi and R. M. K.Sinha, New Age International (P) Limited Publishers, 1996.

4. Power Electronics: by Daniel W.Hart, Mc Graw Hill, 2011.

Online Learning Resources:

1. https://ocw.mit.edu/courses/6-334-power-electronics-spring-2007
2. https://archive.nptel.ac.in/courses/108/101/108101126

III Year I Semester	PROFESSIONAL CORE DIGITAL CIRCUITS	L	T	P	C
		3	0	0	3

Pre-requisite:
Knowledge of electronic components and semiconductor devices, number systems, binary arithmetic, Boolean or switching algebra and logic gates.

Course Objectives:

- To know the simplification methods of Boolean functions
- To understand the realization of arithmetic, data routing and memory logic circuits.
- To know the operation and design of various counters and registers.
- To understand the analysis and design of synchronous sequential circuits.
- To understand the basic concepts of digital integrated circuits.

Course Outcomes:
At the end of the course, the student will be able to,

CO1: Use the concepts of Boolean algebra, K-map, tabulation method in minimization of switching functions and able to design the arithmetic combinational circuits.
CO2: Realize different types of data routing combinational circuits and PLDs.
CO3: Apply knowledge of flip-flops in designing of registers and counters.
CO4: Analyze synchronous sequential circuits and apply different methods for the design of synchronous sequential circuits.
CO5: Understand the logic families in the form of digital integrated circuits.

UNIT – I:
Combinational logic circuits – I
Definition of combinational logic, canonical forms, Generation of switching equations from truth tables, simplification of logic functions using Boolean theorems, NAND and NOR implementations, Karnaugh maps – 3,4,5 variables, Incompletely specified functions (Don't care terms), Simplifying Max term equations, Quine-McCluskey minimization technique, General approach to combinational logic design, Look ahead carry adder, Cascading full adders, 4-bit adder-subtractor circuit, BCD adder circuit, Excess 3 adder, Binary comparators.

UNIT – II:
Combinational logic circuits – II
Decoders, BCD decoders, 7 segment decoder, higher order decoder, multiplexer, higher order multiplexing, de-multiplexers, higher order de-multiplexing, realization of Boolean functions using decoders, multiplexers, encoders, priority encoder, Read only and Read/Write Memories, Programmable ROM, PAL, PLA-Basics structures, programming tables of

PROM, PAL, PLA, realization of Boolean functions.

Unit – III

Sequential logic circuits

Timing considerations of flip-flops, master-slave flip-flop, edge triggered flip-flops, characteristic equations, flip-flops with reset and clear terminals, excitation tables, conversion from one flip-flop to another flip-flop, design of asynchronous and synchronous counters, design of modulus-N counters, Johnson counter, ring counter, design of registers - buffer register, control buffer register, shift register, bi-directional shift register, universal shift register.

UNIT – IV

Sequential Circuit Design

Mealy and Moore models, State machine notation, Synchronous Sequential circuit analysis, Construction of state diagrams, Analysis of clocked sequential circuits, realization of sequence detector circuit, state reduction and assignments, design procedure.

UNIT – V

Digital integrated circuits:

Logic levels, propagation delay time, power dissipation, fan-out and fan-in, noise margin, logic families – RTL and DTL Circuits, TTL, Emitter-Coupled Logic, Metal-Oxide Semiconductor, Complementary MOS, CMOS Transmission Gate Circuits.

Textbooks:

1. Switching and finite automata theory Zvi. Kohavi, 3rd edition, Cambridge University Press, 2010.
2. M. Morris Mano and M. D. Ciletti, "Digital Design", 4th Edition, Pearson Education,2006.

Reference Books:

1. Fundamentals of Logic Design by Charles H. Roth Jr, Jaico Publishers, 5th Edition, 1992.
2. Switching Theory and Logic Design by A. Anand Kumar,Prentice Hall India Pvt., Limited, Third Edition, 2016.

Online Learning Resources:

1. https://nptel.ac.in/courses/117106086.
2. https://nptel.ac.in/courses/108105113.
3.

III Year I Semester	PROFESSIONAL CORE POWER SYSTEMS-II	L	T	P	C
		3	0	0	3

Pre-requisite:
Power systems-I, Electrical circuit Analysis.

Course Objectives:

- To understand the concepts of GMD&GMR to compute inductance & capacitance of transmission lines.
- To distinguish the models of short, medium and long length transmission lines and analyze their performance.
- To learn the effect of travelling waves on transmission lines with different terminal conditions.
- To learn the concepts of corona, the factors effecting corona and effects of transmission lines.
- To design the sag and tension of transmission lines as well as to learn the performance of line insulators.

Course Outcomes:
After the completion of the course the student should be able to:

CO1: Calculate parameters of transmission lines for different circuit configurations.
CO2: Analyze the performance of short, medium and long transmission lines.
CO3: Analyze the effect of travelling waves on transmission lines.
CO4: Estimate the effects of corona in transmission lines.
CO5: Calculate sag and tension of transmission lines and design the line insulators.

UNIT–I
Transmission Line Parameters Calculations
Conductor materials – Types of conductors – Calculation of resistance for solid conductors – Calculation of inductance for Single-phase and Three-phase single and double circuit lines– Concept of GMR and GMD–Symmetrical and asymmetrical conductor configuration with and without transposition–Bundled conductors, Skin and Proximity effects.
Calculation of capacitance for 2 wire and 3 wire systems – Effect of ground on capacitance – Capacitance calculations for symmetrical and asymmetrical single and Three-phase single and double circuit lines without and with Bundled conductors.

UNIT–II

Performance Analysis of Transmission Lines

Classification of Transmission Lines – Short, medium, long lines and their model representation –Nominal-T, Nominal-π and A, B, C, D Constants for symmetrical Networks.

Rigorous Solution for long line equations –Representation of Long lines – Equivalent T and Equivalent π network models - Surge Impedance and Surge Impedance Loading of Long Lines - Regulation and efficiency for all types of lines – Ferranti effect.

UNIT – III

Power System Transients

Types of System Transients – Propagation of Surges – Attenuation–Distortion–Reflection and Refraction Coefficients.

Termination of lines with different types of conditions: Open Circuited Line–Short Circuited Line, Line terminated through a resistance and line connected to a cable. Reflection and Refraction at a T-Junction.

UNIT–IV

Corona& Effects of transmission lines

Description of the phenomenon – Types of Corona - critical voltages and power loss – Advantages and Disadvantages of Corona - Factors affecting corona - Radio Interference.

UNIT–V

Sag and Tension Calculations and Overhead Line Insulators:

Sag and Tension calculations with equal and unequal heights of towers–Effect of Wind and Ice weight on conductor – Stringing chart and sag template and its applications.

Types of Insulators – Voltage distribution in suspension insulators–Calculation of string efficiency and Methods for String efficiency improvement – Capacitance grading and Static Shielding.

Text Books:

1. Electrical Power Systems – by C.L.Wadhwa, New Age International (P) Limited, 1998.
2. Power System Engineering by I.J.Nagarath and D.P.Kothari, Tata McGraw Hill, 3rd Edition, 2019.

Reference Books:

1. Power system Analysis–by John J Grainger William D Stevenson,

TMC Companies, 4th edition
2. Power System Analysis and Design by B.R.Gupta, Wheeler Publishing.
3. A Text Book on Power System Engineering by M.L.Soni, P.V.Gupta, U.S.Bhatnagar A.Chakrabarthy, DhanpatRai Co Pvt. Ltd.2016.
4. Electrical Power Systems by P.S.R. Murthy, B.S. Publications, 2017.

Online Learning Resources:

1. https://archive.nptel.ac.in/courses/108/105/108105104
2. https://archive.nptel.ac.in/courses/108/102/108102047

III Year – I Semester	PROFESSIONAL ELECTIVE- I SIGNALS AND SYSTEMS	L	T	P	C
		3	0	0	3

Course Outcomes:

- Differentiate the various classifications of signals and systems
- Analyze the frequency domain representation of signals using Fourier concepts
- Classify the systems based on their properties and determine the response of LTI Systems.
- Know the sampling process and various types of sampling techniques.
- Apply Laplace and z-transforms to analyze signals and Systems (continuous & discrete).

UNIT- I: INTRODUCTION: Definition of Signals and Systems, Classification of Signals, Classification of Systems, Operations on signals: time-shifting, time-scaling, amplitude-shifting, amplitude-scaling. Problems on classification and characteristics of Signals and Systems, Complex exponential and sinusoidal signals, Singularity functions and related functions: impulse function, step function signum function and ramp function.

UNIT–II: FOURIER SERIES AND FOURIER TRANSFORM:
Fourier series representation of continuous time periodic signals, Dirichlet's conditions, Trigonometric Fourier series and Exponential Fourier series, Relation between Trigonometric and Exponential Fourier series, Complex Fourier spectrum. Deriving Fourier transform from Fourier series, Fourier transform of standard signals, properties of Fourier transforms, Fourier transforms involving impulse function and Signum function. Related problems

UNIT-III:
CORRELATION: Auto-correlation and cross-correlation of functions, properties of correlation function, Energy density spectrum, Parseval's theorem, Power density spectrum, Relation between Convolution and correlation, Detection of periodic signals in the presence of noise by correlation.

SAMPLING THEOREM: Graphical and analytical proof or Band Limited Signals, impulse sampling, Natural and Flat top Sampling, Reconstruction of signal from its samples, Aliasing, Related problems.

UNIT–IV:
LAPLACE TRANSFORMS: Introduction**,** Concept of region of convergence (ROC) for Laplace transforms, constraints on ROC for various classes of signals, Properties of L.T's, Inverse Laplace transform, Relation between L.T's, and F.T. of a signal. Laplace transform of certain signals using waveform synthesis.

UNIT–V:
Z–TRANSFORMS: Concept of Z-Transform of a discrete sequence. Region of convergence in Z- Transform, constraints on ROC for various classes of signals, Inverse Z-transform, properties of Z-transforms, Distinction between Laplace, Fourier and Z transforms.

TEXT BOOKS:

1. Signals, Systems & Communications-B.P.Lathi,BSPublications,2003.
2. Signals and Systems-A.V. Oppenheim, A.S. Willsky and S.H. Nawab,PHI,2ndEdn,1997
3. Signals & Systems-SimonHaykinandVanVeen,Wiley,2ndEdition,2007

REFERENCE BOOKS:

1. PrinciplesofLinearSystemsandSignals–BPLathi,OxfordUniversityPress,2015
2. Signals and Systems–TK Rawat, Oxford University press,2011.

III Year – I Semester	PROFESSIONAL ELECTIVE- I COMPUTER ARCHITECTURE AND ORGANIZATION	L	T	P	C
		3	0	0	3

Pre-requisite:

Basic knowledge in digital electronics, fundamentals of computers.

Course Objectives:

- To explain the basic working of a digital computer.
- To understand the register transfer language and micro operators.
- To learn various addressing modes supported by the processors.
- To be familiar with peripheral interfacing with processors.
- To understand memory hierarchy in computers.

Course Outcomes:

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

CO1: Demonstrate the instruction cycle of a computer.
CO2: Understand various micro operations and register transfer language.
CO3: Describe parallel processing and pipelining.
CO4: Interface different peripherals with processors.
CO5: Know the advantages of cache and virtual memory.

UNIT-I

Basic Computer Organization and Design: Instruction Codes, Computer Registers, Computer Instructions, Timing and Control, Instruction Cycle, Memory-Reference Instructions, Input- Output and Interrupt, Complete Computer Description, Design of Basic Computer, Design of Accumulator Logic.

UNIT-II

Register Transfer and Micro operations: Register Transfer Language, Register Transfer, Bus and Memory Transfers, Arithmetic Micro operations, Logic Micro operations, Shift Micro operations, Arithmetic Logic Shift Unit. Micro programmed Control: Control Memory, Address Sequencing, Micro program Example, Design of Control Unit.

UNIT-III

Central Processing Unit: Introduction, General Register Organization, Stack Organization, Instruction Formats, Addressing Modes, Data Transfer and Manipulation, Program Control, Reduced Instruction Set Computer(RISC) Pipeline and Vector

Processing: Parallel Processing, Pipelining, Arithmetic Pipeline, Instruction Pipeline, RISK Pipeline, Vector Processing, Array Processors.

UNIT-IV

Input/output Organization: Peripheral Devices, I/O interface, Asynchronous data transfer, Modes of transfer, priority Interrupt, Direct memory access, Input-Output Processor (IOP), Serial Communication.

UNIT-V

Memory Organization: Memory Hierarchy, Main memory, Auxiliary memory, Associate Memory, Cache Memory, and Virtual memory, Memory Management Hardware.

Text Books:

1. Computer System Architecture, M. Morris Mano, Prentice Hall of India Pvt. Ltd., 3rd Edition, Sept. 2008.

References Books:

1. Computer Architecture and Organization, William Stallings, PHI Pvt. Ltd., Eastern Economy Edition, Sixth Edition, 2003.
2. Computer Organization and Architecture, Linda Null, Julia Lobur, Narosa Publications ISBN 81- 7319-609-5
3. Computer System Organization by John. P. Hayes.

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III Year – I Semester	OPEN ELECTIVE- I PRINCIPLES OF OPERATING SYSTEMS	L	T	P	C
		3	0	0	3

Course Objectives:

- Understand the basic concepts and principles of operating systems, including process management, memory management, file systems, and Protection To understand the register transfer language and micro-operators.
- Make use of process scheduling algorithms and synchronization techniques to achieve better performance of a computer system.
- Illustrate different conditions for deadlock and their possible solutions.

UNIT - I

Operating Systems Overview: Introduction, Operating system functions, Operating systems operations, Computing environments, Free and Open-Source Operating Systems System Structures: Operating System Services, User and Operating-System Interface, system calls, Types of System Calls, system programs, Operating system Design and Implementation, Operating system structure, Building and Booting an Operating System, Operating system debugging.

UNIT - II

Processes: Process Concept, Process scheduling, Operations on processes, Inter-process communication. Threads and Concurrency: Multithreading models, Thread libraries, Threading issues. CPU Scheduling: Basic concepts, Scheduling criteria, Scheduling algorithms, Multiple processor scheduling.

UNIT – III

Synchronization Tools: The Critical Section Problem, Peterson's Solution, Mutex Locks, Semaphores, Monitors, Classic problems of Synchronization. Deadlocks: system Model, Deadlock characterization, Methods for handling Deadlocks, Deadlock prevention, Deadlock avoidance, Deadlock detection, Recovery from Deadlock.

UNIT - IV

Memory-Management Strategies: Introduction, Contiguous memory allocation, Paging, Structure of the Page Table, Swapping. Virtual Memory Management: Introduction, Demand paging, Copy-on-write, Page replacement, Allocation of frames, Thrashing Storage Management: Overview of Mass Storage Structure, HDD Scheduling.

UNIT - V

File System: File System Interface: File concept, Access methods, Directory Structure; File system Implementation: File system structure, File-system Operations, Directory implementation, Allocation method, Free space management;
File System Internals: File-System Mounting, Partitions and Mounting, File Sharing.

Text Books:

1. Operating System Concepts, Silberschatz A, Galvin P B, Gagne G, 10th Edition, Wiley, 2018.
2. Modern Operating Systems, Tanenbaum A S, 4th Edition, Pearson ,2016

Reference Books:

1. Operating Systems -Internals and Design Principles, Stallings W, 9th edition, Pearson, 2018
2. Operating Systems: A Concept Based Approach, D.M Dhamdhere, 3rd Edition, McGraw- Hill, 2013

Online Learning Resources:

1. https://nptel.ac.in/courses/106/106/106106144/
2. http://peterindia.net/OperatingSystems.htmL

III Year I Semester	RENEWABLE ENERGY SOURCES	L	T	P	C
		3	0	0	3

Pre-requisite: Basic Electrical Engineering

Course Objectives:

- To study the solar radiation data, equivalent circuit of PV cell and its I-V & P-V characteristics.
- To understand the concept of Wind Energy Conversion & its applications.
- To study the principles of biomass, hydel and geothermal energy.
- To understand the principles of ocean Thermal Energy Conversion, waves and power associated with it.
- To study the various chemical energy sources such as fuel cell and hydrogen energy along with their operation and equivalent circuit.

Course Outcomes:

After the completion of the course the student should be able to:

CO1: Analyze solar radiation data, extra-terrestrial radiation, radiation on earth's surface and solar Energy Storage.

CO2: Illustrate the components of wind energy systems.

CO3: Illustrate the working of biomass, hydel plants and Geothermal plants.

CO4: Demonstrate the principle of Energy production from OTEC, Tidal and Waves.

CO5: Evaluate the concept and working of Fuel cells & MHD power generation.

UNIT–I

Solar Energy

Introduction - Renewable Sources - prospects, solar radiation at the Earth Surface - Equivalent circuit of a Photovoltaic (PV) Cell - I-V & P-V Characteristics - Solar Energy Collectors: Flat plate Collectors, concentrating collectors - Solar Energy storage systems and Applications: Solar Pond - Solar water heating - Solar Green house.

UNIT–II

Wind Energy

Introduction - basic Principles of Wind Energy Conversion, the nature of Wind - the power in the wind - Wind Energy Conversion - Site selection considerations - basic components of Wind Energy Conversion Systems (WECS) - Classification - Applications.

UNIT–III

Biomass, Hydel and Geothermal Energy

Biomass: Introduction - Biomass conversion technologies- Photosynthesis. Factors affecting Bio digestion.

Hydro plants: Basic working principle – Classification of hydro systems**:** Large, small, micro hydel plants.

Geothermal Energy: Introduction, Geothermal Sources – Applications - operational and Environmental problems.

UNIT–IV

Energy From oceans, Waves & Tides:

Oceans: Introduction - Ocean Thermal Electric Conversion (OTEC) – methods - prospects of OTEC in India.

Waves: Introduction - Energy and Power from the waves - Wave Energy conversion devices.

Tides: Basic principle of Tide Energy -Components of Tidal Energy.

UNIT–V

Chemical Energy Sources:

Fuel Cells: Introduction - Fuel Cell Equivalent Circuit - operation of Fuel cell - types of Fuel Cells - Applications.

Hydrogen Energy: Introduction - Methods of Hydrogen production - Storage and Applications

Magneto Hydro Dynamic (MHD) Power generation: Principle of Operation - Types.

Text Books:

1. G.D.Rai, Non-Conventional Energy Sources, Khanna Publications, 2011.
2. John Twidell& Tony Weir, Renewable Energy Sources, Taylor & Francis, 2013.

Reference Books:

1. S.P.Sukhatme&J.K.Nayak, Solar Energy-Principles of Thermal Collection and Storage, TMH, 2011.
2. John Andrews & Nick Jelly, Energy Science- principles, Technologies and Impacts, Oxford, 2nd edition, 2013.
3. ShobaNath Singh, Non- Conventional Energy Resources, Pearson Publications, 2015.

Online Learning Resources:

1. https://archive.nptel.ac.in/courses/103/103/103103206
2. https://archive.nptel.ac.in/courses/103/107/103107157

III Year I Semester	CONCEPTS OF ENERGY AUDITING & MANAGEMENT	L	T	P	C
		3	0	0	3

Pre-requisite:

Basics of Conservation of Electrical Energy

Course Objectives:

- To understand basic concepts of Energy Audit & various Energy conservation schemes.
- To design energy an energy management program.
- To understand concept of Energy Efficient Motors and lighting control efficiencies.
- To estimate/calculate power factor of systems and propose suitable compensation techniques.
- To calculate life cycle costing analysis and return on investment on energy efficient technologies.

Course Outcomes:

After the completion of the course the student should be able to:

CO1: Understand the principles of energy audit along with various Energy related terminologies.
CO2: Asses the role of Energy Manager and Energy Management program.
CO3: Design a energy efficient motors and good lighting system.
CO4: Analyse the methods to improve the power factor and identify the energy instruments for various real time applications.
CO5: Evaluate the computational techniques with regard to economic aspects.

UNIT–I

Basic Principles of Energy Audit

Energy audit- definitions - concept - types of **Energy** audit - energy index - cost index - pie charts - Sankey diagrams and load profiles - Energy conservation schemes- Energy audit of industries- energy saving potential - energy audit of process industry, thermal power station - building energy audit - Conservation of Energy Building Codes (ECBC-2017)

UNIT–II:

Energy Management

Principles of energy management - organizing energy management program - initiating - planning - controlling - promoting - monitoring - reporting. Energy manager - qualities and functions - language - Questionnaire – check list for top management.

UNIT–III:

Energy Efficient Motors and Lighting

Energy efficient motors - factors affecting efficiency - loss distribution - constructional details - characteristics – variable speed - RMS - voltage variation-voltage unbalance-over motoring-motor energy audit. lighting system design and practice - lighting control - lighting energy audit.

UNIT–IV

Power Factor Improvement and Energy Instruments

Power factor – methods of improvement - location of capacitors - Power factor with non-linear loads - effect of harmonics on power factor - power factor motor controllers – Energy Instruments- watt meter - data loggers - thermocouples - pyrometers - lux meters - tongue testers.

UNIT–V

Economic Aspects and their Computation

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

Text Books:

1. Energy management by W.R.Murphy & G.Mckay Butter worth - Heinemann publications - 1982.
2. Energy management hand book by W.CTurner - John wiley and sons - 1982.

Reference Books:

1. Energy efficient electric motors by John.C.Andreas - Marcel Dekker Inc Ltd-2nd edition - 1995
2. Energy management by Paul o' Callaghan - Mc-graw Hill Book company-1st edition - 1998
3. Energy management and good lighting practice : fuel efficiency- booklet12-EEO

Online Learning Resources:

1. https://nptel.ac.in/courses/108106022
2. https://archive.nptel.ac.in/courses/108/106/108106022

III Year I Semester	POWER ELECTRONICS LAB	L	T	P	C
		0	0	3	1.5

Course objectives:

- To learn the characteristics of various power electronic devices and analyze firing circuits and commutation circuits of SCR.
- To analyze the performance of single–phase and three–phase full–wave bridge converters with both resistive and inductive loads.
- To understand the operation of AC voltage regulator with resistive and inductive loads.
- To understand the working of Buck converter and Boost converter.
- To understand the working of single-phase & three-phase inverters.

Course outcomes:

After the completion of the course the student should be able to:

CO1: Analyse characteristics of various power electronic devices and design firing circuits for SCR.

CO2: Analyse the performance of single–phase dual, three–phase full–wave bridge converters and dual converter with both resistive and inductive loads.

CO3: Examine the operation of Single-phase AC voltage regulator and Cyclo converter with resistive and inductive loads.

CO4: Differentiate the working and control of Buck converter and Boost converter.

CO5: Differentiate the working & control of Square wave inverter and PWM inverter.

Any 10 of the Following Experiments are to be conducted

1. Characteristics of SCR - Power MOSFET & Power IGBT.
2. R, RC & UJT firing circuits for SCR.
3. Single -Phase semi-converter with R & RL loads.
4. Single -Phase full-converter with R & RL loads.
5. Three- Phase full-converter with R & RL loads.
6. Single-phase dual converter in circulating current & non circulating current mode of operation.
7. Single-Phase AC Voltage Regulator with R & RL Loads.
8. Single-phase step down Cycloconverter with R & RL Loads.
9. Boost converter in Continuous Conduction Mode operation.
10. Buck converter in Continuous Conduction Mode operation.

11. Single -Phase square wave bridge inverter with R & RL Loads.
12. Single - Phase PWM inverter.
13. Three-phase bridge inverter with 120^0 and 180^0 conduction mode.
14. SPWM control of Three-phase bridge inverter

III Year I Semester	ANALOG AND DIGITAL CIRCUITS LAB	L	T	P	C
		0	0	3	1.5

Course Objectives:

To impart knowledge on

- Analysis of transistor amplifiers
- Analysis of feedback amplifiers and oscillators
- Realization of digital circuits such data routing, registers and counters.

Course Outcomes:

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

CO1: Analyse diode clipper/clamper circuits and transistor biasing.

CO2: Illustrate the operation of feedback amplifiers and oscillator circuits.

CO3: Analyze the applications of linear IC’s

CO4: Demonstrate the operation of digital circuits such as arithmetic, data routing, registers and counters.

Any 5 of the Following Experiments are to be conducted from each PART A.

1. Analysis of clipper and clamper circuits.
2. Analysis of self-bias to a transistor.
3. Analysis of voltage series and current series feedback amplifiers.
4. Analysis of Wien Bridge oscillator and RC-phase shift oscillator.
5. Analysis of Integrator and Differentiator Circuits using IC 741.
6. Analysis of Monostable and Astable multivibrator operation using IC 555 Timer.
7. Analysis of Schmitt Trigger Circuits using IC 741 and IC 555.
8. Verify the PLL characteristics using IC 565.
9. Analysis of 8 bit A to D and D to A circuits

PART-B

1. Design of Full adder and Full Subtractor using logic gates.
2. Realization of parallel adder/subtractor using IC 7483.
3. Implementation of 3 to 8 line decoder using logic gates and IC 7445.
4. Implementation of 8 to 1 multiplexer using logic gates and IC 74151.
5. Verify the operation of master-slave JK flip-flop using IC7476.
6. Realization of the following shift registers using IC7495.
   a) SISO
   b) SIPO
   c) PISO
   d) PIPO
7. Implementation ofMod-10 ripples counter using flip-flops and IC 7490.
8. Implementation of Mod-8 synchronous up/down counters using flip-flops.
9. Implementation of 4 bit Ring Counter and Johnson Counter using D flip-flops/J-K flip-flops.

		L	T	P	C
III Year I Semester	**SKILL ENHANCEMENT COURSE SOFT SKILLS**	**0**	**1**	**2**	**2**

III Year I Semester	ENGINEERING SCIENCE TINKERING LAB	L	T	P	C
		0	0	2	1

The aim of tinkering lab for engineering students is to provide a hands-on learning environment where students can explore, experiment, and innovate by building and testing prototypes. These labs are designed to demonstrate practical skills that complement theoretical knowledge.

Course Objectives : To

1. **Encourage Innovation and Creativity**
2. **Provide Hands-on Learning**
3. **Impart Skill Development**
4. **Foster Collaboration and Teamwork**
5. **Enable Interdisciplinary Learning**
6. **Impart Problem-Solving mind-set**
7. **Prepare for Industry and Entrepreneurship**

These labs bridge the gap between academia and industry, providing students with the practical experience. Some students may also develop entrepreneurial skills, potentially leading to start-ups or innovation-driven careers. Tinkering labs aim to cultivate the next generation of engineers by giving them the tools, space, and mind-set to experiment, innovate, and solve real-world challenges.

List of experiments:

1) Make your own parallel and series circuits using breadboard for any application of your choice.
2) Demonstrate a traffic light circuit using breadboard.
3) Build and demonstrate automatic Street Light using LDR.
4) Simulate the Arduino LED blinking activity in Tinkercad.
5) Build and demonstrate an Arduino LED blinking activity using Arduino IDE.
6) Interfacing IR Sensor and Servo Motor with Arduino.
7) Blink LED using ESP32.
8) LDR Interfacing with ESP32.
9) Control an LED using Mobile App.
10) Design and 3D print a Walking Robot
11) Design and 3D Print a Rocket.
12) Build a live soil moisture monitoring project, and monitor soil moisture levels of a remote plan in your computer dashboard.
13) Demonstrate all the steps in design thinking to redesign a motor bike.

Students need to refer to the following links:

1) https://aim.gov.in/pdf/equipment-manual-pdf.pdf

2) https://atl.aim.gov.in/ATL-Equipment-Manual/
3) https://aim.gov.in/pdf/Level-1.pdf
4) https://aim.gov.in/pdf/Level-2.pdf
5) https://aim.gov.in/pdf/Level-3.pdf

Course Outcomes: The students will be able to experiment, innovate, and solve real-world challenges.

III Year I Semester	EVALUATION OF COMMUNITY SERVICE INTERNSHIP	L	T	P	C
		-	-	-	2

III Year II Semester	ELECTRICAL MEASUREMENTS AND INSTRUMENTATION	L	T	P	C
		3	0	0	3

Pre-requisite:

Basics of Electrical and Electronics Engineering.

Course Objectives:

- To understand and analyze the factors that effect the various measuring units.
- To choose the appropriate meters for measuring of voltage, current, power, power factor and energy qualities and understand the concept of standardization.
- Describe the operating principle of AC & DC bridges for measurement of resistance, inductance and capacitance.
- To understand the concept of the transducer and their effectiveness in converting from one form to the other form for the ease of calculating and measuring purposes.
- To understand the operating principles of basic building blocks of digital systems, record and display units.

Course Outcomes:

After the completion of the course the student should be able to:

CO1: Know the construction and working of various types of analog instruments.

CO2: Describe the construction and working of wattmeter and power factor meters

CO3: Know the construction and working various bridges for the measurement resistance inductance and capacitance

CO4: Know the operational concepts of various transducers

CO5: Know the construction and operation digital meters

UNIT - I

Analog Ammeter and Voltmeters

Classification – deflecting, control and damping torques – PMMC, moving iron type and electrostatic instruments – Construction – Torque equation – Range extension – Errors and compensations – advantages and disadvantages. Instrument transformers: Current Transformer and Potential Transformer – theory –Ratio and phase angle errors–Numerical Problems.

UNIT - II

Analog Wattmeters and Power Factor Meters

Electrodynamometer type wattmeter (LPF and UPF) – Power factor meters: Dynamometer and M.I type (Single phase and Three phase) – Construction – torque equation – advantages and disadvantages. Potentiometers: Principle and operation of D.C Crompton's potentiometer – Standardization –Applications –AC Potentiometer (Polar and coordinate types) –Standardization – Applications – Numerical Problems.

UNIT - III

Measurements of Electrical parameters

DC Bridges: Method of measuring low, medium and high resistance –Wheat stone's bridge for measuring medium resistance– Kelvin's double bridge for measuring low resistance – Loss of charge method for measurement of high resistance – Megger – measurement of earth resistance – Numerical Problems.

AC Bridges: Measurement of inductance and quality factor – Maxwell's bridge – Hay's bridge – Anderson's bridge. Measurement of capacitance and loss angle – Desauty's bridge – Schering Bridge – Wien's bridge –Numerical Problems.

UNIT - IV

Transducers

Definition – Classification – Resistive, Inductive and Capacitive Transducer – LVDT – Strain Gauge – Thermistors – Thermocouples – Piezo electric and Photo Diode Transducers – Hall effect sensors – Numerical Problems.

UNIT - V

Digital meters

Digital Voltmeters – Successive approximation DVM – Ramp type DVM and Integrating type DVM – Digital frequency meter – Digital multimeter – Digital tachometer – Digital Energy Meter – Q meter. CRO – measurement of phase difference and Frequency using lissajious patterns – Numerical Problems.

Text Books:

1. Electrical Measurements and measuring Instruments by E.W. Golding and F.C.Widdis - 5th Edition - Wheeler Publishing.
2. Modern Electronic Instrumentation and Measurement Techniques by A.D. Helfrick and W.D. Cooper - PHI - 5th Edition - 2002.

Reference Books:

1. Electrical & Electronic Measurement & Instruments by A.K.Sawhney Dhanpat Rai & Co. Publications - 19th revised edition - 2011.
2. Electrical and Electronic Measurements and instrumentation by R.K.Rajput

- S.Chand - 3rd edition.
3. Electrical Measurements by Buckingham and Price - Prentice – Hall
4. Electrical Measurements by Forest K. Harris. John Wiley and Sons

Online Learning Resources:

1. https://archive.nptel.ac.in/courses/108/105/108105153

III Year II Semester	MICROPROCESSORS AND MICROCONTROLLERS	L	T	P	C
		3	0	0	3

Pre-requisite:
Basic knowledge in digital electronics, fundamentals of computers.

Course objectives:

- To understand the organization and architecture of Microprocessor
- To understand addressing modes to access memory
- To understand 8051 micro controller architecture
- To understand the programming principles for 8086 and 8051
- To understand the interfacing of Microprocessor with I/O as well as other devices
- To understand how to develop cyber physical systems

Course Outcomes:
After the completion of the course the student should be able to:

CO1: Know the concepts of the Microprocessor capability in general and explore the evaluation of microprocessors.
CO2: Analyse the instruction sets - addressing modes - minimum and maximum modes operations of 8086 Microprocessors
CO3: Analyse the Microcontroller and interfacing capability
CO4: Describe the architecture and interfacing of 8051 controller
CO5: Know the concepts of PIC micro controller and its programming.

UNIT - I
Introduction to Microprocessor Architecture
Introduction and evolution of Microprocessors – Architecture of 8086 – Memory Organization of 8086 – Register Organization of 8086– Introduction to 80286 - 80386 - 80486 and Pentium (brief description about architectural advancements only).

UNIT - II
Minimum and Maximum Mode Operations
Instruction sets of 8086 - Addressing modes – Assembler directives –Simple Programs- General bus operation of 8086 – Minimum and Maximum mode operations of 8086 – 8086 Control signal interfacing – Read and write cycle timing diagrams.

UNIT - III
Microprocessors I/O interfacing
8255 PPI– Architecture of 8255–Modes of operation– Interfacing I/O devices to 8086 using 8255–Interfacing A to D converters– Interfacing D to A converters– Stepper motor interfacing– Static memory interfacing with 8086 – Architecture and interfacing of DMA

controller (8257).

UNIT - IV

8051 Microcontroller

Overview of 8051 Microcontroller – Architecture– Memory Organization – Register set – Instruction set – Simple Programs - I/O ports and Interrupts – Timers and Counters – Serial Communication – Interfacing of peripherals.

UNIT - V

PIC Architecture

Block diagram of basic PIC 18 micro controller – registers I/O ports – Programming in C for PIC: Data types - I/O programming - logical operations - data conversion.

Text Books:

1. Ray and Burchandi - "Advanced Microprocessors and Interfacing"- Tata McGraw–Hill - 3rd edition - 2006.
2. Kenneth J Ayala - "The 8051 Microcontroller Architecture- Programming and Applications" - Thomson Publishers - 2nd Edition.
3. PIC Microcontroller and Embedded Systems using Assembly and C for PIC 18 - - Muhammad Ali Mazidi - RolindD.Mckinay - Danny causey -Pearson Publisher 21st Impression.

Reference Books:

1. Microprocessors and Interfacing - Douglas V Hall - Mc–Graw Hill - 2nd Edition.
2. R.S. Kaler - "A Text book of Microprocessors and Micro Controllers" - I.K. International Publishing House Pvt. Ltd.
3. Ajay V. Deshmukh - "Microcontrollers – Theory and Applications" - Tata McGraw–Hill Companies –2005.
4. Ajit Pal - "Microcontrollers – Principles and Applications" - PHI Learning Pvt Ltd - 2011.

Online Learning Resources:

1. https://archive.nptel.ac.in/courses/108/105/108105102
2. https://archive.nptel.ac.in/courses/108/103/108103157
3. https://nptel.ac.in/courses/106108100

PRAKASAM ENGINEERING COLLEGE
(AUTONOMOUS)
Approved by AICTE, Affiliated to JNTUK and Accredited by NAAC ‘A’

R23 III Year ELECTRICAL AND ELECTRONICS ENGINEERING

III Year II Semester	POWER SYSTEM ANALYSIS	L	T	P	C
		3	0	0	3

Pre-requisite:

Concepts of electrical circuits and power systems-II

Course Objectives:

- To develop the impedance diagram (p.u) and formation of Y_{bus}
- To learn the different load flow methods.
- To learn the Z_{bus} building algorithm.
- To learn short circuit calculation for symmetrical faults
- To learn the effect of unsymmetrical faults and their effects.
- To learn the stability of power systems and method to improve stability.

Course Outcomes:

After the completion of the course the student should be able to:

CO1: Draw impedance diagram for a power system network and calculate per unit quantities.

CO2: Apply the load flow solution to a power system using different methods.

CO3: Form Z_{bus} for a power system networks and analyse the effect of symmetrical faults.

CO4: Find the sequence components for power system Components and analyse its effects of unsymmetrical faults.

CO5: Analyse the stability concepts of a power system.

UNIT - I

Circuit Topology

Graph theory definitions – Formation of element node incidence and bus incidence matrices – Primitive network representation – Formation of Y_{bus} matrix by singular transformation and direct inspection methods.

Per Unit Representation

Per Unit Quantities–Single line diagram – Impedance diagram of a power system – Numerical Problems.

UNIT - II

Power Flow Studies

Necessity of power flow studies – Derivation of static power flow equations – Power flow solution using Gauss-Seidel Method – Newton Raphson Method (Rectangular and polar coordinates form) – Decoupled and Fast Decoupled methods – Algorithmic approach – Numerical Problems on 3–bus system only.

UNIT - III

Z-Bus Algorithm

Formation of Z_{bus}**:** Algorithm for the Modification of Z_{bus} Matrix (without mutual impedance) – Numerical Problems.

Symmetrical Fault Analysis

Reactance's of Synchronous Machine – Three Phase Short Circuit Currents - Short circuit MVA calculations for Power Systems – Numerical Problems.

UNIT - IV

Symmetrical Components

Definition of symmetrical components – symmetrical components of unbalanced three phase systems – Power in symmetrical components – Sequence impedances and Sequence networks of Synchronous generator , Transformers and Transmission line-Numerical Problems.

Unsymmetrical Fault analysis

Various types of faults: LG– LL– LLG and LLL on unloaded alternator- Numerical problems.

UNIT - V

Power System Stability Analysis

Elementary concepts of Steady state – Dynamic and Transient Stabilities – Swing equation – Steady state stability – Equal area criterion of stability – Applications of Equal area criterion – Factors affecting transient stability – Methods to improve steady state and transient stability – Numerical problems.

Text Books:

1. Power System Analysis by Grainger and Stevenson - Tata McGraw Hill.2003
2. Modern Power system Analysis – by I.J.Nagrath & D .P.Kothari: Tata McGraw–Hill Publishing Company - 3rd edition - 2007.

Reference Books:

1. Power System Analysis – by A.R.Bergen - Prentice Hall - 2nd edition - 2009.
2. Power System Analysis by HadiSaadat – Tata McGraw–Hill 3rd edition - 2010.
3. Power System Analysis by B.R.Gupta - A H Wheeler Publishing Company Limited - 1998.
4. Power System Analysis and Design by J.Duncan Glover - M.S.Sarma - T.J.Overbye – Cengage Learning publications - 5th edition - 2011.

Online Learning Resources:

1. https://archive.nptel.ac.in/courses/117/105/117105140
2. https://archive.nptel.ac.in/courses/108/105/108105104

III Year II Semester	SWITCHGEAR AND PROTECTION	L	T	P	C
		3	0	0	3

Pre-requisite:

Basic concepts of Electrical Machines and Power Systems.

Course Objectives:

- To explain the working principles and applications of circuit breakers in power systems, including MCBs, oil, SF6, and vacuum breakers.
- To provide an understanding of electromagnetic protection mechanisms, particularly relays used in fault detection and system protection (overcurrent, under-voltage, directional, differential).
- To analyze protection techniques for generators and transformers, including fault protection schemes like percentage differential protection and Buchholz relays.
- To explore feeder and busbar protection methods using advanced relay systems such as distance and static relays.
- To study over-voltage protection systems including lightning arresters and neutral grounding methods to safeguard the power system.

Course Outcomes: At the end of the course, student will be able to

CO1: Understand and describe the operation of circuit breakers, including their ratings, principles of arc interruption, and types.

CO2: Analyze relay-based protection systems, identifying and explaining their roles in overcurrent, undervoltage, and fault detection.

CO3: Design protection schemes for generators and transformers, addressing faults like restricted earth faults and inter-turn faults.

CO4: Implement feeder and busbar protection using advanced relays such as distance, impedance, and static relays.

CO5: Evaluate over-voltage protection strategies, including the use of lightning arresters, and understand various neutral grounding techniques.

UNIT – I

Circuit Breakers

Miniature Circuit Breaker(MCB)– Elementary principles of arc interruption– Restriking Voltage and Recovery voltages– Restriking phenomenon - RRRV– Average and Max. RRRV– Current chopping and Resistance switching– Concept of oil circuit breakers– Description and operation of Air Blast– Vacuum and SF_6 circuit breakers– Circuit Breaker ratings and specifications– Concept of Auto reclosing.

UNIT – II

Electromagnetic Protection

Relay connection – Balanced beam type attracted armature relay - induction disc and induction cup relays–Torque equation - Relays classification–Instantaneous– DMT and IDMT types– Applications of relays: Over current and under voltage relays– Directional relays– Differential relays and percentage differential relays– Universal torque equation–Distance relays: Impedance– Reactance– Mho and offset mho relays– Characteristics of distance relays and comparison.

UNIT – III

Generator Protection

Protection of generators against stator faults– Rotor faults and abnormal conditions–restricted earth fault and inter turn fault protection– Numerical examples.

Transformer Protection

Percentage differential protection– Design of CT's ratio– Buchholz relay protection–Numerical examples.

UNIT – IV

Feeder and Bus bar Protection & Static Relays:

Over current Protection schemes – PSM - TMS – Numerical examples – Carrier current and three zone distance relay using impedance relays. Protection of bus bars by using Differential protection. Static relays: Introduction – Classification of Static Relays – Basic Components of Static Relays.

UNIT – V

Protection against over voltage and grounding

Generation of over voltages in power systems– Protection against lightning over voltages–Valve type and zinc oxide lighting arresters. Grounded and ungrounded neutral systems – Effects of ungrounded neutral on system performance – Methods of neutral grounding: Solid–resistance–Reactance–Arcing grounds and grounding Practices.

Text Books:

1. Power System Protection and Switchgear by Badri Ram and D.N Viswakarma - Tata McGraw Hill Publications - 2nd edition - 2011.
2. Power system protection- Static Relays with microprocessor applications by T.S.Madhava Rao - Tata McGraw Hill - 2nd edition.

Reference Books:

1. Fundamentals of Power System Protection by Paithankar and S.R.Bhide. - PHI - 2003.
2. Art & Science of Protective Relaying – by C R Mason - Wiley Eastern Ltd.

Online Learning Resources:

1. https://archive.nptel.ac.in/courses/108/107/108107167
2. https://archive.nptel.ac.in/courses/108/105/108105167

III Year II Semester	ADVANCED CONTROL SYSTEMS	L	T	P	C
		3	0	0	3

Pre-requisite:

Basic concepts of Control Systems.

Course Objectives:

- To understand the concept of controllability, observability, and their tests for continuous-time systems, as well as the principle of duality in state-space analysis.
- To understand the state-space methods to assess controllability, observability, and design state feedback controllers via pole placement.
- To know the stability of nonlinear systems using phase-plane analysis, describing functions, and Lyapunov's stability theorems.
- To Learn optimal control strategies using the calculus of variations, including constrained minimization and the minimum principle.
- To learn Optimal control and state regulator problems.

Course Outcomes: At the end of the course, student will be able to

CO1: Explain controllability, observability, and the principle of duality in state-space systems.

CO2: Apply state-space methods to analyze controllability, observability, and design state feedback controllers.

CO3: Analyze the stability of nonlinear systems using phase-plane analysis and Lyapunov's stability theorems.

CO4: Examine the minimization of functional and control variable inequality constraints.

CO5: Formulate and solve the optimal regulator problems.

UNIT – I

Controllability - Observability and Design of Pole Placement

General concepts of controllability and observability -Tests for controllability and observability for continuous time systems - Principle of duality - Effect of state feedback on controllability and observability - Design of state feedback control through pole placement, full order and reduced order observers.

UNIT – II

Nonlinear Systems

Introduction to nonlinear systems - Types of nonlinearities. Introduction to phase plane analysis, construction of phase trajectories-Analytical and Isocline method, Describing function - Describing functions of on-off nonlinearity, on-off nonlinearity with hysteresis, and relay with dead zone.

UNIT – III

Stability analysis by Lyapunov Method

Stability in the sense of Lyapunov – Lyapunov's stability and Lyapunov's instability theorems – Direct method of Lyapunov for the linear and nonlinear continuous time autonomous systems.

UNIT – IV

Calculus of Variations

Minimization of functionals - functionals of single function – Constrained minimization – Minimum principle – Control variable inequality constraints – Control and state variable inequality constraints.

UNIT –V

Optimal Control

Necessary conditions for optimal control, Formulation of the optimal control problem, minimum time problem, minimum energy problem, minimum fuel problem, state regulator problem, output regulator problem.

Text Books:

1. Modern Control Engineering – by K. Ogata - Prentice Hall of India - 3rd edition - 1998.
2. Automatic Control Systems by B.C. Kuo - Prentice Hall Publication.

Reference Books:

1. Modern Control System Theory – by M. Gopal - New Age International Publishers - 2nd edition – 1996.
2. Optimal control theory: an Introduction by Donald E.Kirk by Dover publications.
3. Control Systems Engineering by I.J. Nagarath and M.Gopal - New Age International (P) Ltd.

Online Learning Resources:

1. https://archive.nptel.ac.in/courses/108/103/108103007
2. https://archive.nptel.ac.in/courses/108/107/108107115

III Year II semester	RENEWABLE AND DISTRIBUTED ENERGY TECHNOLOGIES	L	T	P	C
		3	0	0	3

Pre-requisite: Power system I

Course Objectives:

- To understand the basic concepts on wind energy systems.
- To understand the various relations between speed, power and energy in the wind systems.
- To analyze the solar energy systems, various components of solar thermal systems, applications in the relevant fields and design of PV systems.
- To design the Hydel system components and to get an idea on different other sources like tidal, geothermal and gas based units.
- To understand the concepts of hybrid renewable energy systems.

Course Outcomes:

After the completion of the course the student should be able to:

CO1: Illustrate basic concepts of renewable and distributed sources of wind energy.
CO2: Demonstrate the components of wind energy conversion systems.
CO3: Model PV systems and analyze MPPT Techniques.
CO4: Illustrate the concept of Energy Production from Hydro - Tidal and Geothermal.
CO5: Explain the aspects of hybrid renewable energy systems.

UNIT – I

Introduction and Wind energy systems

Brief idea on renewable and distributed sources - their usefulness and advantages. Wind Energy Systems: Estimates of wind energy potential-wind maps-Aerodynamic and mechanical aspects of wind machine design - Conversion to electrical energy - Aspects of location of wind farms.

UNIT – II

Wind power and energy

Wind speed and energy - Speed and power relations - Power extraction from wind - Tip speed ratio (TSR) - TSR characteristics- Functional structure of wind energy conversion systems - Pitch and speed control - Power vs speedcharacteristics - Fixed speed and variable speed wind turbine control - Power optimization - Electrical generators - Self-Excited and Doubly-Fed Induction Generators operation and control.

UNIT – III

Solar PV Systems

Present and new technological developments in photovoltaic - estimation of solar irradiance - components of solar energy systems - solarthermal system-applications- Modelling of PV cell - current-voltage and power-voltage characteristics - Effects of temperature and irradiance - Solar array simulator - Sun tracking - Peak power operations - PV system - MPPT techniques: Perturb and observe method, hill climbing and incremental conductance methods-Effects of partial shading on the characteristic curves and associated MPPT techniques - Solar park design outline-Solar Pond-Types of PV systems.

UNIT – IV

Small Hydro and other sources

Hydel:Small-Mini-Medium -Plant layouts Water power estimates -use of hydrographs -hydraulic turbine - characteristics and part load performance - design of wheels - draft tubes and penstocks.

Other sources**:** Tidal - geothermal - gas-based generations.

UNIT – V

Hybrid Renewable systems

Requirements of hybrid/combined use of different renewable and distributed sources -Need of energy storage- Control of frequency and voltage of distributed generation in Stand-alone and Grid-connected mode - use of energy storage and power electronics interfaces for the connection to grid and loads - Design and optimization of size of renewable sources andtheir storages.

Text Books :

1. Math J. Bollen - Fainan Hassan 'Integration of Distributed Generation in the Power System' - IEEE Press - 2011.
2. G.D.Rai 'Non-Conventional Energy Sources' KHANNA PUBLISHERS.

Reference Books

1. Studies' Craig Anderson and Rudolf I. Howard 'Wind and Hydropower Integration: Concepts - Considerations and Case - Nova Publisher - 2012.
2. Amanda E. Niemi and Cory M. Fincher 'Hydropower from Small and Low-Head Hydro Technologies' - Nova Publisher - 2011.
3. D. YogiGoswami - Frank Kreith and Jan F. Kreider 'Principles of Solar Engineering' - Taylor & Francis 2000.
4. Math J. Bollen - Fainan Hassan 'Integration of Distributed Generation in the Power System' - IEEE Press - 2011.
5. S. Heier and R. Waddington 'Grid Integration of Wind Energy Conversion Systems' – Wiley - 2006.

6. Loi Lei Lai and Tze Fun Chan 'Distributed Generation: Induction and Permanent Magnet Generators' - Wiley-IEEE Press - 2007.
7. G.N. Tiwari 'Solar Energy Technology' - Nova Science Publishers - 2005.

Online Learning Resources:

1. https://archive.nptel.ac.in/courses/103/103/103103206
2. https://archive.nptel.ac.in/courses/103/107/103107157

III Year II Semester	ELECTRIC DRIVES	L	T	P	C
		3	0	0	3

Pre-requisite: Electrical Circuit Analysis, Power electronics, Electrical Machines and Control Systems.

Course Objectives:

- To learn the fundamentals of electric drive and different electric braking methods.
- To analyze the operation of three phase converter controlled dc motors and four quadrant operation of dc motors using dual converters.
- To discuss the DC-DC converter control of dc motors.
- To understand the concept of speed control of induction motor by using AC voltage controllers, voltage source inverters and slip power recovery scheme.
- To learn the speed control mechanism of synchronous motors.

Course Outcomes:

After the completion of the course the student should be able to:

CO1: Explain the fundamentals of electric drive and different electric braking methods.

CO2: Analyze the operation of three-phase converter fed dc motors and four quadrant operations of dc motors using dual converters.

CO3: Describe the DC-DC converter fed control of dc motors in various quadrants of operation

CO4: Know the concept of speed control of induction motor by using AC voltage controllers and voltage source inverters and differentiate the stator side control and rotor side control

CO5: Learn the concepts of speed control of synchronous motor with different methods.

UNIT - I

Fundamentals of Electric Drives

Electric drive and its components– Fundamental torque equation – Load torque components – Nature and classification of load torques – Steady state stability – Load equalization– Four quadrant operation of drive (hoist control) – Braking methods**:** Dynamic Braking, Plugging and Regenerative Braking –Numerical problems.

UNIT - II

Converter Fed DC Motor Drives

3-phase half and fully-controlled converter fed separately and self-excited DC motor drive – Output voltage and current waveforms – Speed-torque characteristics and expressions – 3-phase Dual converter fed DC motor drives – Numerical problems.

UNIT - III

DC–DC Converter Fed DC Motor Drives

Single quadrant, two quadrant and four quadrant DC-DC converter fed separately excited and self-excited DC motors – Continuous Current Mode of operation - Output voltage and current waveforms – Speed-torque characteristics and expressions – Closed loop operation (qualitative treatment only) – Numerical problems.

UNIT - IV

Control of 3-phase Induction motor Drives

Stator voltage control using 3-phase AC voltage regulators – Waveforms –Speed torque characteristics– Variable Voltage Variable Frequency control of induction motor by PWM voltage source inverter – Closed loop V/f control of induction motor drives (qualitative treatment only). Static rotor resistance control – Slip power recovery schemes – Static Scherbius drive – Static Kramer drive – Performance and speed torque characteristics– Numerical problems.

UNIT - V

Control of Synchronous Motor Drives

Separate control of synchronous motor – self-control of synchronous motor employing load commutated thyristor inverter - closed loop control of synchronous motor drive (qualitative treatment only)– PMSM: Basic operation and advantages – Numerical problems.

Text Books:

1. Fundamentals of Electric Drives – G K Dubey - Narosa Publications - 2nd edition – 2002.
2. Power Semiconductor Drives - S.B.Dewan - G.R.Slemon - A.Straughen - Wiley India - 1984.

Reference Books:

1. Electric Motors and Drives Fundamentals - Types and Apllications - by Austin Hughes and Bill Drury - Newnes.4th edition - 2013.
2. Thyristor Control of Electric drives – Vedam Subramanyam Tata McGraw Hill Publications - 1987.
3. Power Electronic Circuits - Devices and applications by M.H.Rashid - PHI - 3rd edition - 2009.

Online Learning Resources:

1. https://archive.nptel.ac.in/courses/108/104/108104140
2. https://nptel.ac.in/courses/108104011

PRAKASAM ENGINEERING COLLEGE
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R23 III Year ELECTRICAL AND ELECTRONICS ENGINEERING

III Year II Semester	DIGITAL SIGNAL PROCESSING	L	T	P	C
		3	0	0	3

Pre-requisite:

Laplace Transforms, Z- Transforms, Fourier series and transforms.

Course Objectives:

- To explore the basic concepts of digital signal processing.
- To connect the time domain signal to frequency domain signals using Fourier transform.
- To understand the basic structures of IRR systems.
- To understand and design FIR Digital filters.
- To explore the concepts of multiple sampling rates for DSP.

Course Outcomes:

After the completion of the course the student should be able to:

CO1: Know the concepts of Digital signal processing - frequency domain representation &z- transform.

CO2: Compute discrete Fourier transform and fast Fourier transforms for different sequences.

CO3: Design IIR filters through analog filter approximation and basic structure of IIR filters.

CO4: Design FIR filters with window techniques and basic structure of FIR filters.

CO5: Learn the concepts of Multirate Signal Processing.

UNIT - I

Introduction to Digital Signal Processing

Discrete time signals & sequences - Classification of Discrete time systems - stability of LTI systems - Invertability - Response of LTI systems to arbitrary inputs. Solution of Linear constant coefficient difference equations. Frequency domain representation of discrete time signals and systems. Review of Z-transforms - solution of difference equations using Z-transforms - System function.

UNIT - II

Discrete Fourier Transforms and FFT Algorithms

Discrete Fourier Series representation of periodic sequences -Properties of Discrete Fourier Series - Discrete Fourier transforms: Properties of DFT - linear filtering methods based on DFT - Fast Fourier transforms (FFT) - Radix-2 decimation in time and decimation in frequency FFT Algorithms - Inverse FFT.

UNIT - III

Design and Realizations of IIR Digital Filters

Analog filter approximations – Butterworth and Chebyshev filters - Design of IIR Digital filters from analog filters withexamples. Analog and Digital frequency transformations.
Basic structures of IIR systems – Direct-Form Structures - Transposed Structures - Cascade-Form Structures - Parallel-Form Structures Lattice and Lattice-Ladder Structures.

UNIT - IV

Design and Realizations of FIR Digital Filters

Characteristics of FIR Filters with Linear Phase - Frequency Response of Linear Phase FIR Filters - Design of FIR Digital Filters using Window Techniques and Frequency Sampling technique - Comparison of IIR & FIR filters.
Basic structures of FIR systems – Direct-Form Structure - Cascade-Form Structures Linear Phase Realizations - Lattice structures.

UNIT - V

Multirate Digital Signal Processing

Decimation –Interpolation-Sampling Rate Conversion by a Rational Factor–Implementation of sampling rate converters–Applications of Multirate Signal Processing-Digital Filter Banks.

Text Books:

1. Digital Signal Processing – Principles Algorithms and Applications: John G. Proakis - Dimitris G.Manolakis - 4th Edition - Pearson Education / PHI - 2007.
2. Discrete Time Signal Processing – A.V.Oppenheim and R.W. Schaffer - PHI.
3. Digital Signal Processing: A Computer based approach. Sanjit K Mitra - 4th Edition - TMH - 2014.

Reference Books:

1. Digital Signal Processing: Andreas Antoniou - TATA McGraw Hill - 2006.
2. Digital Signal Processing: MH Hayes - Schaum's Outlines - TATA Mc-Graw Hill - 2007.
3. DSP Primer - C. Britton Rorabaugh - Tata McGraw Hill - 2005.
4. Fundamentals of Digital Signal Processing using Matlab – Robert J. Schilling - Sandra L.Harris - Thomson - 2007.
5. Digital Signal Processing – Alan V. Oppenheim - Ronald W. Schafer - PHI Ed. - 2006.
6. Digital Signal Processing – K Raja Rajeswari - 1st edition - I.K. International Publishing - House - 2014.

Online Learning Resources:

1. https://nptel.ac.in/courses/117102060
2. https://archive.nptel.ac.in/courses/108/101/108101174

III Year II Semester	HIGH VOLTAGE ENGINEERING	L	T	P	C
		3	0	0	3

Pre-requisite:
Material Science, Electromagnetic Fields and Basics of Transient Circuits.

Course Objectives:

- To understand HV breakdown phenomena in gases.
- To understand the breakdown phenomenon of liquids and solid dielectrics.
- To acquaint with the generating principle of operation and design of HVDC, AC voltages.
- To understand the generating principles of Impulse voltages & currents.
- To understand various techniques for AC, DC and Impulse measurements of high voltages and currents.

Course Outcomes:

After the completion of the course the student should be able to:

CO 1: Recognise the dielectric properties of gaseous materials used in HV equipment.

CO 2: Differentiate the break down phenomenon in liquid and solid dielectric materials.

CO 3: Acquaint with the techniques of generation of high AC and DC voltages

CO 4: Acquaint with the techniques of generation of high Impulse voltages and currents.

CO 5: Getting the knowledge of measurement of high AC - DC - Impulse voltages and currents.

UNIT - I

Break down phenomenon in Gaseous and Vacuum:

Insulating Materials: Types, properties and its applications. Gases as insulating media – Collision process – Ionization process – Townsend's criteria of breakdown in gases and its limitations – Streamers Theory of break down – time lag – Paschen's law- Paschen's curve, Penning Effect.

Breakdown mechanisms in Vacuum.

UNIT - II

Break down phenomenon in Liquids:

Liquid as Insulator – Pure and commercial liquids – Breakdown in pure and commercial liquids- Mechanisms.

Break down phenomenon in Solids:

Intrinsic breakdown – Electromechanical breakdown – Thermal breakdown – Breakdown of composite solid dielectrics.

UNIT - III

Generation of High DC voltages:
Voltage Doubler Circuit - Voltage Multiplier Circuit – Vande- Graaff Generator.
Generation of High AC voltages:
Cascaded Transformers – Resonant Transformers –Tesla Coil.

UNIT - IV

Generation of Impulse voltages:
Specifications of impulse wave – Analysis of RLC circuits - Marx Circuit.
Generation of Impulse currents:
Definitions – Circuits for producing Impulse current waves – Wave shape control - Tripping and control of impulse generators.

UNIT - V

Measurement of High DC & AC Voltages:
Resistance potential divider - Generating Voltmeter - Capacitor Voltage Transformer (CVT) - Electrostatic Voltmeters – Sphere Gaps.
Measurement of Impulse Voltages & Currents:
Potential dividers with CRO - Hall Generator - Rogowski Coils.

Text Books:

1. High Voltage Engineering: Fundamentals by E.Kuffel - W.S.Zaengl - J.Kuffel by Elsevier - 2nd Edition.
2. High Voltage Engineering by M.S.Naidu and V. Kamaraju – TMH Publications - 3rd Edition.

Reference Books:

1. High Voltage Engineering and Technology by Ryan - IET Publishers - 2nd edition.
2. High Voltage Engineering by C.L.Wadhwa - New Age Internationals (P) Limited – 1997.
3. High Voltage Insulation Engineering by RavindraArora - Wolfgang Mosch - New Age International (P) Limited - 1995.

Online Learning Resources:

1. https://archive.nptel.ac.in/courses/108/104/108104048
2. https://bharatsrajpurohit.weebly.com/high-voltage-engineering-course.html

III Year II Semester	FUNDAMENTALS OF ELECTRIC VEHICLES	L	T	P	C
		3	0	0	3

Pre-requisite:

Basic knowledge in Physics, Chemistry and Basics of Electrical and Electronics.

Course Objectives:

- To familiarize the students with the need and advantages of electric and hybrid electric vehicles.
- To understand various power converters used in electric vehicles.
- To be familiar all the different types of motors suitable for electric vehicles.
- To know various architecture of hybrid electric vehicles.
- To have knowledge on latest developments in batteries and other storage systems.

Course Outcomes:

After the completion of the course the student should be able to:

CO1: Illustrate the use and advantages of different types of electric vehicles.
CO2: Use suitable power converters for EV application.
CO3: Select suitable electric motor for EV power train.
CO4: Design HEV configuration for a specific application.
CO5: Analyse various storage systems and battery management system for EVs.

UNIT – I

Introduction

Fundamentals of vehicles – Vehicle model – Calculation road load and tractive force –Components of conventional vehicles – Drawbacks of conventional vehicles – Need for electric vehicles– Advantages and applications of Electric Vehicles – History of Electric Vehicles – EV Market in India and outside India – Types of Electric Vehicles.

UNIT – II

Components of Electric Vehicles

Main components of Electric Vehicles – Electric Traction MotorandController – Power Converters – Rectifiers used in EVs – Bidirectional DC–DC Converters – Voltage Source Inverters – PWM inverters used in EVs.

UNIT – III

Motors for Electric Vehicles

Characteristics of traction drive – requirements of electric machines for EVs – Comparison of Different motors for Electric and Hybrid Vehicles – Induction Motors – Synchronous Motors – Permanent Magnetic Synchronous Motors – Brushless DC Motors – Switched Reluctance Motors (Construction details and working only).

UNIT – IV
Hybrid Electric Vehicles
Evolution of Hybrid Electric Vehicles – Advantages and Applications of Hybrid Electric Vehicles – Architecture of HEVs – Series and Parallel HEVs – Complex HEVs – Range extended HEVs – Examples – Merits and Demerits.

UNIT – V
Energy Sources for Electric Vehicles
Batteries– Types of Batteries – Lithium-ion – Nickel-metal hydride – Lead-acid – Comparison of Batteries – Battery Charging – Fast Charging –Battery Management System – Ultra capacitors – Flywheels – Compressed air energy storage (CAES)– Fuel Cell – it's working.

Text Books

1. Iqbal Hussein - Electric and Hybrid Vehicles: Design Fundamentals - CRC Press - 2021.
2. Tom Denton, Hayley Pells - Electric and hybrid vehicles, Third Edition, 2024

Reference Books:

1. Kumar - L. Ashok - and S. Albert Alexander. Power Converters for Electric Vehicles. CRC Press - 2020.
2. Chau - Kwok Tong. Electric vehicle machines and drives: design - analysis and application. John Wiley & Sons - 2015.
3. Berg - Helena. Batteries for electric vehicles: materials and electrochemistry. Cambridge university press - 2015.

Online Learning Resources:

1. MOOC at https://www.edx.org/learn/electric-cars
2. https://archive.nptel.ac.in/courses/108/106/108106170

III Year II Semester	ELECTRICAL WIRING ESTIMATION AND COSTING	L	T	P	C
		3	0	0	3

Pre-requisite:

Electrical Circuits, Basics of Power Systems and Electrical Machines.

Course Objectives:

- Introduce the electrical symbols and simple electrical circuits
- Able to learn the design of electrical installations.
- Able to learn the design of electrical installation for different types of buildings and small industries.
- Learn the basic components of electrical substations.
- Familiarize with the motor control circuits

Course Outcomes:

After the completion of the course the student should be able to:

CO1: Demonstrate the various electrical apparatus and their interconnections.

CO2: Examine various components of electrical installations.

CO3: Estimate the cost for installation of wiring for different types of building and small industries.

CO4: Illustrate the components of electrical substations.

CO5: Design suitable control circuit for starting of three phase induction motor and synchronous motor.

UNIT - I

Electrical Symbols and Simple Electrical Circuits

Identification of electrical symbols - Electrical wiring Diagrams - Methods of representation of wiring diagrams - introduction to simple light and fan circuits - system of connection of appliances and accessories.

UNIT - II

Design Considerations of Electrical Installations

Electric supply system - Three-phase four wire distribution system - protection of electric installation against overload - short circuit and earth fault - earthing - neutral and earth wire - types of loads - systems of wiring - permissible of voltage drops and sizes of wires - estimating and costing of electrical installations.

UNIT - III

Electrical Installation for Different Types of Buildings and Small Industries

Electrical installations for electrical buildings - estimating and costing of material - simple examples on electrical installation for residential buildings - electrical installations for commercial buildings - electrical installation for small industries-case study.

UNIT - IV

Substations

Introduction - types of substations - outdoor substations-pole mounted type - indoor substations-floor mounted type - simple examples on quantity estimation-case study.

UNIT - V

Motor control circuits

Introduction to AC motors - starting of three phase squirrel cage induction motors - starting of wound rotor motors - starting of synchronous motors - contractor control circuit components - basic control circuits - motor protection – Schematic and wiring diagrams for motor control circuits.

Text Books:

1. Electrical Design and Estimation Costing - K. B. Raina and S.K.Bhattacharya – New Age International Publishers - 2007.

References Books:

1. Electrical wiring estimating and costing – S.L.Uppal and G.C.Garg – Khanna publishers - 6th edition - 1987.
2. A course in electrical installation estimating and costing – J.B.Gupta – Kataria SK & Sons - 2013.

Online Learning Resources:

1. https://onlinecourses.swayam2.ac.in/nou25_ec07/preview

III Year II Semester	ELECTRICAL MEASUREMENTS AND INSTRUMENTATION LAB	L	T	P	C
		0	0	3	1.5

Course Objectives:

- To understand students how different types of meters work and their construction.
- To make the students understand how to measure resistance, inductance and capacitance by AC & DC bridges.
- To understand the testing of CT and PT.
- To Understand and the characteristics of Thermo couples, LVDT, Capacitive transducer, piezoelectric transducer and measurement of strain and choke coil parameters.
- To study the procedure for standardization and calibration of various methods.

Course Outcomes:

After the completion of the course the student should be able to:

CO1: Know about the phantom loading and calibration process.

CO2: Measure the electrical parameters voltage - current - power- energy and electrical characteristics of resistance - inductance and capacitance.

CO3: Gain the skill knowledge of various brides and their applications.

CO4: Learn the usage of CT's - PT's for measurement purpose.

CO5: Know the characteristics of transducers and measure the strains - frequency and phase difference.

Any 10 of the following experiments are to be conducted

1. Calibration of dynamometer wattmeter using phantom loading
2. Measurement of resistance using Kelvin's double Bridge and Determination of its tolerance.
3. Measurement of Capacitance using Schering Bridge.
4. Measurement of Inductance using Anderson Bridge.
5. Calibration of LPF Wattmeter by direct loading.
6. Measurement of 3 phase reactive power using single wattmeter method for a balanced load.
7. Testing of C.T. using mutual inductor – Measurement of % ratio error and phase angle of given C.T. by Null deflection method.
8. P.T. testing by comparison – V.G as Null detector – Measurement of % ratio error and phase angle of the given P.T.
9. Determination of the characteristics of a Thermocouple.
10. Determination of the characteristics of a LVDT.
11. Determination of the characteristics for a capacitive transducer.
12. Measurement of strain for a bridge strain gauge.
13. Measurement of Choke coil parameters and single-phase power using three

voltmeter and three ammeter methods.

14. Calibration of single-phase Induction Type Energy Meter.
15. Calibration of DC ammeter and voltmeter using Crompton DC Potentiometer.
16. AC Potentiometer: Polar Form / Cartesian Form - Calibration of AC voltmeter - Parameters of choke.

III Year II Semester	MICROPROCESSORS AND MICROCONTROLLERS LAB	L	T	P	C
		0	0	3	1.5

Pre-requisite:
Concepts of Microprocessors and Microcontrollers

Course Objectives:

- To study programming based on 8086 microprocessor and 8051 microcontroller.
- To study 8086 microprocessor based ALP using arithmetic, logical and shift operations.
- To study to interface 8086 with I/O and other devices.
- To study parallel and serial communication using 8051& PIC 18 micro controllers.

Course Outcomes:
After the completion of the course the student should be able to:

CO1: Write assembly language program using 8086 microprocessor based on arithmetic - logical number systems and shift operations.
CO2: Write assembly language programs for numeric operations and array handling problems.
CO3: Write a assembly program on string operations.
CO4: Interface 8086 with I/O and other devices.
CO5: Do parallel and serial communication using 8051 & PIC 18 micro controllers.
CO6: Program microprocessors and microcontrollers for real world applications.

List of experiments

Any 10 of the following experiments are to be conducted:

8086 Microprocessor Programs

1. Arithmetic operations – Two 16-bit numbers and multibyte numbers :addition - subtraction - multiplication and division – Signed and unsigned arithmetic operations - ASCII – Arithmetic operations.
2. Logic operations – Shift and rotate – Converting packed BCD to unpacked BCD - BCD to ASCII conversion – BCD numbers addition.
3. Arrange the given array in ascending and descending order
4. Determine the factorial of a given number
5. By using string operation and Instruction prefix**:** Move block - Reverse string Sorting - Inserting - Deleting - Length of the string - String comparison.
6. Find the first and n^{th} number of 'n' natural numbers of a Fibonacci series.
7. Find the number and sum of even and odd numbers of a given array
8. Find the sum of 'n' natural numbers and squares of 'n' natural numbers
9. Arithmetic operations on 8051

10. Conversion of decimal number to hexa equivalent and hexa equivalent to decimal number
11. Find the Sum of elements in an array and also identify the largest & smallest number of a given array using 8051

Programs on Interfacing

12. Interfacing 8255–PPI with 8086.
13. Stepper motor control using 8253/8255.
14. Reading and Writing on a parallel port using 8051
15. Timer in different modes using 8051
16. Serial communication implementation using 8051
17. Understanding three memory areas of 00 – FF Using 8051 external interrupts.
18. Traffic Light Controller using 8051.

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III Year II Semester	IOT APPLICATIONS OF ELECTRICAL ENGINEERING LAB	L	T	P	C
		0	1	2	2

Pre-requisite: Concepts of Computer Organization, Computer Networks.

Course Objectives:

- To understand the working of Arduino.
- To learn the programming of Raspberry PI.
- To know various sensors with Arduino/Raspberry Pi.
- To interface various displays with Arduino/Raspberry Pi.
- To connect with various wireless communication devices

Course Outcomes:

At the end of the course - students will be able to:
CO1:Operate the Arduino Integrated Development Environment with embedded c.
CO2: Program the embedded Python in Raspberry Pi OS.
CO3: Interface various sensors with Arduino/Raspberry Pi in the IoT environment.
CO4:Connect different displays with Arduino/Raspberry Pi
C05:Interconnect with wireless communication technologies.

<u>Topics to be covered in Tutorials</u>

Module–1: Programming Arduino: (3 hrs)

Arduino - Classification of Arduino Boards - Pin diagrams – Arduino Integrated Development Environment (IDE) – Programming Arduino.

Module–2: Sensors: (5 hrs)

Working of temperature sensor, proximity sensor, IR sensor, Light sensor, ultrasonic sensor, PIR Sensor, Colour sensor, Soil Sensor, Heart Beat Sensor, Fire Alarms etc. Actuators: Stepper Motor, Servo Motor and their integration with Arduino/Raspberry Pi.

Module–3: Raspberry Pi: (2 hrs)

Introduction, Classification of Rasperberry Pi Series - Pin diagrams – Programming Rasperberry Pi.

Module–4: Display: (2 hrs)

Working of LEDs, LED, OLED display, LCDs, Seven Segment Display, Touch Screen etc. Analog Input and Digital Output Converter etc. and their integration with Arduino/Raspberry Pi.

Module–5: Wireless Communication Devices: (4 hrs)

Working of Bluetooth, Wi-Fi, Radio Frequency Identification (RFID), GPRS/GSM Technology, ZigBee, etc and their integration with Arduino/Raspberry Pi. Features of Alexa.

List of experiments

Any 10 of the following experiments are to be conducted:

1. Familiarization with Arduino/Raspberry Pi and perform necessary software installation.
2. Interfacing of LED/Buzzer with Arduino/Raspberry Pi and write a program to turn ON LED for 1 sec after every 2 seconds.
3. Interfacing of Push button/Digital sensor (IR/LDR) with Arduino/Raspberry Pi and write a program to turn ON LED when push button is pressed or at sensor detection.
4. Interfacing of temperature sensor with Arduino/Raspberry Pi and write a program to print temperature and humidity readings.
5. Interfacing of Organic Light Emitting Diode (OLED) with Arduino/Raspberry Pi
6. Interfacing of Bluetooth with Arduino/Raspberry Pi and write a program to send sensor data to smartphone using Bluetooth.
7. Interfacing of Bluetooth with Arduino/Raspberry Pi and write a program to turn LED ON/OFF when ‘1’/’0’ is received from smartphone using Bluetooth.
8. Write a program on Arduino/Raspberry Pi to upload and retrieve temperature and humidity data to thingspeak cloud.
9. Interfacing of 7 Segment Display with Arduino/Raspberry Pi
10. Interfacing of Joystick with Arduino/Raspberry Pi
11. Interfacing of Analog Input & Digital Output with Arduino/Raspberry Pi
12. Night Light Controlled & Monitoring System
13. Interfacing of Fire Alarm Using Arduino/Raspberry Pi
14. IR Remote Control for Home Appliances
15. A Heart Rate Monitoring System
16. Alexa based Home Automation System

III Year – II SEMESTER	AUDIT COURSE RESEARCH METHODOLOGY	L	T	P	C
		2	0	0	-

Minor Engineering Courses offered by EEE Department for Other Branches (Except EEE Branch)

I	CONCEPTS OF CONTROL SYSTEMS	L	T	P	C
		3	0	0	3

Pre-requisite:

Basic Engineering Mathematics

Course Objectives:

- To learn the mathematical modeling of physical systems and to use block diagram algebra and signal flow graph to determine overall transfer function
- To analyze the time response of first and second order systems and improvement of performance using PI, PD, PID controllers.
- To investigate the stability of closed loop systems using Routh's stability criterion and root locus method.
- To learn Frequency Response approaches for the analysis of LTI systems using Bode plots, polar plots and Nyquist stability criterion.
- To learn state space approach for analysis of LTI systems and understand the concepts of controllability and observability.

Course Outcomes:

After the completion of the course the student should be able to:

CO1: Derive the transfer function of physical systems and determination of overall transfer function using block diagram algebra and signal flow graphs.

CO2: Determine time response specifications of second order systems and to determine error constants.

CO3: Analyze absolute and relative stability of LTI systems using Routh's stability criterion and the root locus method.

CO4: Analyze the stability of LTI systems using frequency response methods.

CO5: Represent physical systems as state models and determine the response. Understanding the concepts of controllability and observability.

UNIT – I

Mathematical Modelling of Control Systems

Classification of control systems - open loop and closed loop control systems and their differences - transfer function of linear system - differential equations of electrical networks - translational and rotational mechanical systems – block diagram algebra – Feedback characteristics.

UNIT-II

Time Response Analysis

Standard test signals – time response of first and second order systems – time domain specifications - steady state errors and error constants – P, PI , PD &PID Controllers.

UNIT–III

Stability and Root Locus Technique

The concept of stability – Routh-Hurwitz Criteria – limitations of Routh-Hurwitz criterion-Root locus concept – construction of root loci (simple problems).

UNIT–IV

Frequency Response Analysis

Introduction to frequency domain specifications – Bode diagrams – Transfer function from the Bode diagram – phase margin and gain margin.

UNIT–V

State Space Analysis of Linear Time Invariant (LTI) Systems

Concepts of state - state variables and state model - state space representation of transfer function - State Transition Matrix and it's properties.

Text Books:

1. Modern Control Engineering by Kotsuhiko Ogata - Prentice Hall of India.
2. Automatic control systems by Benjamin C.Kuo - Prentice Hall of India - 2nd Edition.

Reference Books:

1. Control Systems principles and design by M.Gopal - Tata Mc Graw Hill education Pvt Ltd. - 4th Edition.
2. Control Systems by Manik Dhanesh N - Cengage publications.
3. Control Systems Engineering by I.J.Nagarath and M.Gopal - Newage International Publications - 5th Edition.
4. Control Systems Engineering by S.Palani - Tata Mc Graw Hill Publications.

Online Learning Resources:

1. https://archive.nptel.ac.in/courses/107/106/107106081
2. https://archive.nptel.ac.in/courses/108/106/108106098
3. https://nptelvideos.com/video.php?id=1423&c=14

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II	MINOR ENGINEERING COURSES	L	T	P	C
		3	0	0	3
FUNDAMENTALS OF ELECTRICAL MEASUREMENTS AND INSTRUMENTATION					

Pre-requisite:

Basics of Electrical and Electronics Engineering.

Course Objectives:

- Interpret the working principles of various analog measuring instruments.
- Understand the concepts behind power and energy measurement procedures.
- Calculate resistance, inductance, and capacitance using various bridges.
- Evaluate the importance of and understand the concepts of various transducers.
- Comprehend the types of digital meters and their functionalities.

Course Outcomes:

After completing the course, the student will be able to:

CO1: Choose the appropriate instrument for the measurement of AC and DC voltage and current.

CO2: Analyse the operation of wattmeters and energy meters.

CO3: Differentiate between the operations of AC and DC bridges.

CO4: Describe the working principles of various transducers.

CO5: Recognize the importance of digital meters and explain their working principles.

UNIT – I: Fundamentals of Analog Measurement

Analog Ammeter and Voltmeter: Classification of instruments – Deflecting, controlling, and damping torques.Types of Instruments: PMMC and Moving Iron type – Construction, working principle, advantages, and disadvantages.Applications and simple numerical problems.

UNIT – II: Measurement of Power and Energy

Analog Wattmeter: Electrodynamometer type wattmeters – Low Power Factor (LPF) and Unity Power Factor (UPF) designs, advantages, and disadvantages. Energy Meters: Induction type Energy Meter – Construction and working principle Simple numerical problems.

UNIT – III: Measurement of Electrical Parameters

DC Bridges:Measurement of resistance – Low (Kelvin's double bridge), medium (Wheatstone bridge), and high resistance (Loss of charge method).

AC Bridges:Measurement of inductance (Maxwell's Bridge) and capacitance (Schering Bridge), Numerical problems.

UNIT – IV: Transducers and Sensors

Classification of Transducers: Basics and applications.Resistive: Strain Gauge. Inductive: Linear Variable Differential Transformer (LVDT). Capacitive: Piezoelectric – Applications

UNIT – V: Introduction to Digital Measurement

Digital Instruments:Digital Voltmeters (Successive approximation type),Digital Frequency Meters and Multimeters, Digital Tachometers and Energy Meters, – Overview and applications.

Text Books:

1. Electrical & Electronic Measurement & Instruments by A.K.Sawhney, DhanpatRai & Co. Publications – 19th revised edition - 2011.
2. Electronic Instrumentation by H.S.Kalsi - THM.

Reference Books:

1. Electrical Measurements and measuring Instruments by E.W. Golding and F.C.Widdis - 5 th Edition - Wheeler Publishing.
2. Modern Electronic Instrumentation and Measurement Techniques by A.D. Helfrick and W.D. Cooper - PHI - 5th Edition - 2002.
3. Electrical and Electronic Measurements and instrumentation by R.K.Rajput - S.Chand - 3rdedition.

Online Learning Resources:

1. https://archive.nptel.ac.in/courses/108/105/108105153

III	MINOR ENGINEERING COURSES	L	T	P	C
		3	0	0	3
CONCEPTS OF POWER SYSTEM ENGINEERING					

Pre-requisite: Basic Electrical Engineering

Course Objectives:

- To understand the types of electric power plants and their working principles.
- To understand the concepts of electric power transmission and distribution.
- To gain the knowledge of protection and grounding of power system components.
- To learn the economic aspects of electrical energy.
- To learn the importance of power factor improvement and voltage control.

Course Outcomes:

After the completion of the course the student should be able to:

CO1: Know the concepts of power generation by various types of power plants.
CO2: Learn about short transmission line parameters and distribution systems schemes.
CO3: Learn about protection equipment and grounding methods of power system.
CO4: Calculate the tariff by applying the economic aspects of electrical energy.
CO5: Know the importance of power factor improvement and voltage control in power systems.

UNIT - I

Electrical power Generation Concepts & Types

Sources for Generation of Electrical Energy – working principle and Schematic diagram approaches of Thermal Power Plant – Hydro Power Plant - Nuclear Power Plant – Gas Power Plants – Comparison between Power Plants. Importance of Renewable energy sources.

UNIT - II

Transmission and Distribution Concepts

Types of Conductors Materials – Parameters of Transmission Line – Classification of Overhead Transmission Lines – Performance of Short Transmission Lines – Simple Problems.

Basic concepts of Sub Station – Distribution Systems – Connection Schemes of Distribution Systems – Structure of Cables – Differences between Overhead & Underground systems.

UNIT - III

Protection and Grounding

List of Faults – Basic concepts of fuse – Circuit Breakers – Relays – SF_6 Circuit Breakers – Vacuum Circuit Breakers – Operation of Lightning Arrester – Grounding and its advantages - Methods of Neutral Grounding: Resistance - Reactance and Resonant Grounding – Numerical Problems.

UNIT - IV

Economic Aspects

Definitions of Load – Load curves& Load Duration Curves - Load Factor - Demand Factor – Utilization Factor – Types of Tariff - Cost of Electrical Energy – Expression for Cost of Electrical Energy – Numerical Problems.

UNIT - V

Power Factor Improvement and Voltage Control

Power Factor – Effects and Causes of low Power Factor- Shunt & Series Capacitor Compensation - Numerical Problems – Need of Voltage Control – Types of Voltage regulating Devices.

Text Books:

1. Principles of Power System,V K Mehta and Rohit Mehta, S.Chand Publishers, 2022.

Reference Books:

1. Electrical Power Systems, C.L.Wadhwa, NewAge International Publishers, 2012.

Online Learning Resources:

1. https://nptel.ac.in/courses/108102047

<table>
<tr><td rowspan="2">IV</td><td rowspan="2">MINOR ENGINEERING COURSES</td><td>L</td><td>T</td><td>P</td><td>C</td></tr>
<tr><td>3</td><td>0</td><td>0</td><td>3</td></tr>
<tr><td colspan="6">FUNDAMENTALS OF POWER ELECTRONICS</td></tr>
</table>

Pre-requisite:

Basic concepts of Electrical and Electronic Circuits and Semiconductor Physics.

Course Objectives:

- To know the characteristics of various power semiconductor devices.
- To learn the operation of single phase full–wave converters.
- To learn the operation of three phase full–wave converters and AC/AC converters.
- To learn the operation of different types of DC-DC converters.
- To learn the operation of PWM inverters for voltage control.

Course Outcomes:

After the completion of the course the student should be able to:

CO1: Illustrate the static and dynamic characteristics SCR - Power MOSFET and Power IGBT.

CO2: Analyse the operation of phase controlled rectifiers.

CO3: Analyse the operation of Three-phase full–wave converters - AC Voltage Controllers.

CO4: Examine the operation and design of different types of DC-DC converters.

CO5: Analyse the operation of PWM inverters for voltage control.

UNIT – I

Power Semi-Conductor Devices

Power Diode – Characteristics –Silicon controlled rectifier (SCR) – Two transistor analogy - Static and Dynamic characteristics– Turn-on Methods.

Static and Dynamic Characteristics of Power MOSFET and Power IGBT.

UNIT – II

Single-phase AC-DC Converters

Single-phase half wave-controlled rectifiers - R load and RL load with and without freewheeling diode - Single-phase fully controlled bridge converter with R load and RL load - Continuous conduction - Expression for output voltages – Single-phase Semi-Converter with R load and RL load– Continuous conduction.

UNIT – III

Three-phase AC-DC Converters & AC – AC Converters

Three-phase fully controlled rectifier with R and RL load - Three-phase semi converter with R and RL load - Expression for Output Voltage.

AC power control by phase control with R and RL loads - Expression for rms output voltage.

UNIT – IV

DC–DC Converters

Basic Chopper Operation with R and RL load–Step-up chopper –Classification of Choppers –Time Ratio Control –Current Limit Control.

UNIT - V

DC–AC Converters

Introduction - Single-phase half bridge and full bridge inverters with R and RL loads – Voltage control of Single-phase inverters –PWM inverters - Sinusoidal Pulse Width Modulation.

Text Books:

1. Power Electronics – by P.S.Bhimbra - Khanna Publishers.
2. Power Electronics: Essentials & Applications by L.Umanand - Wiley - Pvt. Limited - India - 2009.

Reference Books:

1. Power Electronics: Converters - Applications and Design by Ned Mohan - Tore M Undeland - William P Robbins - John Wiley & Sons.
2. Power Electronics: Circuits - Devices and Applications – by M. H. Rashid - Prentice Hall of India - 2nd edition - 1998
3. Power Electronics: by Daniel W.Hart - Mc Graw Hill.

Online Learning Resources:

1. https://ocw.mit.edu/courses/6-334-power-electronics-spring-2007
2. https://archive.nptel.ac.in/courses/108/101/108101126

V	MINOR ENGINEERING COURSES	L	T	P	C
		3	0	0	3
FUNDAMENTALS OF UTILIZATION OF ELECTRICAL ENERGY					

Pre Requisites:
Electrical Machines, Power Electronics and Drives and Power Systems –II.

Course Objectives:
To make the students learn about:

- Able to maintain electric drives used in an industries.
- Able to identify a heating/ welding scheme for a given application.
- Able to maintain/ Trouble shoot various lamps and fittings in use.
- Able to figure-out the different schemes of traction schemes and its main components.
- Able to design a suitable scheme of speed control for the traction systems.

Course Outcomes:
After learning the course, the students should be able to

CO1: Get knowledge of electric drives used in an industries
CO2: Get knowledge of principle of electric heating, welding and its applications and design simple resistance furnaces.
CO3: Design residential illumination schemes.
CO4: Get knowledge of electric braking methods, control of traction motors
CO5: Calculate tractive effort, power, acceleration and velocity of traction.

UNIT – I
Electric Drives
Type of electric drives, choice of motor, starting and running characteristics, speed control, temperature rise – cooling and heating time constant, applications of electric drives, types of industrial loads, continuous, intermittent and variable loads, load equalization.

UNIT – II
Electric Heating and Welding
Advantages and methods of electric heating, resistance heating, induction heating and dielectric heating. Electric welding, resistance and arc welding, electric welding equipment, comparison between A.C. and D.C. Welding.

UNIT – III
Fundamentals of Illumination
Introduction, terms used in illumination, laws of illumination, polar curves, photometry, integrating sphere,sources of light. Discharge lamps, MV and SV lamps – comparison

between tungsten filament lamps and fluorescent tubes, Basic principles of light control, Types and design of lighting and flood lighting.

UNIT – IV

Electric Traction – I

System of electric traction and track electrification, Review of existing electric traction systems in India, Special features of traction motor, methods of electric braking-plugging, rheostatic braking and regenerative braking.

UNIT – V

Electric Traction –II

Mechanics of train movement. Speed-time curves for different services – trapezoidal and quadrilateral speed time curves. Calculations of tractive effort, power, specific energy consumption for given run, effect of varying acceleration and braking retardation, adhesive weight, braking retardation, and coefficient of adhesion.

Text Books:

1. Utilization of Electric Energy, E. Openshaw Taylor and V. V. L. Rao, Universities Press, 2009.
2. Art & Science of Utilization of electrical Energy, Partab, Dhanpat Rai & Co., 2004.
3. Utilization of Electrical Power including Electric drives and Electric traction – byJ.B.Gupta, S.K. Kataria & Sons.

Reference Books:

1. Generation, distribution and utilization of electrical energy, C.L Wadhwa, Wiley Eastern Limited,1993.
2. Electrical Power, S. L. Uppal, Khanna pulishers,1988.

Online Learning Resources:

1. https://archive.nptel.ac.in/courses/108/104/108104140
2. https://nptel.ac.in/courses/108105060

<table>
<tr><td rowspan="2">VI</td><td rowspan="2">MINOR ENGINEERING COURSES</td><td>L</td><td>T</td><td>P</td><td>C</td></tr>
<tr><td>3</td><td>0</td><td>0</td><td>3</td></tr>
<tr><td colspan="6">BASICS OF ELECTRIC DRIVES AND APPLICATIONS</td></tr>
</table>

Pre-requisite:

Electrical Machines, Control Systems and Fundamentals of Power Electronics.

Course Objectives:

To make the students learn about:

- To learn the fundamentals of electric drive and different electric braking methods.
- To analyze the operation of single phase converter controlled dc motors and four quadrant operation of dc motors using dual converters.
- To discuss the DC-DC converter control of dc motors in various quadrants.
- To understand the concept of speed control of induction motor by using AC voltage controllers and voltage source inverters.
- To understand the speed control mechanism of synchronous motors

Course Outcomes: After the completion of the course the student should be able to:

CO1: Explain the fundamentals of electric drive and different electric braking methods.

CO2: Analyze the operation of single-phase converter fed dc motors and four quadrant operations of
dc motors using dual converters.

CO3: Describe the converter control of DC motors in various quadrants of operation

CO4: Know the concept of speed control of induction motor by using AC voltage controllers.

CO5: Explains the speed control mechanism of synchronous motors.

UNIT - 1

Fundamentals of Electric Drives

Electric drive and its components– Fundamental torque equation – Load torque components – Classification of load torques –Load equalization– Four quadrant operation of drive (hoist control).

UNIT - 2

Controlled Converter Fed DC Motor Drives

1- phase half and fully-controlled converter fed separately and self-excited DC motor drive – Output voltage and current waveforms and their expressions – Speed-torque characteristics.

UNIT - 3

DC–DC Converters Fed DC Motor Drives

Single quadrant – Two quadrant and four quadrant DC-DC converter fed separately excited and self-excited DC motors – Continuous current operation -Output voltage and current waveforms – Speed–torque characteristics.

UNIT - 4

Control of 3-phase Induction motor Drives

Stator voltage control using 3-phase AC voltage regulators – Waveforms –Speed torque characteristics– Variable Voltage Variable Frequency control. Static rotor resistance control– Static Scherbius drive – Static Kramer drive – Performance and speed torque characteristics.

UNIT - 5

Control of Synchronous Motor Drives

Separate control of synchronous motor – self-control of synchronous motor employing load commutated thyristor inverter - closed loop control of synchronous motor drive (qualitative treatment only).

Text Books:

1. Fundamentals of Electric Drives, G. K. Dubey, Narosa Publications, 2002.
2. Power Semiconductor Drives, S.B.Dewan,G.R.Slemon, A.Straughen, WileyIndia, 2009.

Reference Books:

1. Electric Motors and Drives Fundamentals- Types and Apllications - by Austin Hughes and Bill Drury - Newnes.4th edition - 2013.
2. Thyristor Control of Electric drives – Vedam Subramanyam Tata McGraw Hill Publications- 1987.
3. Power Electronic Circuits- Devices and applications by M.H.Rashid - PHI - 3rd edition -2009.
4. Power Electronics handbook by Muhammad H.Rashid- Elsevier - 2nd edition - 2010.

Online Learning Resources:

1. https://archive.nptel.ac.in/courses/108/104/108104140
2. https://nptel.ac.in/courses/108104011

*Honors Engineering Courses offered EEE Branch students Power Systems

I	HONORS ENGINEERING COURSES (POWER SYSTEMS)	L	T	P	C
		3	0	0	3
ELECTRIC POWER QUALITY					

Pre-requisite: Power systems, Power Electronics.

Course Objectives:

- To learn effects responsible to power quality phenomena.
- To learn about the transient over voltages and over voltage protection.
- To identify sources for long duration over voltages and understand the working of voltage regulating equipment.
- Learn the effects of harmonic distortion on different electrical equipment.
- To explain the relationship between distributed generation and power quality and importance of monitoring.

Course Outcomes:

After the completion of the course the student should be able to:

CO 1: Differentiate between different types of power quality problems.

CO 2: Explain the sources transient over voltages and over voltage protection.

CO 3: Explain the principles long duration over voltages and voltage regulation improvement methods.

CO 4: Analyse voltage distortion and current distortion and their indices.

CO 5: Know the concepts of inter facing the distributed generation technologies and power quality monitoring.

UNIT - I

Introduction

Overview of power quality – Concern about the power quality – General classes of power quality and voltage quality problems – Transients – Long–duration voltage variations – Short–duration voltage variations – Voltage unbalance – Waveform distortion – Voltage fluctuation – Power frequency variations – Voltage Sag – Voltage Swell.

UNIT - II

Transient over Voltages and over voltage protection

Sources of Transient over voltages - Principles of over voltage protection- Devices for over voltage protection – Utility Capacitor Switching Transients - Utility System Lightning Protection – Managing Ferro resonance – Switching Transient Problems with Loads.

UNIT - III

Long – Duration Voltage Variations and voltage regulation

Principles of regulating the voltage – Devices for voltage regulation – Utility voltage regulator application – Capacitor for voltage regulation – End user capacitor application – Regulating utility voltage with distributed resources – voltage flicker.

UNIT - IV

Harmonic distortion and solutions

Voltage distortion verses current distortion –Harmonic indices: THD - TDD and True Power Factor– Sources of harmonics – Effect of harmonic distortion – Impact on capacitors, transformers, motors and meters – Concept of Point of common coupling – Passive and active filtering – Numerical problems.

UNIT - V

Distributed Generation and Monitoring

Resurgence of distributed generation – DG technologies – Interface to the utility system – Power quality issues and operating conflicts – DG on low voltage distribution networks.

Monitoring

Power quality monitoring and considerations – Historical perspective of PQ measuring instruments – PQ measurement equipment – Assessment of PQ measuring data.

Textbooks:

1. Electrical Power Systems Quality - Dugan R C - McGranaghan M F - Santoso S - and Beaty H W - Second Edition - McGraw–Hill - 2012 - 3rd edition.
2. Electric power quality problems –M.H.J.Bollen IEEE series-Wiley india publications - 2011.
3. Power Quality Primer - Kennedy B W - First Edition - McGraw–Hill - 2000.

Reference Books:

1. Understanding Power Quality Problems: Voltage Sags and Interruptions - Bollen M HJ - First Edition - IEEE Press; 2000.
2. Power System Harmonics - Arrillaga J and Watson N R - Second Edition - John Wiley & Sons - 2003.
3. Electric Power Quality control Techniques - W. E. Kazibwe and M. H. Sendaula - Van Nostrad Reinhold - New York.
4. Power Quality C.Shankaran - CRC Press - 2001

5. Harmonics and Power Systems –Franciso C.DE LA Rosa–CRC Press (Taylor & Francis)
6. Power Quality in Power systems and Electrical Machines–EwaldF.fuchs-Mohammad A.S.Masoum–Elsevier.

Online Learning Resources:

1. https://nptel.ac.in/courses/108102179
2. https://nptel.ac.in/courses/108107157

PRAKASAM ENGINEERING COLLEGE
(AUTONOMOUS)
Approved by AICTE, Affiliated to JNTUK and Accredited by NAAC 'A'
R23 III Year ELECTRICAL AND ELECTRONICS ENGINEERING

II	HONORS ENGINEERING COURSES (POWER SYSTEMS)	L	T	P	C
		3	0	0	3
SMART GRID TECHNOLOGIES					

Pre-requisite: Basic Electrical Engineering, Power Systems, Signals & Systems

Course Objectives:

- To introduce students to the architecture, functions, and components of smart grids.
- To explore the communication and control technologies integral to smart grids.
- To examine the integration of renewable energy and distributed generation.
- To understand demand-side management and smart grid applications.
- To highlight challenges related to security, privacy, and regulation in smart grid implementation.

Course Outcomes: At the end of the course, student will be able to

CO 1: Understand the structure and benefits of smart grids.

CO 2: Analyze communication technologies and protocols in smart grids.

CO 3: Evaluate smart grid components like smart meters, energy storage, and distributed generation.

CO 4: Apply concepts in demand response and load management.

CO 5: Identify and address cyber security challenges in smart grids

UNIT – 1

Introduction to Smart Grids

Evolution of Power Grids: Traditional Grids vs. Smart Grids-Key Characteristics of Smart Grids: Efficiency, Reliability, Flexibility-Smart Grid Architecture: Components and Functions-Generation, Transmission, Distribution, and Consumption Sectors-Smart Grid Vision, Goals, and Benefits-Economic, Environmental, and Operational Benefits-Role of ICT in Smart Grids: Data Management and Communication Infrastructure.

UNIT – 2

Smart Grid Communication and Networking:

Communication Technologies for Smart Grids:Wired (Ethernet, Fiber Optics) and Wireless (Zigbee, Wi-Fi, Cellular)-Power Line Communication (PLC) for Smart Metering and Control-Smart Metering Systems: Functionality and Communication Protocols: Advanced Metering Infrastructure (AMI)-Protocols in Smart Grids: IEC 61850, Modbus, DNP3, and others-Data Acquisition and Control Systems in Smart Grids-Integration of Internet of Things (IoT) in Smart Grid Communication.

UNIT – 3

Smart Grid Components and Technologies

Smart Meters: Role, Functionality, and Types-Energy Storage Systems: Batteries, Supercapacitors, Flywheels, and Their Role in Grid Stability-Distributed Generation and Renewable Energy Integration: Solar, Wind, and Microgrids-Energy Management Systems (EMS): Load Flow Analysis and Optimization Techniques-Smart Grid Automation: SCADA Systems, Automated Metering, and Fault Detection-Real-Time Monitoring and Control: Techniques and Technologies.

UNIT – 4

Integration of Renewable Energy and Demand-Side Management

Challenges in Integrating Renewable Energy into the Grid: Variability, Intermittency, and Storage Solutions-Role of Smart Grids in Renewable Energy Integration: Grid Stability and Power Quality, Wind and Solar Power Forecasting Techniques-Demand-Side Management (DSM) and Smart Appliances: Load Shifting, Load Shedding, and Peak Demand Reduction, Role of Consumers in Grid Optimization (Smart Home Technologies)-Electric Vehicle (EV) Integration and Smart Charging Infrastructure

UNIT – 5

Security, Privacy, and Policy Issues in Smart Grids

Cyber security in Smart Grids: Threats, Vulnerabilities, and Risks :Cyber Attacks on Critical Infrastructure-Privacy Concerns and Data Protection in Smart Grid Systems: Consumer Data, Smart Meters, and Privacy Regulations-Authentication, Authorization, and Secure Communication Protocols: IEC 62351 Security Standards-Smart Grid Regulations and Policies: Global Standards and Frameworks.

NIST, IEC, IEEE Standards, Policy Challenges in Grid Modernization and Renewable Energy Adoption-Future Trends and Challenges in Smart Grid Development.

Textbooks:

1. "Smart Grids: Infrastructure, Technology, and Solutions" by Stuart Borlase
2. "Smart Grid: Fundamentals of Design and Analysis" by James A. Momoh
3. "Renewable Energy: Power for a Sustainable Future" by Godfrey Boyle
4. Smart Grid Security: An End-to-End View of Security in the New Electric Grid" by Tony Flick and Justin Morehouse

Reference Books:

1. "Smart Grid: Technology and Applications" by Janaka Ekanayake, Kithsiri Liyanage, Jiangzhou Wang, Nick Jenkins, and Xiangyu Zhang
2. "The Smart Grid: Enabling Energy Efficiency and Demand Response" by Galina P. L. P. Shapiro.
3. "The Smart Grid: Enabling Energy Efficiency and Demand Response" by Clark W. Gellings.

Online Learning Resources:

1. https://archive.nptel.ac.in/courses/108/107/108107113

		L	T	P	C
III	HONORS ENGINEERING COURSES (POWER SYSTEMS)	3	0	0	3
POWER SYSTEM DEREGULATION					

Pre-requisite: Power System Analysis, Power System Operation and Control.

Course Objectives:

- To familiarize the students with concepts and need for deregulated power systems.
- To impart the knowledge of power market development in India and across the world.
- To understand the key factors in equipment specification and system design.
- To learn about Ancillary Services Management
- To familiarize with the Electric Energy Trading.

Course Outcomes: At the end of the course, student will be able to

CO 1: Illustrate the operation of deregulated electricity market systems and typical issues in electricity markets

CO 2: Analyze various types of electricity market operational and control issues using new mathematical models.

CO 3: Summarize power wheeling transactions and congestion management.

CO 4: Analyze impact of ancillary services.

CO 5: Understand the Power market scenarios and Electric Energy Trading in the World.

UNIT – 1

Deregulation of The Electric Supply Industry

Introduction, concept of Deregulation, Different entities in deregulated electricity markets; Independent System Operator (ISO), Market Operator; Background to Deregulation and the Current Situation Around the World; Benefits from a Competitive Electricity Market; After-Effects of Deregulation.

Market Structure and Operation

Objectives of Market operations; Electricity Market Models –Pool Company, Bilateral Contracts and Hybrid; Power Market Types – Energy Services, Ancillary Services and Transmission Markets; Forward and Real-Time Markets; Market Power.

UNIT – 2

Power System Operation in Competitive Environment

Introduction, Role of the Independent System Operator; Operational planning activities of ISO – in Pool and Bilateral Markets; Operational planning activities of a Genco – in Pool

Markets, Bilateral Markets; Market participation issues; Unit Commitment in Deregulated Environment; Competitive Bidding.

UNIT – 3

Transmission Open Access and Pricing Issues

Introduction, Power Wheeling; Transmission Open Access; Cost components in transmission; Pricing of Power Transactions – Embedded Cost Based and Incremental Cost Based Transmission Pricing. Security Management in Deregulated Environment; Congestion Management in Deregulation.

UNIT – 4

Ancillary Services Management

General description of some ancillary services; Ancillary Service Management in various countries; Check-List of Ancillary Services Recognized by Various markets; Reactive Power as an Ancillary service.

UNIT – 5

Electric Energy Trading

Introduction, Essence of Electric Energy Trading, Energy Trading Framework, Derivative Instruments of Energy Trading, Portfolio Management, Energy Trading Hubs, Brokers in Electricity Trading, Green Power Trading.

Text Books:

1. Operation of restructured power systems – K. Bhattacharya, M.H.J. Bollen andJ.E. Daalder, Springer(For Units – 1,2.3, and 4)
2. Market operations in electric power systems – M. Shahidehpour, H. YaminandZ. Li,Wiley(For Units – 1 and 5)

Reference Books:

1. Power System Economics: Designing markets for electricity – S. Stoft, wiley.
2. Loi LeiLai, "PowerSystemRestructuringandDeregulation", 1st edition, JohnWiley&SonsLtd., 2012.

Online Learning Resources:

1. https://nptel.ac.in/courses/108101005

IV	HONORS ENGINEERING COURSES (POWER SYSTEMS)	L	T	P	C
		3	0	0	3
REAL TIME CONTROL OF POWER SYSTEMS					

Pre-requisite: Power systems, Power System Analysis and Protection

Course Objectives:

- To understand the importance of state estimation in power systems.
- To know the importance of security and contingency analysis.
- To understand SCADA, its objectives and its importance in power systems.
- To know the significance of voltage stability analysis.
- To provide an in-depth understanding of the operation of deregulated electricity market systems.

Course Outcomes:

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

CO 1: Illustrate different types of state estimations
CO 2: Describe security and contingency evaluation
CO 3: Demonstrate the computer control of power systems
CO 4: To classify and compare the voltage stability issues.
CO 5: Describe the various conditions of deregulation

UNIT – I:

State Estimation: Different types of State Estimations, Theory of WLS state estimation, sequential and non-sequential methods to process measurements. Observability, Pseudo measurements, Bad data detection, identification and elimination.

UNIT – II:

Security and Contingency Evaluation : Security concept, Security Analysis and monitoring, Contingency Analysis for Generator and line outages by iterative linear power flow method, Fast Decoupled model, and network sensitivity methods.

UNIT – III:

Computer Control of Power Systems: Need for real time and computer control of power systems, operating states of a power system, Supervisory Control And Data Acquisition (SCADA) systems implementation considerations, energy control centers, software requirements for implementing the above functions.

UNIT – IV:

Voltage Stability, voltage collapse, and voltage security, relation of voltage stability to rotor angle stability. Voltage stability analysis Introduction to voltage stability analysis `P-V' curves and `Q-V' curves, voltage stability in mature power systems, long-term voltage stability, power flow analysis for voltage stability, voltage stability static indices and Research Areas.

UNIT – V:

Need and conditions for deregulation. Introduction of Market structure, Market Architecture, Spot market, forward markets and settlements. Review of Concepts marginal cost of generation, least-cost operation, incremental cost of generation. Power System Operation.

Text Books:

1. Allen J. Wood and Bruce F. Wollenberg: Power Generation operation and control, John Wiley & Sons, 1984.
2. John J.Grainger and William D.Stevenson, Jr.: Power System Analysis, McGraw-Hill, 1994, International Edition
3. Prabha Kundur: Power System Stability and Control -, McGraw Hill, 1994.
4. Steven stoft: Power System Economics-Designing Markets for Electricity, IEEE Press and Wiley – Interscience -2002.

Reference Books:

1. R.N.Dhar : Computer-Aided Power Systems Operation and Analysis, Tata McGraw Hill, 1982.
2. L.P.Singh: Advanced Power System Analysis and Dynamics, Wiley Eastern Ltd. 1986.

Online Learning Resources:

1. https://nptel.ac.in/courses/108104191

<table>
<tr><td rowspan="2">V</td><td rowspan="2">HONORS ENGINEERING COURSES
(POWER SYSTEMS)</td><td>L</td><td>T</td><td>P</td><td>C</td></tr>
<tr><td>3</td><td>0</td><td>0</td><td>3</td></tr>
<tr><td colspan="6">ADVANCED POWER SYSTEMS PROTECTION</td></tr>
</table>

Pre-requisite: Basic Concepts of Power Electronics, Electronic circuits, and Power Systems.

Course Objectives:

- To analyze the static relay components and understand the role of components in static relay operation.
- To understand the fundamentals of amplitude and phase comparators and study the different types of comparators and apply comparator techniques in static relays.
- To explore the different types of static relays and understand the working mechanisms of each type in power system protection.
- To explain the importance and working principles of Pilot Relaying Schemes and study the various pilot relaying methods.
- To study the working of microprocessor-based relays and numerical relays and analyze the architecture and components of numerical relays

Course Outcomes: At the end of the course, student will be able to

CO1: Understand the fundamentals of static relays and analyze the working of static relay components.

CO2: Analyze and compare the operation of comparators and select suitable comparator techniques.

CO3: Explain the principles of static over current relays and apply in power system protection.

CO4: Apply pilot relaying in power system protection and evaluate the performance of pilot relaying schemes.

CO5: Illustrate the microprocessor and numerical relay protection

UNIT – 1

Static Relays classification and Tools: Comparison of Static with Electromagnetic Relays, Basic classification, Level detectors and Amplitude and phase Comparators – Duality – Basic Tools – Schmitt Trigger Circuit, Multivibrators, Square wave Generation – Polarity detector – Zero crossing detector – Thyristor and UJT Triggering Circuits. Phase sequence Filters – Speed and reliability of static relays.

UNIT – 2

Amplitude and Phase Comparators (2 Input): Generalized equations for Amplitude and Phase comparison – Derivation of different characteristics of relays – Rectifier Bridge circulating and opposed voltage type amplitude comparators – Averaging & phase splitting type amplitude comparators – Principle of sampling comparators.

Phase Comparison: Block Spike and phase Splitting Techniques – Transistor Integrating type, phase comparison, Rectifier Bridge Type Comparison – Vector product devices.

UNIT – 3

Static over current (OC) relays – Instantaneous, Definite time, Inverse time OC Relays, static distance relays, static directional relays, static differential relays, measurement of sequence impedances in distance relays, multi input comparators, elliptic & hyperbolic characteristics, switched distance schemes, Impedance characteristics during Faults and Power Swings.

UNIT – 4

Pilot Relaying Schemes: Wire Pilot Protection: Circulating current scheme – Balanced voltage scheme – Transley scheme – Half-wave comparison scheme - Carrier Current Protection Schemes, relative merits & demerits: Phase comparison protection – Carrier aided distance protection – transfer scheme, blocking scheme and acceleration scheme.

UNIT – 5

Microprocessor based relays and Numerical Protection: Over current relays – impedance relay – directional relay – reactance relay.

Numerical Protection: Numerical relay - numerical relaying algorithms -mann-morrison technique - Differential equation technique and discrete fourier transform technique - numerical over current protection - numerical distance protection.

Text Books:

1. Power System Protection with Static Relays – by TSM Rao, TMH.
2. Power system protection & switchgear by Badri Ram & D N viswakarma, TMH.

Reference Books:

1. Protective Relaying Vol-II Warrington, Springer.
2. Art & Science of Protective Relaying - C R Mason, Willey.
3. Power System Stability KimbarkVol-II, Willey.
4. Electrical Power System Protection –C.Christopoulos and A.Wright- Springer
5. Protection & Switchgear –Bhavesh Bhalaja, R.PMaheshwari, NileshG.Chothani-Oxford publisher

Online Learning Resources:

1. https://nptel.ac.in/courses/108104191

VI	HONORS ENGINEERING COURSES (POWER SYSTEMS)	L	T	P	C
		3	0	0	3
FLEXIBLE AC TRANSMISSION SYSTEMS					

Pre-requisite: Fundamentals of Electrical Engineering, Power systems, Power Electronics

Course Objectives:

- To understand the role of FACTS controllers and their impact on improving the performance, stability, and efficiency of transmission systems.
- To analyze Compensation Techniques to explore the effects of static shunt and series compensation techniques on voltage regulation, power flow control, and system stability.
- To study Shunt Compensation Devices for Investigating the working principles and applications of Static Var Compensator (SVC) and Static Synchronous Compensator (STATCOM) for reactive power compensation.
- To select FACTS Devices by assess various power system scenarios and determine the most suitable FACTS device for specific applications to enhance power transfer capability.
- To examine Advanced Controllers by understanding the principles of operation, control strategies, and applications of Unified Power Flow Controller (UPFC) and Interline Power Flow Controller (IPFC) for comprehensive power flow management.

Course Outcomes:

After the completion of the course the student should be able to:

CO1: Know the performance improvement of transmission system with FACTS.
CO2: Demonstrate the effect of static shunt and series compensation.
CO3: Illustrate the use of SVC and STATCOM for Shunt Compensations
CO4: Determine an appropriate FACTS device for different types of applications.
CO5: Know the principle of operation and various controls of UPFC& IPFC

UNIT – I:

FACTS concepts, Transmission interconnections, power flow in an AC System, loading capability limits, Dynamic stability considerations, importance of controllable parameters, basic types of FACTS controllers, benefits from FACTS controllers.

UNIT – II:

Static shunt compensation: Objectives of shunt compensation, midpoint voltage regulation, voltage instability prevention, improvement of transient stability, Power oscillation damping, methods of controllable VAr generation, variable impedance type static VAr generation, switching converter type VAr generation, hybrid VAr generation.Basic concept of voltage and current source converters, comparison of current source converters with voltage source converters.

UNIT – III:

SVC and STATCOM: The regulation slope, Transfer function and dynamic performance, Transient stability enhancement and power oscillation damping, Operating point control and summary of compensation control.

UNIT – IV:

Static series compensation: Concept of series capacitive compensation, improvement of transient stability, power oscillation damping, functional requirements. GTO thyristor controlled series capacitor (GSC), thyristor switched series capacitor (TSSC), and thyristor controlled series capacitor (TCSC), control schemes for GSC, TSSC and TCSC.

UNIT – V:

Unified Power Flow Controller: Basic operating principle, Conventional transmission control capabilities, Independent real and reactive power flow control, Comparison of the UPFC to series compensators and phase angle regulators. Inter line Power Flow Controller (IPFC) - Introduction, operation and applications.

Text Books:

1. "Understanding FACTS Devices" N.G.Hingorani and L.Guygi, IEEE Press. Indian Edition is available:--Standard Publications

Reference Books:

1. Sang.Y.Hand John.A.T, "Flexible AC Transmission systems" IEEE Press (2006).
2. HVDC & FACTS Controllers: applications of static converters in power systems- Vijay K.Sood- Springer publishers.

Online Learning Resources:

1. https://nptel.ac.in/courses/108107114
2. https://nptel.ac.in/courses/117103488

<table>
<tr><td rowspan="2">VII</td><td rowspan="2">HONORS ENGINEERING COURSES
(POWER SYSTEMS)</td><td>L</td><td>T</td><td>P</td><td>C</td></tr>
<tr><td>3</td><td>0</td><td>0</td><td>3</td></tr>
<tr><td colspan="6">AI APPLICATIONS IN POWER SYSTEMS</td></tr>
</table>

Pre-requisites:

Fundamentals of Power systems, Artificial Intelligence, Optimization Techniques

Course Objectives:

- Understand the fundamentals of Artificial Neural Networks (ANN), including key terminologies, neuron models, activation functions, and learning strategies.
- Explore and apply advanced ANN paradigms such as Back Propagation, Radial Basis Function networks, and Kohonen's Self-Organizing Maps.
- Study classical and fuzzy sets, their properties, operations, and applications in handling uncertainty and decision-making.
- Design and implement Fuzzy Logic Controllers (FLC) for control systems using fuzzification, inference, and defuzzification techniques.
- Apply AI techniques like back propagation and fuzzy logic in real-world applications, such as load forecasting and load frequency control in power systems.

Course Outcomes: At the end of the course, student will be able to

CO 1: Describe the fundamental concepts and components involved in the functioning of ANN and Fuzzy Logic systems.

CO 2: Explain the functionality of different ANN models (e.g., perceptron, back propagation) and fuzzy set operations.

CO 3: Apply ANN algorithms and fuzzy logic techniques to solve practical problems like load forecasting and control systems.

CO 4: Analyze the performance and limitations of various ANN models and fuzzy controllers in different applications.

CO 5: Design and implement ANN-based solutions and fuzzy logic controllers for engineering applications, such as power system control and frequency regulation.

UNIT– 1

Introduction

Artificial Neural Networks (ANN) – Humans and computers – Biological Neural Networks – ANN Terminology – Models of Artificial neuron – activation functions –typical architectures – biases and thresholds – learning strategy(supervised, unsupervised and reinforced) learning rules, perceptron training and classification using Discrete and Continuous perceptron algorithms, limitations and applications of perceptron training algorithm– linear separability and non-separability with examples.

UNIT– 2

ANN Paradigms

Generalized delta rule – Back Propagation algorithm- Radial Basis Function (RBF) network. Kohonen's self-organizing feature map (KSOFM), Learning Vector Quantization (LVQ) – Functional Link Networks (FLN) – Bidirectional Associative Memory (BAM) – Hopfield Neural Network.

UNIT– 3

Classical and Fuzzy Sets

Introduction to classical sets - properties, Operations and relations; Fuzzy sets, Membership, Uncertainty, Operations, properties, fuzzy relations, cardinalities, membership functions.

UNIT– 4

Fuzzy Logic Controller (FLC)

Fuzzy logic system components: Fuzzification, Inference engine (development of rule base and decision-making system), Defuzzification to crisp sets- Defuzzification methods.

UNIT– 5

Application of AI Techniques

Load forecasting using back propagation algorithm –load flow studies using back propagation algorithm, single area and two area load frequency control using fuzzy logic.

Text Books:

1. Introduction to Artificial Neural Systems - Jacek M. Zuarda, Jaico Publishing House, 1997.
2. Fuzzy logic with Fuzzy Applications – T.J Ross – McGraw Hill Inc, 1997.

Reference Books:

1. Neural Networks, Fuzzy logic, Genetic algorithms: synthesis and applications by RajasekharanandPai – PHI Publication.
2. Introduction to Neural Networks using MATLAB 6.0 by S N Sivanandam,SSumathi,S N Deepa TMGH.
3. Introduction to Fuzzy Logic using MATLAB by S N Sivanandam,SSumathi,S N Deepa Springer, 2007.

Online Learning Resources:

1. https://nptel.ac.in/courses/127105006

VIII	HONORS ENGINEERING COURSES (POWER SYSTEMS)	L	T	P	C
		0	0	3	1.5
POWER SYSTEMS LAB					

Course Objectives:

- To Understand and determine sequence impedances of an alternator using direct methods and fault analysis techniques, including the application of sequence voltages.
- To Measure sequence impedance of three-phase transformers, analyze poly-phase connections of single-phase transformers, and determine the equivalent circuit of a three-winding transformer.
- To Study the Ferranti effect, measure ABCD parameters, and evaluate the performance of long transmission lines with and without compensation, including shunt and reactor compensation techniques.
- To determine differential and percentage bias relay operations, analyze overcurrent relay characteristics, and understand relay-based protection schemes for generators and transformers.
- To Apply theoretical concepts to practical scenarios, conduct experiments to measure system parameters, and analyze the impact of different protection and compensation techniques on power system performance.

Course Outcomes:

After the completion of the course, the student should be able to:

CO 1: Calculate the sequence impedances of the synchronous machine.

CO 2: Calculate the sequence impedances and explain the connections of the transformer.

CO 3: Describe the Ferranti effect and compensation in transmission lines.

CO 4: Analyze the performance and importance of transmission line parameters.

CO 5: Analyze the operation of various protection relays.

List of experiments

Any 10 of the following experiments are to be conducted:

1. Determination of Sequence Impendences of an Alternator by direct method.
2. Determination of Sequence impedances of an Alternator by fault Analysis.
3. Measurement of sequence impedance of a three phase transformer
    a) By application of sequence voltage.
    b) Using fault analysis.
4. Poly-phase connection on three single phase transformers and measurement of phase angle.
5. Determination of equivalent circuit of 3-winding Transformer.
6. Study of Ferranti effect in long transmission line.

7. Measurement of ABCD parameters on transmission line.
8. Performance of long transmission line without compensation.
9. To determine and verify the reactor compensation of transmission line.
10. Performance of long transmission line with shunt compensation.
11. To study the differential and percentage bias integrated relay operations.
12. Performance characteristics of Over current relay
13. To study the protection of generator and transformer.

IX	HONORS ENGINEERING COURSES (POWER SYSTEMS)	L	T	P	C
		0	0	3	1.5
ADVANCED POWER SYSTEMS SIMULATION LAB					

Course Objectives:

- To utilize advanced analytical and computational approaches to evaluate and enhance the stability of multi-machine power systems.
- To apply optimal power flow techniques to improve system efficiency and analyze unit commitment strategies for cost-effective power generation.
- To conduct load flow studies and assess contingency scenarios to ensure the reliability and resilience of power systems.
- To implement state estimation techniques and power quality improvement strategies to maintain system reliability and performance.
- To analyze the stability of Single Machine Infinite Bus (SMIB) systems under different conditions, with and without controllers, to improve system dynamics.

Course Outcomes:

After the completion of the course the student should be able to:

CO 1: Analyze the multi machine stability by advanced approaches.
CO 2: Calculate optimal power flows and analyze unit commitment by optimal methods.
CO 3: Analyze the load flow and contingency cases of power systems
CO 4: Illustrate the state estimations and power quality improvements
CO 5: Analyze the stability of SMIB with and without controllers

List of experiments

Any 10 of the following experiments are to be conducted:

1. Multi Machine Transient stability using modified Euler’s method.
2. Multi Machine Transient stability using R-K 2nd order method.
3. Optimal Power Flow using Newton’s method.
4. Unit Commitment using dynamic programming.
5. Optimal Power Flow using Genetic Algorithm.
6. Distribution system load flow solution using Forward-Backward sweep Method.
7. Contingency analysis of a Power System
8. State estimation of a power system using Weighted Least Squares Error Method
9. Stability Analysis of SMIB using State space approach without PSS controller
10. Stability Analysis of SMIB using State space approach with PSS controller
11. Power Quality improvement using D-STATCOM

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Power Electronics

I	HONORS ENGINEERING COURSES (POWER ELECTRONICS)	L	T	P	C
		3	0	0	3
SPECIAL ELECTRICAL MACHINES					

Pre-requisite:

Basic knowledge on magnetic circuits and electrical machines.

Course Objective:

- To describe the operation and characteristics of permanent magnet dc motor.
- To understand the performance and control of stepper motors, and their applications.
- To explain operation and control of switched reluctance motor.
- To distinguish between brush dc motor and brush less dc motor.
- To explain the theory of travelling magnetic field and applications of linear motors.

Course Outcomes:

After the completion of the course the student should be able to:

CO 1: Demonstrate the merits of PM motors.
CO 2: Choose best control scheme for stepper motors.
CO 3: Construct the various converter circuits for Switched Reluctance Motors.
CO 4: Analyse the characteristics of Brushless dc Motor.
CO 5: Understand the applications and operation of Linear Induction Motors.

UNIT - I

Permanent Magnet Materials and PMDC motors

Introduction - classification of permanent magnet materials used in electrical machines - minor hysteresis loop and recoil line - Stator frames of conventional dc machines - Development of electronically commutated dc motor from conventional dc motor – Permanent magnet materials and characteristics - B-H loop and demagnetization characteristics-high temperature effects-reversible losses - Irreversible losses - Mechanical properties - handling and magnetization - Application of permanent magnets in motors - power density - operating temperature range - severity of operation duty- Hysteresis - Eddy current Motors.

UNIT - II

Stepper Motors

Principle of operation of Stepper Motor – Constructional details - Classification of stepper motors – Different configuration for switching the phase windings - Control circuits for stepper motors – Open loop and closed loop control of two phase hybrid stepping motor.

UNIT - III

Switched Reluctance Motors

Construction and Principle of operation of Switched Reluctance Motor – Comparison of conventional and switched reluctance motors – Design of stator and rotor pole arcs.

Torque producing principle and torque expression – Different converter configurations for SRM – Drive and power circuits for SRM – Position sensing of rotor – Applications of SRM.

UNIT - IV

Permanent Magnet Brushless DC Motor

Principle of operation of BLDC motor - Types of constructions - Surface mounted and interior type permanent magnet BLDC Motors - Torque and EMF equations for Square wave & Sine wave for PMBLDC Motor – Torque - Speed characteristics of Square wave & Sine wave for PMBLDC Motor - Merits & demerits of Square wave & Sine wave for PMBLDC Motor - Performance and efficiency – Applications.

UNIT - V

Linear Induction Motors (LIM)

Construction– principle of operation – Double sided LIM from rotating type Induction Motor – Schematic of LIM drive for traction – Development of one sided LIM with back iron - equivalent circuit of LIM.

Text Books:

1. Brushless Permanent magnet and reluctance motor drives, Clarenden press, T.J.E. Miller, 1989, Oxford.
2. Special electrical Machines, K.Venkata Ratnam, University press, 2009, New Delhi.

Reference Books:

1. E. G. Janardhanan, 'Special Electrical Machines' PHI Learning Private Limited.
2. Krishnan, Ramu. Switched reluctance motor drives: modeling, simulation, analysis, design, and applications. CRC press, 2017.

3. Krishnan, Ramu. Permanent magnet synchronous and brushless DC motor drives. CRC press, 2017.

Online Learning Resources:

1. https://nptel.ac.in/courses/108102156

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R23 III Year ELECTRICAL AND ELECTRONICS ENGINEERING

II	HONORS ENGINEERING COURSES (POWER ELECTRONICS)	L	T	P	C
		3	0	0	3
MACHINE MODELING AND ANALYSIS					

Pre-requisites: Electrical Circuits and Electrical Machines

Course Objectives:

- Analyze the performance of electrical machines under both steady-state and transient conditions
- Apply the transformation and derive the mathematical model of three phase Induction/synchronous motors
- Learn the dynamic modeling of special machines for the performance analysis

Course Outcomes:

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

CO1: Develop mathematical modeling of DC machines for steady state & transient analysis.

CO2: Illustrate the phase/reference frame transformations and Develop mathematical modeling of three phase induction motor.

CO3: Interpret the knowledge of reference frame theory and obtain d-q axis modeling of induction Motorsin different reference frames.

CO4: Distinguish different inductances of a synchronous motor and obtain synchronous motor modeling inthe rotor's dq_0 reference frame.

CO5: Develop the mathematical models of special electrical machines.

UNIT– 1

DC Motor Modeling :

Importance of mathematical modeling of electrical machines, Mathematical model of separately excited D.C. motor and D.C. Series motor in state variable form – Mathematical model of D.C. shunt motor and D.C. Compound motor in state variable form, Steady state analysis – Transient state analysis, Transfer function of the D.C. motor, Sudden application of inertia load.

UNIT– 2

Reference Frame Theory & 3-phase Induction Motor dq model:

Linear transformation – Phase transformation (abc to αβ0) – Power equivalence, Active transformation (αβ0 to dq0), transformations in complex plane, Commonly used reference frames and transformation between reference frames, Circuit model of a 3 phase Induction motor – Flux linkage equation – dq transformation of flux linkages in the complex plane – voltage equations

UNIT– 3

Modeling of 3-phase Induction motor in various reference frames

Voltage equation transformation to a synchronous reference frame, dq model of induction motor in the stator reference frame, rotor reference frame and arbitrary reference frame, power equation, electromagnetic torque equation, state space model in induction motor with flux linkages as variables and current-flux variables

UNIT– 4

Modeling of 3-phase Synchronous Motor

Synchronous machine inductances – Circuits model of a 3-phase synchronous motor – derivation of voltage equations in the rotor's dq0 reference frame electromagnetic torque – State space model with flux linkages as variables.

UNIT– 5

Special Machines:

Modeling of Permanent Magnet Synchronous motors – Modeling of Brushless DC Motor, Analysis of Switch Reluctance Motors.

Text Books

1. Generalized theory of Electrical Machines - Fifth edition, Khanna Publishers P. S. Bimbhra, 1985.
2. AC Motor control and electric vehicle applications – Kwang Hee Nam – CRC press, Taylor & Francis Group, 2010

Reference Books:

1. Electric Motor Drives - Modeling, Analysis& control - R. Krishnan- Pearson Publications- 1st edition -2002.
2. Switched Reluctance Motor Drives: Modeling, Simulation, Analysis, Design, and Applications - R.Krishnan , CRC Press, Year: 2001
3. Analysis of Electric Machinery and Drive Systems, 3rd Edition-Wiley-IEEE Press-Paul Krause, Oleg Wasynczuk, Scott D. Sudhoff, Steven Pekarek, Junr 2013..

Online Learning Resources:

1. https://archive.nptel.ac.in/courses/108/106/108106023/

<table>
<tr><td rowspan="2">III</td><td rowspan="2">HONORS ENGINEERING COURSES
(POWER ELECTRONICS)</td><td>L</td><td>T</td><td>P</td><td>C</td></tr>
<tr><td>3</td><td>0</td><td>0</td><td>3</td></tr>
<tr><td colspan="6">POWER ELECTRONIC CONVERTERS</td></tr>
</table>

Pre-requisite: Power Electronics

Course Objectives:

- To learn the characteristics of switching devices and use of gate driver circuits
- To understand the need of isolation and analyse the performance of different isolated switch mode converters
- To learn the working of different multilevel inverters and understand their merits and demerits
- To apply PWM techniques for controlling fundamental voltage and mitigate harmonics in inverters

Course Outcomes: After the completion of the course the student should be able to

CO 1: Illustrate the characteristics of Switching devices and use gate drive circuits. Illustrate the operation of multilevel inverters and compare their features.

CO 2: Analyze the performance of isolated switch mode converters.

CO 3: Investigate the PWM Control of single-phase and three-phase inverters and compare various PWM techniques.

CO 4: Investigate the PWM Control of CHB and diode clamped multilevel inverters.

UNIT– 1

Overview of Switching Devices

Power MOSFET, IGBT, GTO, GaN devices-static and dynamic characteristics, gate drive circuits for switching devices.

UNIT– 2

Isolated DC-DC Converters

Need for isolated converters, Forwarded converter, forward converter with demagnetizing winding, flyback converter, push-pull converter, half-bridge converter, full bridge converter, flux walking capacitors in half-bridge and full-bridge converters.

UNIT– 3

PWM Inverters

Voltage control of single-phase inverters employing phase displacement Control, Bipolar PWM, Unipolar PWM. Three-phase Voltage source inverters: Six stepped VSI operation-

Voltage Control of Three-Phase Inverters employing Sinusoidal PWM, Third Harmonic PWM, Space Vector Modulation- Comparison of PWM Techniques- Three phase current source inverters.

UNIT– 4

Multilevel Inverters

Introduction, Multilevel Concept, Types of Multilevel Inverters, Diode-Clamped Multilevel Inverter, Principle of Operation, Features of Diode-Clamped Inverter, Improved Diode Clamped Inverter, Cascaded H-bridge Multilevel Inverter, Principle of Operation, Features of Cascaded H-bridge Inverter, Fault tolerant operation of CHB Inverter, Comparison of DCMLI & CHB, Modular multilevel converters, principle of operation.

UNIT– 5

PWM Multilevel Inverters

CHB Multilevel Inverter: Stair case modulation-SHE PWM- Phase shifted Multicarrier modulation-Level shifted PWM- Diode clamped Multilevel inverter: SHE PWM-Sinusoidal PWM- Space vector PWM-Capacitor voltage balancing.

Text Books

1. Power Electronics: Converters, Applications, and Design- Ned Mohan, Tore M. Undeland, ,William P. Robbins, John Wiley& Sons2nd Edition, 2003.
2. Power Electronics-Md.H.Rashid –Pearson Education Third Edition- First IndianReprint-2008.
3. High-power converters and AC drives -Wu, Bin, and Mehdi Narimani-John Wiley & Sons, 2017.

Reference Books:

1. Elements of Power Electronics – Philip T. Krein, Oxford University press, 2014.
2. Power Electronics Daniel W. Hart - McGraw-Hill,2011.

Online Learning Resources:

1. https://nptel.ac.in/courses/108105066
2. https://nptel.ac.in/courses/108102584
3. https://nptel.ac.in/courses/108101126

<table>
<tr><td rowspan="2">IV</td><td rowspan="2">HONORS ENGINEERING COURSES
(POWER ELECTRONICS)</td><td>L</td><td>T</td><td>P</td><td>C</td></tr>
<tr><td>3</td><td>0</td><td>0</td><td>3</td></tr>
<tr><td colspan="6">POWER QUALITY AND CUSTOM POWER DEVICES</td></tr>
</table>

Pre-requisite:

Basic knowledge in power systems and power electronics.

Course Objectives:

- To be familiar with the causes and effects of power quality issues.
- To know the techniques for mitigation of power quality issues.
- To study the effect of harmonics and to design filters
- To understand the working of custom power devices.
- To use a suitable device for power quality improvement

Course Outcomes: At the end of the course, student will be able to

CO 1: Identify the issues related to power quality in power systems.
CO 2: Categorize short and long duration voltage variations in power systems.
CO 3: Analyze the effects of harmonics and study of different mitigation techniques.
CO 4: Illustrate the importance of custom power devices and their applications.
CO 5: Compare different compensation techniques to minimize power quality disturbances.

UNIT– 1

Introduction to power quality

Overview of Power Quality, Concern about the Power Quality, General Classes of Power Quality Problems, Voltage Unbalance, Waveform Distortion, Voltage fluctuation, Power Frequency Variations, Power Quality Terms, Voltage Sags, swells, flicker and Interruptions - Sources of voltage and current interruptions, Nonlinear loads.

UNIT– 2

Transient and Long Duration Voltage Variations

Source of Transient Over Voltages - Principles of Over Voltage Protection, Devices for Over Voltage Protection, Utility Capacitor Switching Transients, Utility Lightning Protection, Load Switching Transient Problems.

Principles of Regulating the Voltage, Device for Voltage Regulation, Utility Voltage Regulator Application, Capacitor for Voltage Regulation, End-user Capacitor Application, Regulating Utility Voltage with Distributed generation.

UNIT– 3

Harmonic Distortion and solutions

Voltage vs. Current Distortion, Harmonics vs. Transients - Power System Quantities under Non-sinusoidal Conditions, Harmonic Indices, Sources of harmonics, Locating Sources of Harmonics, System Response Characteristics, Effects of Harmonic Distortion, Inter harmonics, Harmonic Solutions Harmonic Distortion Evaluation, Devices for Controlling Harmonic Distortion, Harmonic Filter Design, Standards on Harmonics.

UNIT– 4

Custom Power Devices

Custom power and custom power devices, voltage source inverters, reactive power and harmonic compensation devices, compensation of voltage interruptions and current interruptions, static series and shunt compensators, compensation in distribution systems, interaction with distribution equipment, installation considerations.

UNIT– 5

Application of custom power devices in power systems

Static and hybrid Source Transfer Switches, Solid state current limiter - Solid state breaker. P-Q theory – Control of P and Q, Dynamic Voltage Restorer (DVR): Operation and control, Distribution Static Compensator (D-STATCOM). Operation and control of Unified Power Quality Conditioner (UPQC).

Text Books:

1. Electrical Power Systems Quality, Dugan R C, McGranaghan M F, Santoso S, and Beaty H W, Second Edition, McGraw-Hill, 2002.
2. Understanding Power Quality Problems: Voltage Sags and Interruptions, Bollen M H J, First Edition, IEEE Press; 2000.
3. Guidebook on Custom Power Devices, Technical Report, Published by EPRI, Nov 2000
4. Power Quality Enhancement Using Custom Power Devices – Power Electronics and Power Systems, Gerard Ledwich, Arindam Ghosh, Kluwer Academic Publishers, 2002.

Reference Books:

1. Power Quality Primer, Kennedy B W, First Edition, McGraw-Hill, 2000.
2. Power System Harmonics, Arrillaga J and Watson N R, Second Edition, John Wiley & Sons, 2003.
3. Electric Power Quality control Techniques, W. E. Kazibwe and M. H. Sendaula, Van Nostrad Reinhold, New York.
4. Power Quality c.shankaran, CRC Press, 2001
5. Harmonics and Power Systems –Franciso C.DE LA Rosa-CRC Press (Taylor & Francis).

6. Power Quality in Power systems and Electrical Machines-EwaldF.fuchs, Mohammad A.S. Masoum-Elsevier
7. Instantaneous Power Theory and Application to Power Conditioning, H. Akagiet.al., IEEE Press, 2007.
8. Custom Power Devices - An Introduction, Arindam Ghosh and Gerard Ledwich, Springer, 2002.
9. A Review of Compensating Type Custom Power Devices for Power Quality Improvement, Yash Pal et.al., Joint International Conference on Power System Technology and IEEE Power India Conference, 2008. POWERCON 2008.

Online Learning Resources:

1. https://nptel.ac.in/courses/108107157
2. https://nptel.ac.in/courses/108102179
3. https://nptel.ac.in/courses/108106025

V	HONORS ENGINEERING COURSES (POWER ELECTRONICS)	L	T	P	C
		3	0	0	3
POWER ELECTRONICS FOR RENEWABLE ENERGY SYSTEMS					

Pre-requisites:
Power Electronics, Electrical Machines Control Systems.

Course Objectives:

- To Illustrate the I-V characteristics of solar PV modules and use of blocking diodes and bypass diodes for shade mitigation
- To Understand MPPT, usage of power converters for PV and battery charging
- To Understand different Wind turbine technologies and converters for wind energy generation
- To Analyze PV and wind energy integrated systems

Course Outcomes: At the end of the course, student will be able to

CO 1: Illustrate the I-V characteristics of solar PV modules and use of blocking diodes and bypass diodes
for shade mitigation
CO 2: Understand MPPT, usage of power converters for PV and battery charging
CO 3: Understand different Wind turbine technologies and converters for wind energy generation
CO 4: Analyze PV and wind energy integrated systems

UNIT – 1
Solar spectrum, PV materials, Equivalent Circuit for PV cell, effect of series and shunt resistance, fill factor, Cells to Modules to Arrays, I–V Curves, standard test condition, Impacts of Temperature and Insolation on I–V curves, series and parallel connection of PV modules, Shading impacts on I–V curves, Bypass diodes and Blocking diodes for shade mitigation, I–V Curves for different loads.

UNIT – 2
Perturb and observe MPPT method for solar PV inverter, Central inverters, String inverters, Micro inverters, leakage current issue, Transformer for leakage current elimination, Transformer less PV inverters. Battery charger, Characteristics of Batteries, Charge control, Battery charging using DC-DC converter, Dual Active Bridge converter for battery charging.

UNIT – 3
Wind turbine technologies- horizontal axis and vertical axis turbines, power in the wind, wind turbine power curves, Betz limit ratio, advantages and disadvantages of wind energy system. Review of modern wind turbine technologies, Fixed and Variable speed wind

turbines, Doubly Fed Induction Generator, Permanent Magnet Synchronous Generators and their characteristics.

UNIT – 4

Converters for wind generators: AC-DC-AC converters, matrix converters, multilevel converter, Maximum power point tracking for wind turbines, fault ride through capabilities.

UNIT-5

Grid connection principle, Clarke's and Park's transformation, Grid connected photovoltaic system, Grid connected wind energy system, Filters, Grid synchronization & PLL, operation & control of hybrid energy systems, IEEE & IEC codes and standards for renewable energy grid integrations.

Text Books:

1. Renewable and Efficient Electric Power Systems, G. Masters, IEEE- John Wiley and Sons Ltd. Publishers, 2013, 2nd Edition.
2. Grid Converters for Photovoltaic and Wind Power Systems, Remus Teodorescu, Marco Liserre, Pedro Rodriguez, Wiley, 2011, 2nd Edition.
3. Integration and Control of Renewable Energy in Electric Power System, Ali Keyhani Mohammad Marwali and Min Dai, John Wiley publishing company, 2010, 2nd Edition.

Reference Books:

1. Solar Photovoltaic: Fundamentals, technologies & Applications, C. S. Solanki, PHI Publishers, 2019.
2. Integration of Renewable Sources of Energy, F. A. Farret, M. G. Simoes, Wiley, 2017, 2nd Edition.

Online resources:

1. https://onlinecourses.nptel.ac.in/noc22_ee71/preview
2. https://nptel.ac.in/courses/103103206

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VI	HONORS ENGINEERING COURSES (POWER ELECTRONICS)	L	T	P	C
		3	0	0	3
INDUSTRIAL APPLICATIONS OF POWER ELECTRONIC CONVERTERS					

Course Educational Objective: This course enables the student understanding different power converters and their operation in LED lighting, UPS, drives and micro-grid applications.

Course Outcomes: At the end of the course, student will be able to

		Knowledge Level (K)#
CO1	Design and analyze drivers for efficient LED lighting.	
CO2	Illustrate UPS, SMPS, Bi-directional DC-DC (BDC) converters operation and applications.	
CO3	Explain the applications of inverters and rectifiers for high power and low power applications	
CO4	Examine the operation and performance of various power converters.	
CO5	Design and implement power converters for grid integration.	

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5
CO1	--	--	--	--	--
CO2	--	--	--	--	--
CO3	--	--	--	--	--
CO4	--	--	--	--	--

(Please fill the above with Levels of Correlation, viz., L, M, H)

UNIT	CONTENTS	Contact Hours
UNIT–1	**Power Converters for LED Driving:** LED Characteristics, Driving LEDs, Converters (Buck, Boost & Buck-Boost) for LED lightning systems, PFC based LED drivers, Selecting Components for LED Drives, Applications of LEDs.	
UNIT–2	**UPS and SMPS:** Components of UPS, operation and applications of UPS, Basic operation and applications of SMPS, Difference between UPS and SMPS. **Bi-directional DC-DC (BDC) converters:** Electric traction, Automotive Electronics, Battery charging converters, Line Conditioners and Solar	

	Charge Controllers.	
UNIT–3	**High Voltage Power Supplies -** Power supplies for X-ray applications, Power supplies for radar applications, Power supplies for space applications. **Low Voltage High Current Power Supplies:** Power converters for modern Microprocessor and Computer loads.	
UNIT–4	**Power converters for AC Drives:** Two-Level VSI-Based Medium Voltage (MV) drives, NPC/H-Bridge inverter fed drive, ANPC inverter fed drive, Modular Multi level inverter fed drive, and Multi-Module Cascaded Matrix Converter fed MV drive, power converters for PMSM & BLDC motors.	
UNIT–5	**Power converters for micro-grid and grid connection of renewable energy sources:** Design, control of converters, grid synchronization and filtering requirements, Solid State Transformers technologies in Distribution system.	

Text Books:

1. Steve Winder, Power Supplies for LED Driving, Newnes, 2016, 2nd Edition.
2. Abraham I. Pressman, Keith Billings &Taylor Morey, Switching Power Supply Design, McGraw HillInternational, 2009, 3rd Edition.
3. Ali Emadi, A. Nasiri, and S. B. Bekiarov, Uninterruptible Power Supplies and Active Filters, CRCPress, 2004, 1stEdition.
4. Ali Keyhani Mohammad Marwali ,Min Dai, Integration and Control of Renewable Energy in Electric Power System, , John Wiley publishing company, 2010, 2ndEdition.

Reference Books:

1. Muhammad H. Rashid ,Power Electronics Handbook, Butterworth-Heinemann, 2023, 5th Edition
2. M Singh, K Khanchandani, Power Electronics, McGraw-Hill Education, 2006, 2nd Edition.
3. B.L. Theraja, A Textbook of Electrical Technology - Volume III, 2007,1st Edition.
4. William Ribbens, Understanding Automotive Electronics: An Engineering Perspective, ButterworthHeinemann, 2017, 8th Edition.
5. Paul C. Krause, Oleg W, Scott D. Sudhoff,Analysis of Electric Machinery & Drive systems, IEEE Press, 2013, 3rd Edition.
6. High-power Converters and AC Drives, Bin-Wu, Wiley-Blackwell, 2017, 2nd Edition.

VII	**HONORS ENGINEERING COURSES (POWER ELECTRONICS)**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**
ADVANCED ELECTRICAL DRIVES					

Pre-requisite: Knowledge of Power Electronics, Electrical Machines and Control Systems

Course Objectives:

- To provide a comprehensive understanding of advanced control schemes for induction motor drives.
- To familiarize students with control strategies for PMSM, BLDC, and SRM drives.
- To impart knowledge on minimizing torque ripple and improving performance in motor drives.

Course Outcomes: After the completion of the course, student will be able to

CO1: Understand the concepts of scalar and vector control methods for drive systems.

CO2: Select and implement proper control techniques for induction motor and Synchronous motor for specific applications.

CO3: Analyze and design control techniques and converters for SRM drives

CO4: Analyze and design controllers and converters for BLDC drives.

Unit I: Vector Control of Induction Motor Drives

Principles of scalar and vector control, principle of direct vector control, indirect vector control, implementation-block diagram; estimation of flux, flux weakening operation.

UNIT-II Direct Torque Control of Induction Motor Drives

Principle of Direct torque control (DTC), concept of space vectors, DTC control strategy of induction motor, comparison between vector control and DTC, applications, space vector modulation-based DTC of induction motors.

Unit III Control of Synchronous Motor Drives

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

Unit-IV Control of Switched Reluctance Motor Drives

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

Unit-V Control of BLDC Motor Drives

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

Text Books:

1. Bose B. K., "Power Electronics and Variable Frequency Drives"", IEEE Press, Standard Publisher Distributors. 2001.
2. Krishnan R., "Electric Motor Drives – Modelling, Analysis and Control", Prentice Hall of India Private Limited.

Reference Books:

1. Switched Reluctance Motors and Their Control-T. J. E. Miller, Magna Physics, 1993.
2. Power electronic converters applications and design-Mohan, Undeland, Robbins-Wiley Publications
3. De Doncker, Rik W., Pulle, Duco W.J., Veltman, Andre, "Advanced Electrical Drives", Springer, 2020.
4. Ned Mohan, "Advanced Electric Drives: Analysis, Control, and Modeling Using MATLAB/Simulink®", John Wiley & Sons, Inc, 2014.

Online Learning Resources:

1. https://nptel.ac.in/courses/108104011
2. https://nptel.ac.in/courses/108102046

VIII	HONORS ENGINEERING COURSES (POWER ELECTRONICS)	L	T	P	C
		3	0	0	3
FACTS CONTROLLERS					

Pre-requisite: Fundamentals of Electrical Engineering, Power systems, Power Electronics

Course Objectives:

- To understand the role of FACTS controllers and their impact on improving the performance, stability, and efficiency of transmission systems.
- To analyze Compensation Techniques to explore the effects of static shunt and series compensation techniques on voltage regulation, power flow control, and system stability.
- To study Shunt Compensation Devices for Investigating the working principles and applications of Static Var Compensator (SVC) and Static Synchronous Compensator (STATCOM) for reactive power compensation.
- To select FACTS Devices by assess various power system scenarios and determine the most suitable FACTS device for specific applications to enhance power transfer capability.
- To examine Advanced Controllers by understanding the principles of operation, control strategies, and applications of Unified Power Flow Controller (UPFC) and Interline Power Flow Controller (IPFC) for comprehensive power flow management.

Course Outcomes:
After the completion of the course the student should be able to:

CO1: Know the performance improvement of transmission system with FACTS.
CO2: Demonstrate the effect of static shunt and series compensation.
CO3: Illustrate the use of SVC and STATCOM for Shunt Compensations
CO4: Determine an appropriate FACTS device for different types of applications.
CO5: Know the principle of operation and various controls of UPFC& IPFC

UNIT – I:
FACTS concepts, Transmission interconnections, power flow in an AC System, loading capability limits, Dynamic stability considerations, importance of controllable parameters, basic types of FACTS controllers, benefits from FACTS controllers.

UNIT – II:
Static shunt compensation: Objectives of shunt compensation, midpoint voltage regulation, voltage instability prevention, improvement of transient stability, Power oscillation damping, methods of controllable VAr generation, variable impedance type static VAr generation, switching converter type VAr generation, hybrid VAr generation.Basic concept of voltage

and current source converters, comparison of current source converters with voltage source converters.

UNIT – III:

SVC and STATCOM: The regulation slope, Transfer function and dynamic performance, Transient stability enhancement and power oscillation damping, Operating point control and summary of compensation control.

UNIT – IV:

Static series compensation: Concept of series capacitive compensation, improvement of transient stability, power oscillation damping, functional requirements. GTO thyristor controlled series capacitor (GSC), thyristor switched series capacitor (TSSC), and thyristor controlled series capacitor (TCSC), control schemes for GSC, TSSC and TCSC.

UNIT – V:

Unified Power Flow Controller: Basic operating principle, Conventional transmission control capabilities, Independent real and reactive power flow control, Comparison of the UPFC to series compensators and phase angle regulators. Inter line Power Flow Controller (IPFC) - Introduction, operation and applications.

Text Books:

1. "Understanding FACTS Devices" N.G.Hingorani and L.Guygi, IEEE Press. Indian Edition is available:--Standard Publications

Reference Books:

1. Sang.Y.Hand John.A.T, "Flexible AC Transmission systems" IEEE Press (2006).
2. HVDC & FACTS Controllers: applications of static converters in power systems- Vijay K.Sood- Springer publishers.

Online Learning Resources:

1. https://nptel.ac.in/courses/108107114
2. https://nptel.ac.in/courses/117103488

IX	HONORS ENGINEERING COURSES (POWER ELECTRONICS)	L	T	P	C
		0	0	3	1.5
POWER CONVERTERS LABORATORY					

Course Objectives:

- To illustrate the working of single and three-phase full converters and semi-converters.
- To analyze the performance of Square-wave inverters and PWM inverters.
- To analyze the performance of DC-DC converters.
- To analyze the performance of three level NPC and Five level CHB inverters.

Course Outcomes:

After the completion of the course the student should be able to:

CO1: Illustrate the working of single and three-phase full converters and semi-converters

CO2: Analyze the performance of Square-wave inverters and PWM inverters

CO3: Analyze the performance of DC-DC converters

CO4: Analyze the performance of Three level NPC and Five level CHB inverters

List of experiments

Any 10 of the following experiments are to be conducted:

1. Analysis of single-phase half-controlled bridge rectifier
2. Analysis of three-phase fully controlled rectifier.
3. Analysis of single-phase square wave inverter.
4. Analysis of three-phase inverter for 120ºmode of conduction.
5. Analysis of three-phase inverter for 180º mode of conduction.
6. Analysis of single-phase inverter with unipolar PWM switching.
7. Analysis of single-phase inverter with bipolar PWM switching.
8. Analysis of three-phase inverter for Sine-PWM method.
9. Analysis of three-phase inverter with SVPWM method.
10. Analysis of Buck DC-DC converter.
11. Analysis of Boost DC-DC converter.
12. Analysis of Buck-Boost DC-DC converter.
13. Analysis of Sine-PWM technique for 3-phase 3-level NPC inverter.
14. Analysis of single-phase 5-level cascaded H-bridge inverter with staircase modulation.
15. Analysis of Phase shift PWM techniques for 3-phase 5-level cascaded H-bridge inverter.
16. Analysis of Level shift PWM techniques for 3-phase 5-level cascaded H-bridge inverter.

X	HONORS ENGINEERING COURSES (POWER ELECTRONICS)	L	T	P	C
		0	0	3	1.5
ELECTRIC DRIVES LABORATORY					

Course Objectives:
This course enables the student to get hands on experience in understanding different control methods of DC drives and advanced electric drives through experimentation.

Course Outcomes:
After the completion of the course the student should be able to:

CO1: Analyze the speed control of DC drive with converter circuits.
CO2: Examine the regenerative braking of DC drives.
CO3: Examine the performance of V/f and vector control methods of AC drives

List of experiments

Any 10 of the following experiments are to be conducted:

1. Armature control based speed control of separately excited DC drive with single-phase full converter.
2. Armature control based speed control of excited DC drive with three-phase full converter.
3. Study of regenerative braking of DC drive
4. Soft starting of three-phase induction motor.
5. Performance characteristics of a three-phase induction motor using V/f control.
6. Vector control based speed control of three-phase induction motor drive
7. Study of direct torque control of three-phase induction motor
8. Speed control of PMSM motor by voltage control method.
9. Speed control of BLDC motor by voltage control method.
10. Vector control based speed control of PMSM drive.
11. Vector control based speed control of BLDC motor drive.
12. Speed control of Switched Reluctance Motor with eddy current loads

XI	HONORS ENGINEERING COURSES (POWER ELECTRONICS)	L	T	P	C
		0	0	3	1.5
RENEWABLE TECHNOLOGIES LABORATORY					

Course Objectives:

- To understand Solar PV Characteristics by developing and analyzing the mathematical model of a solar PV cell and study its characteristics under different operating conditions.
- To evaluate PV Cell Combinations by investigating the performance of solar PV modules in series and parallel configurations by analyzing their I-V and P-V characteristics.
- To explore Power Electronic Converters by examining the role of different power electronic converters in optimizing the performance of PV systems and improving energy conversion efficiency.
- To implement MPPT Algorithms by demonstrating the significance of Maximum Power Point Tracking (MPPT) algorithms to enhance the efficiency of solar PV systems.
- To analyze Wind Energy Generation – Study the working principles of wind turbines, analyze wind turbine performance curves, and evaluate power generation characteristics.
- To model Uninterrupted Power Supply (UPS)by designing and analyzing of an Uninterrupted Power Supply (UPS) system to ensure continuous power delivery in renewable energy applications.

Course Outcomes:

After the completion of the course the student should be able to:

CO1: Analyze the mathematical model and understand its solar PV cell characteristics.

CO2: Demonstrate the effect of series and parallel combination of PV cells by I-V and P-V curves.

CO3: Analyze the effect of suitable power electronic converters for PV system.

CO4: Demonstrate the significance of various MPPT algorithms on PV System.

CO5: Demonstrate wind power generation and wind turbine curves.

CO6: Analyze the model of Uninterrupted Power Supply.

List of experiments

Any 10 of the following experiments are to be conducted:

Software Based Experiments:

1. Simulate the Mathematical Model of a PV cell using Single Diode model and Two Diode model equivalent circuits.
2. Simulate the performance curves (I-V & P-V) of a Solar cell and their variation with change in temperature and irradiation.
3. Simulate the performance curves (I-V & P-V) for PV modules connect in series and their variation with temperature and irradiation.
4. Simulate the performance curves (I-V & P-V) for PV modules connect in parallel and their variation with temperature and irradiation.
5. Simulate the performance curves (I-V & P-V) for the effect of varying the series resistance on the fill factor of the PV cell.
6. Simulate the Buck-Boost Converter with Closed Loop control.
7. Simulate the Maximum Power Point tracking of PV module using INC Algorithm.
8. Simulate the Maximum Power Point tracking of PV module using P & O Algorithm.
9. Simulate the Wind Power Plant model.
10. Simulate the Uninterrupted Power Supply model.

Hardware Based Experiments

Using Solar PV Training System:

11. Single PV module I-V and P-V characteristics with radiation and temperature changing effect.
12. I-V and P-V characteristics with series and parallel combination of modules.
13. Effect of shading on PV Module.
14. Effect of tilt angle on PV Module.
15. Demonstration of bypass and blocking diodeon a PV Module.

Using Wind Energy Training System:

16. Evaluation of cut-in speed of wind turbine.
17. Evaluation of Tip Speed Ratio (TSR) at different wind speeds.
18. Evaluation of Coefficient of performance of wind turbine.
19. Characteristics of turbine (power variation) with wind speed.
20. Power curve of turbine with respect to the rotational speed of rotor at fix wind speeds.
21. Power analysis at turbine output with AC load for a Wind Energy System.

XII	HONORS ENGINEERING COURSES (POWER ELECTRONICS)	L	T	P	C
		0	0	3	1.5
ELECTRIC VEHICLES LABORATORY					

Course Objectives:

- To simulate Power Converters for EVs by analyzing and implementing isolated and non-isolated DC-DC converters for electric vehicle applications using simulation tools.
- To evaluate Motor Control Strategies by Studying and simulating advanced motor control techniques such as Field-Oriented Control (FOC), Direct Torque Control (DTC), and closed-loop control for different EV propulsion motors.
- To design and analyze EV Battery Systems by developing and fabricating a Li-ion battery pack for EV applications and perform controlled charging and discharging experiments.
- To implement Hardware-Based Motor Control with Operation of induction motor and analyze its performance using V/F control and four-quadrant operation modes for EV applications.
- To assess EV System Performance by measuring and analyzing key parameters such as voltage, current, speed, torque, and power flow in propulsion systems under different operating conditions.

Course Outcomes:

After the completion of the course the student should be able to:

CO 1: Simulate and analyze the performance of isolated and non-isolated DC-DC converters for electric vehicle applications.

CO 2: Implement and evaluate field-oriented and direct torque control (DTC) strategies for induction motor drives in EVs.

CO 3: Design and simulate a closed-loop control system for switched reluctance motor (SRM) and BLDC motor drives for EV applications.

CO 4: Construct and analyze a Li-ion battery pack (48V/72V, 3/5 kWh) and study its charging and discharging characteristics.

CO 5: Perform real-time analysis of propulsion motor speed, voltage, current, and power using throttle control.

CO 6: Demonstrate V/F control of induction motors and study the four-quadrant operation of propulsion motors, including motoring and braking modes.

List of experiments

Any 10 of the following experiments are to be conducted:

Software Based Experiments:

1. Simulation of isolated and nonisolated DC-DC converters for EV application.
2. Simulation of Field oriented/DTC controlled Induction Motor drive for EV application.
3. Simulation of Closed loop control of SRM drive for electric vehicle application.
4. Simulation of Field oriented control of PMSM for electric vehicle application.
5. Simulation of closed loop control of BLDC motor drive for electric vehicle application.

Hardware Based Experiments

6. Running the propulsion motor by throttle paddle and analyze the speed,voltage, current, power of the system.
7. Design and fabrication of 48V/72V, 3/5 kWh Li-ion battery pack.
8. Constant current mode of charging/discharging of EV Battery.
9. V/F Control of Induction motor drive for electric vehicle application.
10. Study of four quadrant operation of propulsion motor and analyse all the parameters like voltage, current, speed, toque, and powerflow.
    a) Forward motoring mode
    b) Forward braking mode
    c) Reverse motoring mode
    d) Reverse braking mode