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

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III B.Tech. - II Semester	23EE6D06	L	T	P	C
		3	0	0	3

Communication systems

Course Outcomes:

- Analyze the performance of analog modulation schemes in time and frequency domains.
- Analyze the performance of angle modulated signals.
- Characterize analog signals in time domain as random processes and noise
- Characterize the influence of channel on analog modulated signals
- Determine the performance of analog communication systems in terms of SNR
- Analyze pulse amplitude modulation, pulse position modulation, pulse code modulation and TDM systems.

UNIT – I

Basic tools for communication, Fourier Series/Transform, Properties, Autocorrelation, Energy Spectral Density, Parsevals Relation, Amplitude Modulation (AM), Spectrum of AM, Envelope Detection, Power, Efficiency, Modulation Index

UNIT2 : Double Sideband Suppressed Carrier (DSB-SC) Modulation, Demodulation, Costas Receiver,Single Sideband Modulation (SSB), Hilbert Transform, Complex Pre-envelope/ Envelope, Demodulation of SSB, Vestigial Sideband Modulation (VSB)

UNIT 3 : Angle Modulation, Frequency Modulation (FM), Phase Modulation (PM), Modulation Index, Instantaneous Frequency, Spectrum of FM Signals, Carsons Rule for FM Bandwidth, Narrowband FM Generation, Wideband FM Generation via Indirect Method, FM Demodulation

UNIT 4 : Introduction to Sampling, Spectrum of Sampled Signal, Aliasing, Nyquist Criterion, Signal Reconstruction from Sampled Signal, Pulse Amplitude Modulation, Quantization, Uniform Quantizers – Midrise and Midtread, Quantization noise, , Non uniform Quantizers, Delta Modulation, Differential Pulse Code Modulation (DPCM)

UNIT 5: : Basics of Probability, Conditional Probability, MAP Principle, Random Variables, Probability Density Functions, Applications in Wireless Channels, Basics of Random Processes ,Gaussian Random Process, Noise.

TEXTBOOKS:

1. Simon Haykin, Communications Systems, 4th Edition. John Wiley and Sons, Inc

2.Fundamentals of Wireless Communication by David Tse

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III B.Tech. - II Semester	23EE6D07	L	T	P	C
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Electric Drives

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 quadrantoperations of dc motors using dual converters.

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

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

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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 –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 – VedamSubramanyam 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

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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

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Honors Engineering (Power Systems)	23EEHT01	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: Analyze 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.

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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

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Honors Engineering (Power Systems)	23EEHT02	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, Super capacitors, Flywheels, and Their Role in Grid Stability-Distributed Generation and Renewable Energy Integration: Solar, Wind, and Micro grids-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.

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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 JanakaEkanayake, KithsiriLiyanage, 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

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Honors Engineering (Power Systems)	23EEHT03	L	T	P	C
		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.

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.

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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. BollenandJ.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. LoiLeiLai, "PowerSystemRestructuringandDeregulation", 1st edition, JohnWiley&SonsLtd., 2012.

Online Learning Resources:

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

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Honors Engineering (Power Systems)	23EEHT04	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.

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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. PrabhaKundur: 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

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Honors Engineering (Power Systems)	23EEHT05	3	0	0	3

ADVANCED POWER SYSTEMS PROTECTION

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.

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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 schemeand 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 –BhaveshBhalaja, R.PMaheshwari, NileshG.Chothani-Oxford publisher

Online Learning Resources:

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

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Honors Engineering (Power Systems)	23EEHT06	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.

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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.HandJohn.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

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Honors Engineering (Power Systems)	23EEHT07	L	T	P	C
		3	0	0	3

AI APPLICATIONS IN POWER SYSTEMS

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

CO 2: Explain the functionality of different ANN models 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

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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

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Honors Engineering (Power Systems)	23EEHL01	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.

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List of experiments

Any 10 of the following experiments are to be conducted:

1. Determination of Sequence Impendence's 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.

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Honors Engineering (Power Systems)	23EEHL02	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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Honors Engineering (Power Electronics)	23EEHT08	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.

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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.VenkataRatnam, 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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Honors Engineering (Power Electronics)	23EEHT09	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 Motors in 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

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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 – KwangHee 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, Junr2013..

Online Learning Resources:

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

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Honors Engineering (Power Electronics)	23EEHT10	L	T	P	C
		3	0	0	3

Power Electronic Converters

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.

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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

1. https://nptel.ac.in/courses/108102584

3.https://nptel.ac.in/courses/108101126

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Honors Engineering (Power Electronics)	23EEHT11	L	T	P	C
		3	0	0	3

Power Quality and Custom Power Devices

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.

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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.

Online Learning Resources:

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

https://nptel.ac.in/courses/108106025

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Honors Engineering (Power Electronics)	23EEHT12	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 integratedsystems

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.

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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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Honors Engineering (Power Electronics)	23EEHT13	L	T	P	C
		3	0	0	3

Industrial Applications of Power Electronic Converters

Course 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

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.

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.

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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

1. M Singh, K Khanchandani, Power Electronics, McGraw-Hill Education, 2006, 2nd Edition.
2. B.L. Theraja, A Textbook of Electrical Technology - Volume III, 2007,1st Edition.
3. William Ribbens, Understanding Automotive Electronics: An Engineering Perspective, ButterworthHeinemann, 2017, 8th Edition.
4. Paul C. Krause, Oleg W, Scott D. Sudhoff,Analysis of Electric Machinery & Drive systems, IEEE Press, 2013, 3rd Edition.

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Honors Engineering (Power Electronics)	23EEHT14	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.

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

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Honors Engineering (Power Electronics)	23EEHT15	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 VA rgeneration. 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.

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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.HandJohn.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

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Honors Engineering (Power Electronics)	23EEHL03	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 120°mode of conduction.
5. Analysis of three-phase inverter for 180° mode of conduction.
6. Analysis of single-phase inverter with uni polar 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.

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Honors Engineering (Power Electronics)	23EEHL04	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

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Honors Engineering (Power Electronics)	23EEHL05	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 e 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.

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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:

1. Single PV module I-V and P-V characteristics with radiation and temperature changing effect.
2. I-V and P-V characteristics with series and parallel combination of modules.
3. Effect of shading on PV Module.
4. Effect of tilt angle on PV Module.
5. Demonstration of bypass and blocking diode on a PV Module.

Using Wind Energy Training System:

6. Evaluation of cut-in speed of wind turbine.
7. Evaluation of Tip Speed Ratio (TSR) at different wind speeds.
8. Evaluation of Coefficient of performance of wind turbine.
9. Characteristics of turbine (power variation) with wind speed.
10. Power curve of turbine with respect to the rotational speed of rotor at fix wind speeds.
11. Power analysis at turbine output with AC load for a Wind Energy System.

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Honors Engineering (Power Electronics)	23EEHL06	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 non isolated 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.

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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 analyze all the parameters like voltage, current, speed, toque, and power flow.
    a) Forward motoring mode
    b) Forward braking mode
    c) Reverse motoring mode
    d)Reverse braking mode

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		3	0	0	3

Digital Signal Processing

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 with examples. 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

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

Text Books:

1. Digital Signal Processing – PrinciplesAlgorithms 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

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		3	0	0	3

High Voltage Engineering

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: Recognize 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.

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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

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		0	0	3	1.5

Electrical Measurements and Instrumentation Lab

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 phases 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. Performance characteristics of Solar panel.
17. Di-electric oil testing using HT testing kit.

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		0	0	3	1.5

Microprocessors and Microcontrollers Lab

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 - logicalnumber 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 multibytenumbers: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

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Programs on Interfacing

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
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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		0	1	2	2

IoT Applications of Electrical Engineering

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

Topics to be covered in Tutorials

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

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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. Servo motor control using potentiometer or stepper motor control 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. Measurement of distance using ultrasonic sensor with Arduino.
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

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III B.Tech. - II Semester	RESEARCH METHODOLOGY 23AC6T04	L	T	P	C
		2	0	0	--

Course Outcomes:

- Understand research problem formulation.
- Analyze research related information, Follow research ethics
- Understand that today's world is controlled by Computer, Information Technology, but tomorrow world will be ruled by ideas, concept, and creativity.
- Understand the Sampling process
- Understand the Data Analysis
- Understand the Interpretation of Data and Paper Writing

UNIT – I:

Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem, Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations

UNIT – II:

Effective literature studies approaches, analysis Plagiarism , Research ethics, Effective technical writing, how to write report, Paper Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee

UNIT – III:

Sampling: Concepts of Statistical Population, Sample, Sampling Frame, Sampling Error, Sample Size, Non Response. Characteristics of a good sample. Probability Sample – Simple Random Sample, Systematic Sample, Stratified Random Sample & Multi-stage sampling. Determining size of the sample – Practical considerations in sampling and sample size

UNIT – IV:

Data Analysis: Data Preparation – Univariate analysis (frequency tables, bar charts, pie charts, percentages), Bivariate analysis – Cross tabulations and Chi-square test including testing hypothesis of association.

UNIT – V:

Interpretation of Data and Paper Writing – Layout of a Research Paper, Journals in Computer Science, Impact factor of Journals, When and where to publish ? Ethical issues related to publishing, Plagiarism and Self-Plagiarism.

TEXT BOOKS

1. Stuart Melville and Wayne Goddard, "Research methodology: an introduction for science&engineeringstudents'".
2. Wayne Goddard and Stuart Melville, "Research Methodology: An Introduction"
3. Business Research Methods – Donald Cooper & Pamela Schindler, TMGH, 9th edition
4. Business Research Methods – Alan Bryman & Emma Bell, Oxford University Press.
5. Research Methodology – C.R.Kothari

REFERENCE BOOKS

1. RanjitKumar, 2nd Edition , "Research Methodology: A Step by Step Guide for beginners"
2. Halbert, "Resisting Intellectual Property", Taylor & Francis Ltd,2007.
3. Mayall , "Industrial Design", McGraw Hill,1992.

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		3	0	0	3

RENEWABLE ENERGY SOURCES
OPEN ELECTIVE-I (Except EEE)

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 energy and sizing of digesters.
- 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 & power due to hydrogen energy 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.

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UNIT–III

Biomass systems

Biomass Energy: Fuel classification – Pyrolysis – Direct combustion of heat – Different digesters and sizing.

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.

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

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III B.Tech. - I Semester	23EE5E02	L	T	P	C
		3	0	0	3

CONCEPTS OF ENERGY AUDITING &MANAGEMENT
OPEN ELECTIVE(Except EEE)

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.

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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

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III B.Tech. - II Semester	23EE6E03	L	T	P	C
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FUNDAMENTALS OF ELECTRIC VEHICLES
OPEN ELECTIVE(Except EEE)

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 – Draw backs 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 Motor and Controller –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).

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UNIT – IV

Hybrid Electric Vehicles

Evolution of Hybrid Electric Vehicles – Advantages and Applications of Hybrid Electric Vehicles – Architecture of HEVs – Series and Parallel HEVs- 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 -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

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III B.Tech. - II Semester	23EE6E04	L	T	P	C
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ELECTRICAL WIRING ESTIMATION AND COSTING
OPEN ELECTIVE(Except EEE)

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 smallindustries.
CO4: Illustrate the components of electrical substations.
CO5: Design suitable control circuit for starting of three phase induction motor andsynchronous 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 - estimating and costing of electrical installations.

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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 .

UNIT - IV

Substations

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

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 - basic control circuits - motor protection.

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

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Minor Engineering	23EEMT01	L	T	P	C
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CONCEPTS OF CONTROL SYSTEMS

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 Modeling 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.

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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 ManikDhanesh 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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Minor Engineering	23EEMT02	L	T	P	C
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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.

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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

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Minor Engineering	23EEMT03	L	T	P	C
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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.

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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

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Minor Engineering	23EEMT04	L	T	P	C
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FUNDAMENTALS OF POWER ELECTRONICS

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.

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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

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BASICS OF ELECTRIC DRIVES AND APPLICATIONS

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.

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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 – VedamSubramanyam 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

Dr. S.Srikanth , Professor & HOD	Dr,N.Sumathi Associate Professor, Dept. of EEE,UCEK,	Dr. K.Siva Kumar Professor, Dept. of EE, IIT	Dr. G.Siva Kumar Asst. professor , Dept. of EE, NIT	Dr.S.Jayadeep Product Development Engineer L&T	D.Lakshman Kumar, Asst. professor, Dept. of EEE,SVCEW(A),

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Minor Engineering	23EEMT06	L	T	P	C
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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.

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