ELECTRICAL AND ELECTRONICS ENGINEERING

B.Tech.

DEPARTMENT ELECTIVE COURSES

- STREAM-1 - Power Systems
- STREAM-2 - Power Electronics
- STREAM-3 - Automation and Energy Systems

COURSE CONTENTS

16EE251 RENEWABLE ENERGY TECHNOLOGIES

Hours Per Week :

L	T	P	C
3	1	-	4

Total Hours :

L	T	P
45	15	-

WA/RA	SSH/HSH	CS	SA	S	BS
8	40	-	8	5	-

Course Description and Objectives:

This course deals with the types, purpose and operation of renewable energy technologies. The objective of the course is to understand the implementation of geothermal energy, ocean energy and biomass energy resourses, know the advantages and shortcomings of using hydrogen as an energy carrier in internal combustion engine and fuel cells.

Course Outcomes:

The student will be able to:

- understand the components and operation of geothermal power plant.
- compare the operation of tidal and OTEC power plants.
- explore feasibility of hydrogen usage in fuel cells.
- understand the components and operation of biomass plant.

SKILLS:

- ✓ Identify different types of Renewable energy resources.
- ✓ Differentiate between various biomass energy conversion routes.
- ✓ Select appropriate batteries for specific applications.
- ✓ Understand the concept of distributed generation.

ACTIVITIES:

- *Review the technical aspects of geothermal energy in the World.*
- *Suggest a battery for cell-phone / laptop / tablet / adapter.*
- *Design prototype biogas plant.*
- *Review the technical aspects of ocean energy in the World.*
- *Review the status of Distributed generation in India.*

UNIT - 1 **L-9, T-3**

GEOTHERMAL ENERGY : Availability of geothermal energy, Size and distribution, Recovery of geothermal energy, Types of systems using geothermal energy - Direct heat applications, Power generation; Sustainability of geothermal source, Status of geothermal technology, Economics of geothermal energy.

UNIT - 2 **L-10, T-3**

OCEAN ENERGY : Ocean and Tidal energy conversion, Energy sources in ocean - Ocean tidal, wave and thermal energy; Ocean saline gradient concept, Ocean currents, Ocean chemical energy, Ocean energy conversion routes - electrical and non electrical routes, Advantages and merits of ocean energy technologies, Limitation; Tides - Spring tide, Neap tide, Daily and monthly variation, Tidal range, Tidal Power; Types of tidal power plants - Single basin and double basin schemes; Main requirements in tidal power plants, Energy storage, Prospects of tidal power, Economic factors, Ocean thermal energy conversion (OTEC) – Open and closed cycle operation, Ecological and environmental impacts.

UNIT - 3 **L-8, T-3**

BIOMASS ENERGY : Photosynthesis and origin of biomass energy, Biomass energy resources - Cultivated biomass resources, Waste to biomass resources; Terms and definitions, Incineration, wood and wood waste, Harvesting super trees and energy forests, Pyrolysis, Thermo chemical biomass conversion to energy, Gasification, Anaerobic digestion, Fermentation, Gaseous fuel from biomass, Design of a bio gas plant.

UNIT - 4 **L-9, T-3**

HYDROGEN AND FUEL CELLS: Hydrogen as a renewable energy source, Sources of hydrogen, Fuel for vehicles, Fuel cell technology – Types, Principle of working, construction, Power generation, Fuel cell polarization curve; Conversion of chemical energy into electricity in a fuel cell, Fuel cell power plant structure, Fuel processor and fuel cell stack, Applications, Cogeneration, Fuel cell electric vehicles.

UNIT – 5 **L-9, T-3**

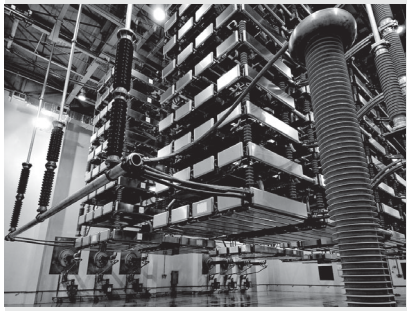
DISTRIBUTED GENERATION: Introduction to the concept of distributed generation - Advantages , needs; Basics on distributed generation Technologies, Effect on system operation - Impact of DG. Power quality implication; Acceptable ranges of voltage and frequency, Flicker, Reactive power compensation, Active filtering and Low voltage ride through requirements.

TEXT BOOKS:

1. G.D. Rai, “Non Conventional Energy Sources”, 4th edition, Khanna Publishers, New Delhi, 2011.
2. Anne-Marie Borbely, Jan F.Kreider, “Distributed Generation”, 1st edition, CRC Press, 2001.

REFERENCES BOOKS:

1. S.P. Sukhatme, J.K.Nayak., “Solar Energy”, 3rd edition, Tata Mc-Graw Hill Education Private Limited, New Delhi, 2010.
2. Godfrey Boyle, “Renewable Energy, Power for a Sustainable Future”, 1st edition, Oxford University Press, U.K., 2012.
3. Chauhan D.S., Srivastava S.K. “Non-Conventional Energy Resources”, 1st edition, New Age, 2009.
4. Georgiadis M.C., “Energy Systems Engineering”, 1st edition, Wiley-VCH, 2008.
5. Viswanathan B., “Fuel Cell Principles and Applications”, 1st edition, Universities Press, India, 2006.
6. Rajput R.K., “Power Plant Engineering”, 4th edition, Laxmi Publications, 2008.



16EE351 HVDC AND FACTS

Hours Per Week :

L	T	P	C
3	-	2	4

Total Hours :

L	T	P
45	-	30

WA/RA	SSH/HSH	CS	SA	S	BS
8	40	5	8	5	5

Course Description and Objectives:

This course deals with fundamental concepts of HVDC Transmission and FACTS Technology which are emerging in the area of power systems. The objective of course is to understand the role of HVDC Transmission and FACTS technology in delivering quality power at bulk levels.

Course Outcomes:

The student will be able to:

- bring out the advantages of HVDC transmission system.
- understand different HVDC converters.
- compensate the effects of harmonics due to converters.
- understand the importance of FACTS technology.
- analyze different FACTS devices in transmission system.

SKILLS:

- ✓ *Analyze performance of given transmission system with and without HVDC converters.*
- ✓ *Identify HVDC converter configurations for given transmission system.*
- ✓ *Design filter for specific HVDC application.*
- ✓ *Select suitable FACTS device for specified power quantity/quality.*

ACTIVITIES:

- *Survey on HVDC links existed in India.*
- *Survey on HVDC links with neighbouring countries.*
- *Design of firing circuits for 12/ 24 pulse HVDC converters.*
- *Design 12/24 pulse HVDC converter.*
- *Survey on FACTS devices existed in India.*

UNIT – 1 **L-10**

INTRODUCTION TO HVDC SYSTEM AND CONVERTERS : Need for power system interconnections, Evolution of AC and DC transmission systems, Comparison of HVDC and HVAC transmission systems, Types of DC links, Components of HVDC system, Modern trends in DC transmission systems, Pulse number, Choice of converter configurations, Analysis of Graetz circuit with and without overlap - Voltage waveforms, Converter bridge characteristics; Inverter mode of operation – voltage waveforms,12 pulse converter operation.

UNIT – 2 **L-9**

DC LINK CONTROL AND HARMONIC ANALYSIS : Principles of DC link control, Converter control characteristics - Constant current control, CEA control, Firing angle control of valves; Starting and stopping of a dc link, Power control, Harmonics and filters – Effects of harmonics, Sources of harmonic generation, Types of filters, Types of over voltages and over current protection, DC circuit breakers.

UNIT – 3 **L-9**

FLEXIBLE AC TRANSMISSION SYSTEMS (FACTS) : Power flow in AC systems, Relative importance of controllable parameters, Line loadability, Basic types of FACTS controllers – Shunt and series controllers; Current source and voltage source converters, Brief description, Definitions of FACTS controllers.

UNIT – 4 **L-9**

STATIC SHUNT AND SERIES COMPENSATORS : Objectives of shunt compensation, Methods of controllable VAR generation - Static VAR compensators, SVC and STATCOM; Comparison.
Objectives of series compensation, Variable impedance type thyristor switched series capacitors (TCSC), Switching converter type series compensators, Static series synchronous compensator (SSSC) - Basic operating control schemes, Power angle characteristics.

UNIT – 5 **L-8**

COMBINED COMPENSATORS : Introduction to unified power flow controller (UPFC), Basic operating principle, Independent real and reactive power flow controller, Control structure, Interline power flow controller (IPFC) – Basic operating principle and characteristics, Control structure.

LABORATORY EXPERIMENTS

LIST OF EXPERIMENTS Total hours: 30

Simulation of the following converters using MATLAB / PSpice

1. single phae semi converter.
2. single phase half wave converter.
3. single phase Full wave converter.
4. 3-phase Full wave converter.
5. 12-pulse converter.
6. Thyristor controlled Reactor (TCR).
7. Thyristor switched capacitor (TSC).
8. single phase half wave converter.
9. single phase Full wave converter.
10. 3-phase Full wave converter.

TEXT BOOKS:

1. Padiyar.K.R.,"HVDC Power Transmission Systems", 2nd edition, New Age Publishers,2010.
2. N.G. Hingorani and L. Guygi, "Understanding FACTS Devices", 1st edition, IEEE Press Publications, 2000.

REFERENCE BOOKS:

1. S. Rao, "EHV - AC, HVDC Transmission & Distribution Engineering",Khanna publishers, 3rd Edition 2003.
2. E Acha, V.G Agelidis and O Anaya-Lara, "Power Electronic Control in Electrical Systems", 1st edition, The Miller – Elsevier, 2009.
3. Young Huasong & Alian T. hons, "Flexible AC Transmission Systems (FACTS)". The Institution of Electrical Engineers, IEE Power and Energy Series 30.
4. Abhijit Chakrabarti, D. P. Kothari, A. K. Mukhopadhyay and Abhinandan De, "An Introduction to: Reactive Power Control and Voltage Stability in Power Transmission Systems", 1st edition, Eastern Economy Edition, 2010.

16EE352 ADVANCED AC TRANSMISSION SYSTEM

Hours Per Week :

L	T	P	C
3	1	-	4

Total Hours :

L	T	P
45	15	-

WA/RA	SSH/HSH	CS	SA	S	BS
8	40	5	8	5	5

Course Description and Objectives:

This course deals with concepts of High / Ultra High voltage transmission lines with their parameters and models. The objective of the course is to understand the intricacies of high voltage transmission lines with problems such as voltage control, corona, over voltage and their effects on power system stability.

Course Outcomes:

The student will be able to:

- identify factors affecting bulk power transmission.
- understand the basic concepts of high voltage AC transmission.
- identify the components used in high voltage AC transmission lines.
- understand the methods of high voltage AC transmission line design.

SKILLS:

- ✓ *Apply different methods of analysis for EHV AC transmission system.*
- ✓ *Calculate positive,negative and zero sequence impedances of transmission lines.*
- ✓ *Analyze transmission capability of EHV AC Transmission system.*
- ✓ *design required compensation to overcome corona and ferranti effect in transmission lines.*

ACTIVITIES:

- *Survey of EHV AC transmission systems in India.*
- *Simulate performance of EHV line in PSCAD.*
- *Simulate required series compensation for EHV AC transmission line.*
- *Simulate required shunt compensation for EHV AC transmission line.*
- *Observe EMI / EMC, corona effects in EHV AC transmission line.*

UNIT - 1 **L-9, T-3**

E.H.V AND U.H.V: A.C. transmission line trends and preliminary aspect of standard transmission voltages, Estimation of line and ground parameters, Bundle conductor systems, Inductance and capacitance of E.H.V lines, Positive, Negative and zero sequence impedances, Line parameters for modes of propagation.

UNIT - 2 **L-9, T-3**

ELECTROSTATIC FIELD AND VOLTAGE GRADIENTS : Calculations of electrostatic field of AC lines, Effect of high electrostatic fields on biological organisms and human beings, Surface voltage gradients and maximum gradients of actual transmission lines, Electrostatic induction in un-energized lines, Measurements of field and voltage gradients for three phase single and double circuit lines.

UNIT - 3 **L-9, T-3**

POWER FREQUENCY VOLTAGE CONTROL AND OVER VOLTAGES IN E.H.V LINES: No load voltage charging currents at power frequency, Voltage control - Shunt and series compensation and Static VAR compensation.

UNIT - 4 **L-9, T-3**

CORONA IN E.H.V AND U.H.V. LINES: Corona generation, Characteristics, Effects of corona, Corona loss formula, Attenuation of traveling waves due to corona, Audio noise due to corona, Measurement of audio noise, Radio interference due to corona, RF properties of radio noise, Frequency spectrum of RI fields, Measurement of RI and RIV.

UNIT - 5 **L-9, T-3**

DESIGN OF E.H.V LINES: Design of E.H.V lines based on steady state and transient limits, E.H.V cables and their characteristics, Real world examples of EHV systems and status in India, EHV/UHV AC transmission capability analysis.

TEXT BOOKS:

1. Rakosh Das Begamudre, “Extra High Voltage AC Transmission Engineering”, 2nd edition New Age International (P) Ltd., New Delhi, 2006.
2. Narain G.Hingorani, Laszio. Gyugyl, “Understanding FACTS Concepts and Technology of Flexible AC Transmission System”, 1st edition, Standard Publishers, Delhi 2001.

REFERENCES BOOKS:

1. Allan Greenwood, “Electrical Transients in Power System”, 1st edition, Wiley & Sons Inc., New York, 2012.
2. K.R.Padiyar,”HVDC Power Transmission Systems”, New Age International (P) Ltd., 1st edition, New Delhi, 2002.

16EE451 ADVANCED POWER SYSTEM ENGINEERING

Hours Per Week :

L	T	P	C
3	1	-	4

Total Hours :

L	T	P
45	15	-

WA/RA	SSH/HSH	CS	SA	S	BS
8	40	5	8	5	5

Course Description and Objectives:

This course introduces recent trends in the areas of power system in order to deliver realiable and quality power to the consumers all the times. The objective of the course is to introduce the concepts of smart grid and distributed generation (DG) and their role in providing realiable and quality power.

Course Outcomes:

The student will be able to:

- understand requirements of smart grid.
- understand the basic concepts of distributed generation, its purpose and effects on conventional distribution system.
- understand the importance of power quality and its mitigation techniques.
- implement deregulated operation of power systems.
- learn and analyze the advanced digital protection techniques in power systems.

SKILLS:

- ✓ Distinguish smart grid from conventional grid.
- ✓ Analyze prominent benefits of distributed generation.
- ✓ Suggest suitable mitigation technique to provide power quality.
- ✓ Recognize importance of deregulated operation of power system.
- ✓ Implement suitable digital protection to power systems.

ACTIVITIES:

- *Design of Intelligent control for any load connected to supply (Ex: Motor, Light, Heater etc.)*
- *Design of simple Grid Tied Inverter for Smart Power Systems*
- *Simulate the effects due to DG in Interconnected system*
- *Simulate and observe harmonics in any non-linear load*
- *Design of simple ADC for protection system*
- *Design of simple DAC for protection system*

UNIT - 1 **L-10, T-3**

SMART GRID : Introduction, Comparison of power grid with smart grid, Power system enhancement, Communication and standards, General view of the smart grid market drivers, Functions of smart grid components, Introduction to smart meters, Advanced metering infrastructure (AMI) drivers and benefits, AMI protocols, Standards and initiatives, AMI needs in the smart grid, Smart vehicles in smart grid.

UNIT - 2 **L-9, T-3**

DISTRIBUTED GENERATION (DG): Overview and technology trends, Implications of DG on distribution system, Loop and secondary network distribution grids, Impact of DG operation, DG planning cost implications of power quality, Cost of energy, Net present value calculations and implications on power converter design, Power quality implication, Acceptable ranges of voltage and frequency, Flicker, Reactive power compensation, Active filtering and low voltage ride through requirements.

UNIT - 3 **L-9, T-3**

INTRODUCTION TO POWER QUALITY : Terms and definitions in power quality - Overloading, Over/ under voltage, Concepts of transients, Short duration and long duration, Sags and swells, Power frequency variations; Harmonic sources - Commercial and industrial loads; Locating harmonic sources, Harmonics Vs transients, Effect of harmonics, Harmonic distortion, Harmonic indices, Quality measurement equipment, Harmonic / spectrum analyzer.

UNIT - 4 **L-8, T-3**

INTRODUCTION TO RESTRUCTURED POWER SYSTEMS: Introduction, Reasons for restructuring / deregulation of power industry, Understanding the restructuring process, Issues involved in deregulation, Reasons and objectives of deregulation of various power systems across the world.

REFORMS IN INDIAN POWER SECTOR: Introduction, Framework of Indian power sector, Working mechanism of ABT, Auction phenomenon, Congestion management, Reforms in future.

UNIT - 5 **L-9, T-3**

DIGITAL PROTECTION OF POWER SYSTEMS : Introduction to digital protection, Digital against analog processing techniques, Advantages of using digital techniques in power system protection, Structure and operation of digital protection system, Digital relay structure, Anti aliasing filters, Sampling of input signals, Analog to digital conversion, Organization of hierarchical protection systems.

TEXT BOOKS:

1. James Momoh, “Smart Grid: Fundamentals of design and analysis”, 1st edition, John Wiley & Sons Inc, IEEE Press 2012.
2. P. Venkatesh, B. V. Manikandan, S. Charles Raja, A. Srinivasan, “Electrical Power Systems: Analysis, Security And Deregulation”, 1st edition, PHI Learning Private Limited, New Delhi, 2012.

REFERENCES BOOKS:

1. Ned Mohan, Tore M. Undeland, William P. Robbins, “Power Electronics: Converters, Applications, and Design”, 3rd edition, Wiley, 2002.
2. Arthur R. Bergen and Vijay Vittal, “Power Systems Analysis”, 2nd edition, Prentice Hall, 1999.

16EE452 HIGH VOLTAGE ENGINEERING

Hours Per Week :

L	T	P	C
3	1	-	4

Total Hours :

L	T	P
45	15	-

WA/RA	SSH/HSH	CS	SA	S	BS
8	40	5	8	5	5

Course Description and Objectives:

This course introduces the basic concepts of high voltage generation, measuremetns and testing of high voltage equipments in the system. The objective of the course is to understand failure mechanisms of solids, liquids and gaseous insulation and their usage in high voltage underground cables, over head transmission lines and transformers.

Course Outcomes:

The student will be able to:

- understand the methods of generating high DC, AC and Impulse voltages.
- develop equivalent circuit models of the different high voltage generators.
- understand the behaviour of high voltage measuring instruments.
- calculate the breakdown strength of gas-filled insulation systems with simple geometrics.

SKILLS:

- ✓ *Determine break down strength of different insulation mediums.*
- ✓ *Suggest appropriate insulation for a given electrical equipment.*
- ✓ *Design of high voltage DC generator circuit.*
- ✓ *Design of CVT for measuring High voltages.*
- ✓ *Testing of electrical equipments at different voltage levels.*

ACTIVITIES:

- *Design and implementation of multi stage voltage multiplayer*
- *Design of impulse voltage generator*
- *Testing of transformer oil and solid instillation*
- *Design and implementation of peak voltmeter*

UNIT - 1 **L- 10, T-3**

INTRODUCTION TO HIGH VOLTAGE TECHNOLOGY AND APPLICATIONS : Electric field stresses, Gas / Vacuum as insulator, Liquid dielectrics, Solids and composites, Surge voltages, Distribution and control, Applications of insulating materials in transformers, Rotating machines, Circuit breakers, Cable, Power capacitors and bushings.

UNIT - 2 **L-9, T-3**

CONDUCTION AND BREAK DOWN IN GASES, LIQUIES AND SOLID DIELECTRICS : Gases as insulating media, Townsend's criteria of breakdown in gases, Break down in electro negative gases, Time lags for break down, Streamer theory of break down in gases, Paschen's law, Pure and commercial liquids, Breakdown in pure and commercial liquids, Intrinsic breakdown, Electromechanical breakdown, Thermal breakdown, Breakdown in composite dielectrics.

UNIT - 3 **L-8, T-3**

GENERATION OF HIGH VOLTAGES AND CURRENTS : Generation of high direct current voltages, Generation of high alternating current voltages, Generation of impulse voltages, Generation of impulse currents, Tripping and control of impulse generators.

UNIT - 4 **L-9, T-3**

MEASUREMENT OF HIGH VOLTAGES AND CURRENTS : Measurement of high direct current voltages, Measurement of high alternating and impulse voltages, Measurement of high currents - Direct, Alternating and impulse; Oscilloscope for impulse voltage and current measurements.

UNIT - 5 **L-9, T-3**

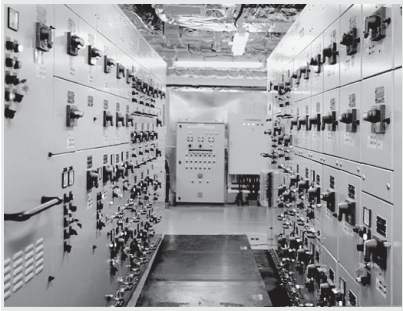
HIGH VOLTAGE TESTING OF ELECTRICAL APPARATUS: Measurement of D.C resistivity, Measurement of dielectric constant and loss factor, Partial discharge measurements, Testing of Insulators and bushings, Testing of cables, Testing of transformers, Radio Interference measurements.

TEXT BOOKS:

1. M.S.Naidu and V. Kamaraju, "High Voltage Engineering" 3rd edition, Tata MC-Graw Hill Publications, 2009.
2. E.Kuffel, W.S.Zaengl, J.Kuffel by Elsevier, "High Voltage Engineering Fundamentals", 2nd edition., Elsevier, 2008.

REFERENCE BOOKS:

1. C.L.Wadhwa, "High Voltage Engineering", 3rd edition, New Age Internationals (P) Limited, 2010.
2. Ravindra Arora, Wolfgang Mosch, "High Voltage Insulation Engineering", 1st edition, New Age International (P) Limited, 2005.



16EE453 ADVANCED SWITCH GEAR FOR POWER SYSTEMS

Hours Per Week :

L	T	P	C
3	1	-	4

Total Hours :

L	T	P
45	15	-

WA/RA	SSH/HSH	CS	SA	S	BS
8	40	-	8	5	-

Course Description and Objectives:

This course introduces advanced concepts of protection for different power system equipments as an extention of switch gear and protection course. The objective of the course is to design various schemes of over current protection, analyze distance, carrier, busbar and numerical protection including microprocessor based protective systems.

Course Outcomes:

The student will be able to:

- understand static over current schemes.
- comprehend how long transmission lines transfer power as well as carrier signals for protection.
- interpret different microprocessor based relaying schemes.
- develop microprocessor based protection mechanism for simple EHV transmission system.

SKILLS:

- ✓ *Design amplitude and phase comparator.*
- ✓ *Suggest proper protection schemes for transformers and generators.*
- ✓ *Suggest proper protection schemes for transmission lines.*
- ✓ *Realize microprocessor based protection scheme for AC transmission system.*

ACTIVITIES:

- *Design amplitude comparator using transistor.*
- *Design phase comparator using transistor.*
- *Design static over current relay using transistor.*
- *Design microprocessor based over current relay.*
- *Design microprocessor based distance relay.*

UNIT - 1 **L-9, T-3**

CLASSIFICATION OF STATIC RELAYS: Basic construction of static relays, Classification of protective schemes, Comparison of Static relays with electromagnetic relays, Amplitude comparator, Phase comparator, Principle of duality.

UNIT - 2 **L-10, T-3**

STATIC OVER CURRENT RELAYS: Instantaneous - Definite time, Inverse time, Directional, IDMT, Very inverse time, Extremely inverse time over current relays, Time current characteristics of over current relays, Applications.

DISTANCE PROTECTION: Static impedance Relay, Static reactance relay, Static MHO relay and their operating principle, Relay characteristic and protective schemes.

UNIT - 3 **L-9, T-3**

PILOT RELAYING SCHEMES: Wire pilot protection, Circulating current scheme, Balanced voltage scheme, Translay scheme, Half wave comparison scheme, Carrier current protection - Phase comparison type, Carrier aided distance protection.

UNIT - 4 **L-8, T-3**

MICROPROCESSOR BASED PROTECTIVE RELAYS–I: Introduction to microprocessor base over current relays, Impedance relay and directional relay, Algorithm and flow chart.

UNIT - 5 **L-9, T-3**

MICROPROCESSOR BASED PROTECTIVE RELAYS–II: Generalized mathematical expression for distance relays, Measurement of R & X, mho and off set mho Relays for microprocessor based relays, Algorithm and flow chart.

TEXT BOOKS:

1 C. Christopoulos and A. Wright, “Electrical Power System Protection”, Springer Science, 2nd edition, 2013.

2 Badri Ram and DN Vishwakarma, “Power system protection and switch gear”, 22nd Reprint, Tata Mc-Graw Hill, 2007.

REFERENCE BOOKS:

1. Y.G. Paithankar and S.R Bhide, “Fundamentals of Power System Protection”, 1st edition, Prentice Hall of India, 2004.

2. Stanley Horowitz, “Protective Relaying for Power System-II”, 4th edition, IEEE press, New York, 2013.

3 T.S.M. Rao, “Digital / Numerical Relays”, 2nd edition, Tata Mc-Graw Hill, New Delhi, 2005.

16EE252 ALTERNATE ENERGY RESOURCES

Hours Per Week :

L	T	P	C
3	1	-	4

Total Hours :

L	T	P
45	15	-

WA/RA	SSH/HSH	CS	SA	S	BS
8	40	-	8	5	-

Course Description and Objectives:

This course deals with the types, purpose and operation of alternate energy technologies. The objective of the course is to understand the implementation of geothermal energy, ocean energy and biomass energy resourses, know the possibilities of energy storage and various technologies involved in it.

Course Outcomes:

The student will be able to:

- understand the components and operation of geothermal power plant.
- compare the operation of tidal and OTEC power plants.
- explore feasibility of hydrogen usage in fuel cells.
- identify possible energy storage technologies

SKILLS:

- ✓ Identify different types of Renewable energy resources.
- ✓ Differentiate between various biomass energy conversion routes.
- ✓ Select appropriate batteries for specific applications.
- ✓ Identify appropriate energy storage options.

ACTIVITIES:

- *Review status aspects of geothermal energy in the World.*
- *Choose a Battery for a cell-phone/ laptop /tablet/ adapter/for various ratings…*
- *Design a prototype of biogas plant.*
- *Review status aspects of ocean energy in India and World.*
- *Review possible energy storage options for renewable energy systems.*

UNIT - 1 **L-9, T-3**

GEOTHERMAL ENERGY : Availability of geothermal energy, Size and distribution, Recovery of geothermal energy, Types of systems using geothermal energy - Direct heat applications, Power generation; Sustainability of geothermal source, Status of geothermal technology, Economics of geothermal energy.

UNIT - 2 **L-10, T-3**

OCEAN ENERGY : Ocean and tidal energy conversion, Energy sources in ocean - Ocean tidal, wave and thermal energy; Ocean saline gradient concept, Ocean currents, Ocean chemical energy, Ocean energy conversion routes - Electrical and non electrical routes, Advantages and merits of ocean energy technologies, Limitation; Tides - Spring tide, Neap tide, Daily and monthly variation, Tidal range, Tidal power; Types of tidal power plants - Single basin and double basin schemes; Main requirements in tidal power plants, Energy storage, Prospects of tidal power, Economic factors, Ocean Thermal energy conversion (OTEC), Open and closed cycle operation, Ecological and environmental impacts.

UNIT - 3 **L-9, T-3**

BIOMASS ENERGY : Photosynthesis and origin of biomass energy, Biomass energy resources - Cultivated biomass resources, Waste to biomass resources; Terms and definitions, Incineration, Wood and wood waste, Harvesting super trees and energy forests, Pyrolysis, Thermo chemical biomass conversion to energy, Gasification, Anaerobic digestion, Fermentation, Gaseous fuel from biomass, Design of a bio gas plant.

UNIT - 4 **L-8, T-3**

HYDROGEN AND FUEL CELLS: Hydrogen as a renewable energy source, Sources of hydrogen, Fuel for vehicles, Fuel cell technology – Types, Principle of working, construction, Power generation, Fuel cell polarization curve; Conversion of chemical energy into electricity in a fuel cell, Fuel cell power plant structure, Fuel processor and fuel cell stack, Applications, Cogeneration, Fuel cell electric vehicles.

UNIT - 5 **L-10, T-3**

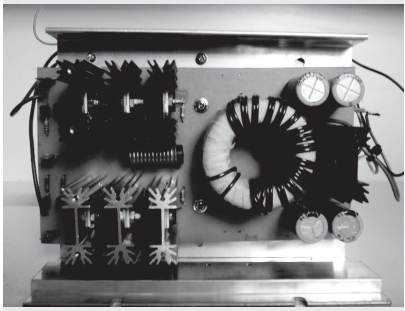
ALTERNATE ENERGY STORAGE TECHNOLOGIES: Necessity of energy storage, Types of energy storage - Flywheel, Super capacitors, Principles and methods, Applications; Fundamental concept of batteries - Measuring of battery performance, Charging and discharging of a battery, Storage density, Energy density and safety issues; Types of batteries – Lead Acid, Nickel, Cadmium, Zinc Manganese dioxide; Introduction to modern batteries - Zinc-Air, Nickel hydride and lithium batteries.

TEXT BOOKS:

1. G.D. Rai, “Non Conventional Energy Sources”, 4th edition, Khanna Publishers, New Delhi, 2011.
2. Anne-Marie Borbely, Jan F.Kreider, “Distributed Generation”, 1st edition, CRC Press, 2001.

REFERENCES BOOKS:

1. S.P. Sukhatme, J.K.Nayak., “Solar Energy”, 3rd edition, Tata Mc-Graw Hill Education Private Limited, New Delhi, 2010.
2. Godfrey Boyle, “Renewable Energy, Power for a Sustainable Future”, 1st edition, Oxford University Press, U.K., 2012.
3. Chauhan D.S., Srivastava S.K. “Non-Conventional Energy Resources”, 1st edition, New Age, 2009.
4. Georgiadis M.C., “Energy Systems Engineering”, 1st edition, Wiley-VCH, 2008.
5. Viswanathan B., “Fuel Cell Principles and Applications”, 1st edition, Universities Press, India, 2006.
6. Rajput R.K., “Power Plant Engineering”, 4thEdition, Laxmi Publications, 2008.



16EE353 POWER SEMICONDUCTOR DEVICES AND PASSIVE COMPONENTS

Hours Per Week :

L	T	P	C
3	1	-	4

Total Hours :

L	T	P
45	15	-

WA/RA	SSH/HSH	CS	SA	S	BS
8	40	-	8	5	-

Course Description and Objectives:

This course introduces the basic concepts of different power semiconductor devices and analyze their performances. The objective of the course is to analyze switching losses in power devices ,design of required protection, cooling and heat sinks for power semiconductor devices.

Course Outcomes:

The student will be able to:

- understand switching characteristics of various power semi conductor devices.
- select components suitable for desired operation of power electronic circuits.
- understand requirements of protection circuits for power semiconductor devices.
- design suitable cooling and heat sinks for power semi conductor devices.

SKILLS:

- ✓ *suggest appropriate switch for power electronic converters.*
- ✓ *design protection circuit for power semi conductor devices.*
- ✓ *specify and design heat sink for power semi conductor devices.*
- ✓ *explore posibilities of converter failures.*

ACTIVITIES:

- *Design variable power supply charger*
- *Design linear voltage regulator*
- *Design Preamplifier for Phones*
- *Design Sensitive Moisture Detector*
- *Design grid tie inverter.*

UNIT – 1 **L-10, T-3**

POWER BJT: Operation, I-V characteristics - Static and switching characteristics; Second break down, On-state losses, Safe operation areas, Design of Snubber circuits for BJTs.

POWER MOSFETS: Operation, I-V characteristics - Static and switching characteristics; Operation limitations, Safe operating areas, Design of snubber circuits MOSFETs.

UNIT – 2 **L-9, T-3**

GATE TURN-OFF THYRISTORS: Operation, I-V characteristics - Static and switching characteristics; Snubber circuits, Protection of GTOs.

I**NSULATED GATE BIPOLAR TRANSISTORS:** Operation, I-V characteristics - Static and switching characteristics; Safe operating areas, Design of snubber circuits for IGBTs.

UNIT – 3 **L-8, T-3**

EMERGING DEVICES AND CIRCUITS :Operation and static I-V characteristics of power junction field effect transistors, Field controlled thyristor, JFET and MOS controlled thyristors.

UNIT – 4 **L-9, T-3**

PASSIVE COMPONENTS AND ELECTROMAGNETIC COMPATIBILITY: Design of inductor and transformer, Selection of capacitors and resistors, Current measurements,Heat sinking circuit layout.

ELECTROMAGNETIC INTERFERENCE (EMI): Sources of EMI, Electromagnetic interference in power electronic equipments.

UNIT – 5 **L-9, T-3**

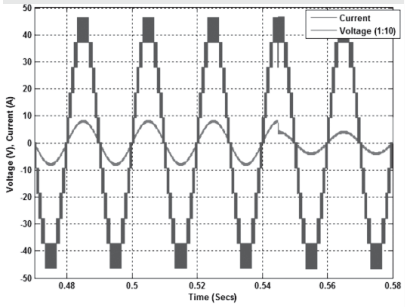
PROTECTION OF DEVICES: Thermal modeling of power switching devices, Snubber circuits, Reverse recovery transients, Supply and load side transients, Voltage protections, Current protections.

TEXT BOOKS :

1. Muhammad H. Rashid, “Power Electronics - Circuits, Devices and Applications”, Academic Press, New Delhi, 2nd edition, 2006.
2. Mohan, Ned. et.al, “Power Electronics Converters, Applications and Design”, Wiley India Pvt. Ltd., New Delhi, 3rd edition 2007.

REFERENCE BOOKS:

1. B. Jayant Baliga, “Fundamentals Of Power Semiconductor Devices”, Springer-Verlag Publication, New Delhi , 1st edition, 2008.
2. Robert Perret, “Power Electronics Semiconductor Devices”, Wiley-ISTE Publications, New Delhi , 1st edition, 2009.
3. Muhammad H. Rashid, “Power Electronics Hand Book”, Academic Press, New Delhi, 1st edition, 2001.



16EE354 ANALYSIS OF INVERTERS

Hours Per Week :

L	T	P	C
3	-	2	4

Total Hours :

L	T	P
45	-	30

WA/RA	SSH/HSH	CS	SA	S	BS
8	40	-	8	5	-

Course Description and Objectives:

This course introduces differnt types of inverters and their design for various applications. The objective of course is to introduce power electronic concept behind operation of various inverters so as to enable to get profound knowledge on analysis and application of different single phase and three phase inverters.

Course Outcomes:

The student will be able to:

- suggest appropriate switching device for an inverter.
- select different firing and protection circuit for various inverters.
- difference between VSI and CSI.
- understand the importance of multi level inverters.

SKILLS:

- ✓ *Design of Pulse Width Modulation (PWM) technique for Inverters.*
- ✓ *Design diode clamped multilevel inverter for specific application.*
- ✓ *Implement space vector modulation scheme for VSI.*
- ✓ *Design cascade type multilevel inverter.*

ACTIVITIES:

- *Design PWM generator.*
- *Design a SPWM inverter for speed control of AC motor.*
- *Design a SVPWM inverter for torque control of AC motor.*
- *Compare THD with various PWM techniques.*
- *Design NPC based inverter for home UPS.*

UNIT - 1 **L- 10**

SINGLE PHASE INVERTERS : Introduction to self commutated switches - MOSFET and IGBT; Operation of half and full bridge inverters , Performance parameters of half and full bridge inverters, Voltage control of single phase inverters using various PWM techniques.

UNIT - 2 **L- 10**

THREE PHASE VOLTAGE SOURCE INVERTERS: Operation of inverter with 180 degree and 120 degree conduction mode with star and delta connected loads, Voltage control of three phase inverters - Single, Multi pulse and sinusoidal PWM techniques.

UNIT - 3 **L- 09**

CURRENT SOURCE INVERTERS: Operation of six-step thyristor inverter , Inverter operation modes, Load commutated inverters, Auto sequential current source inverter (ASCI), Comparison of current source inverter and voltage source inverters.

UNIT - 4 **L- 08**

MULTILEVEL INVERTERS: Types and operation of multi level inverters – Diode clamped, Flying capacitor and cascade; Comparison of multilevel inverters.

UNIT - 5 **L- 08**

RESONANT INVERTERS: Types - Series and parallel resonant inverters; Voltage control of resonant inverters, Operation of class E resonant inverter, Resonant DC link inverter.

LABORATORY EXPERIMENTS

LIST OF EXPERIMENTS Total hours: 30

1. Characteristics of MOSFET.
2. Characteristics of IGBT.
3. Different types of forced commutation techniques.
4. Load voltage in 180 degree conduction mode inverter.
5. Load voltage in 120 degree conduction mode inverter.
6. Analysis of Voltage source inverter.
7. Analysis of Series resonant inverter.
8. Analysis of Parallel resonant inverter.
9. Analysis of Class E resonant inverter
10. Analysis of resonant DC link inverters.

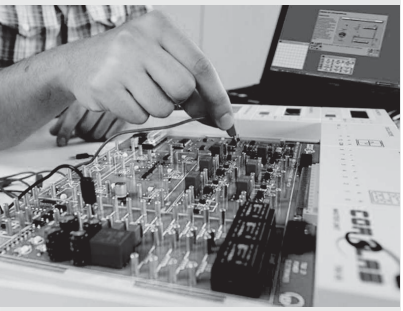
TEXT BOOKS:

1. Rashid M.H., "Power Electronics Circuits, Devices and Applications", Prentice Hall of India, 3rd edition, New Delhi, 2004.
2. Jai P. Agrawal, "Power Electronics Systems", Pearson Education, 2nd edition, 2002.

REFERENCE BOOKS:

1. Reissland, M.U, "Electrical Measurements: Fundamentals, Concepts, Applications" 1st edition, New Age International (P) Ltd. Publishers, 2010.
2. J.B. Gupta, "Electronic and Electrical Measurements and Instrumentation", 12th edition., S.K. Katharia, 2006.
3. Bimal K.Bose "Modern Power Electronics and AC Drives", Pearson Education, 2nd edition, 2003.

STREAM-2 ELECTIVE



16EE454 DESIGN OF POWER ELECTRONIC SYSTEMS

Hours Per Week :

L	T	P	C
3	-	2	4

Total Hours :

L	T	P
45	-	30

WA/RA	SSH/HSH	CS	SA	S	BS
8	40	-	8	5	-

Course Description and Objectives:

This course introduces the design of auxillary components used to support a power electronic circuit such as magnetic, thermal and protective elements. The objective of course is to analysis and design of inductors, transformers, heat sinks and driver circuits for converters.

Course Outcomes:

The student will be able to:

- specify various magnetic components for power semiconductor devices.
- specify design criteria (power, efficiency, ripple voltage and current, harmonic distortions, power factor) for a converter circuit.
- design driver circuits for converter.
- design of heat sink for power electronic devices.

SKILLS:

- ✓ *Design of gate driver circuits for different power semi conductor switches.*
- ✓ *Design of suitable flyback converter for an application.*
- ✓ *Design of suitable forward converter for an application.*
- ✓ *Design of suitable buck-boost converter for an application.*

UNIT - 1 **L-9**

DESIGN OF MAGNETICS COMPONENTS: Concept of magnetic materials , Core and copper winding, Thermal considerations of magnetic materials.

UNIT - 2 **L-10**

DESIGN OF INDUCTORS: Analysis and design of specific Inductor, Inductor design procedure, Numerical problems.

DESIGN OF TRANSFORMERS: Analysis and design of specific transformer, Eddy currents, Transformer leakage inductance, Transformer design procedure, Numerical problems.

UNIT - 3 **L-10**

GATE AND BASE DRIVER CIRCUITS: Different driver circuits - DC coupled drive circuits, Electrically isolated drive circuits and cascode connected drive circuits; Design of thyristor drive circuit, Power device protection in drive circuits.

UNIT - 4 **L-8**

HEAT SINKS: Control of semiconductor device temperature, Heat transfer by conduction, Heat sinks, Heat transfer by radiation and convection.

UNIT - 5 **L-8**

DESIGN OF CONVERTERS: Design of single phase full bridge AC/DC converters, Design of DC-DC converters - Buck, Boost, Buck-boost, Flyback and forward converter.

ACTIVITIES:

- *Design of Gate driver circuits for different power semi conductor switches.*
- *Design flyback converter for Laptop charger*
- *Design flyback converter for LED lighting system*
- *Design flyback converter for Mobile phone charger*
- *Design forward converter LED lighting system*
- *Design forward converter Laptop charger*
- *Design forward converter Mobile phone charger*

LABORATORY EXPERIMENTS

LIST OF EXPERIMENTS Total hours: 30

Design and implementation of :

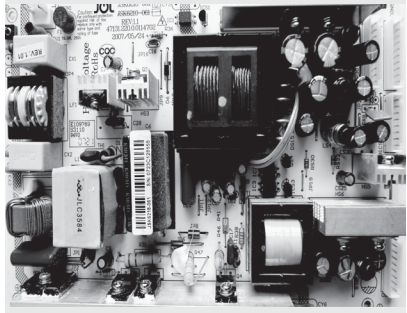
1. Magnetic components in converters.
2. Inductor for flyback converter .
3. Transformer for flyback converter.
4. Gate and base driver circuits for flyback converter .
5. Gate and base driver circuits for forward converter .
6. Gate and base driver circuits for buck converter.
7. Gate and base driver circuits for boost converter.
8. Gate and base driver circuits for buck boost converter.
9. Heat sinks for thyristor.
10. Inductor, capacitor for buck – boost converter.

TEXT BOOKS :

1. Muhammad H. Rashid, “Power Electronics - Circuits, Devices and Applications”, Academic Press, New Delhi, 2nd edition, 2006.
2. Mohan, Ned. et.al, “Power Electronics Converters, Applications and Design”, Wiley India Pvt. Ltd., New Delhi, 3rd edition 2007.

REFERENCE BOOKS:

1. B. Jayant Baliga, “Fundamentals of Power Semiconductor Devices”, Springer-Verlag Publication, New Delhi, 1st edition, 2008.
2. Robert Perret, “Power Electronics Semiconductor Devices”, Wiley-ISTE Publications, New Delhi, New Edition, 2009.



16EE455 SMPS BASED CONVERTERS

Hours Per Week :

L	T	P	C
3	1	-	4

Total Hours :

L	T	P
45	15	-

WA/RA	SSH/HSH	CS	SA	S	BS
8	40	5	8	5	5

Course Description and Objectives:

This course introduces the analysis of various SMPS based converters and their modeling. The objective of course is to understand the concept of SMPS and choose proper SMPS based converters for building drivers.

Course Outcomes:

The student will be able to:

- model and analyze fly back converter.
- model and analyze a forward converter.
- model and analyze luo converter.
- model half bridge and full bridge converter.

SKILLS:

- ✓ *Implement different PWM techniques for converters.*
- ✓ *Design flyback converter.*
- ✓ *Implement forward converter.*
- ✓ *Design luo converter.*

ACTIVITIES:

- *Design flyback converter for LED driver circuit.*
- *Design forward converter for solar fed DC drive applications.*
- *Design luo converter for hybrid electric vehicle applications.*
- *Design DC-DC charge pumping voltage doubler circuit.*

UNIT - 1 **L-9, T-3**

SMPS : Introduction to SMPS, Circuit description of SMPS, Types of SMPS, Different PWM techniques for SMPS.

UNIT - 2 **L-9, T-3**

FLYBACK CONVERTER: Analysis of flyback converter, State space model of flyback converter, Design of control circuit for flyback converter, Applications, Numerical problems.

UNIT - 3 **L-9, T-3**

FORWARD CONVERTER: Analysis of forward converter, State space model of forward converter, Design of control circuit for forward converter, Applications, Numerical problems.

UNIT - 4 **L-9, T-3**

LUO CONVERTER: Analysis of luo converter, State space model of luo converter, Design of control circuit for luo converter, Applications, Numerical problems.

UNIT - 5 **L-9, T-3**

HALF BRIDGE AND FULL BRIDGE CONVERTER: Analysis of half bridge and full bridge converters, State space model of half bridge and full bridge converter, Design of control circuit for half bridge and full bridge converters, Applications.

TEXT BOOKS:

1. M.H. Rashid ,“Power Electronics Handbook”, Elsevier Publication, 2001.
2. Kjeld Thorborg, “Power Electronics – In Theory and Practice”, 1st edition,Overseas Press, 2005.

REFERENCE BOOKS:

1. Ned Mohan, Tore. M.Undeland, William. P.Robbins, “Power Electronics converters, Applications and design”,3rd edition, John Wiley and Sons,2006.
2. M.H. Rashid,”Power Electronics circuits, devices and applications” ,3rd edition, Prentice Hall of India, New Delhi, 2007.

16EE456 ADVANCED CONTROL SYSTEMS

Hours Per Week :

L	T	P	C
3	-	2	4

Total Hours :

L	T	P
45	-	30

WA/RA	SSH/HSH	CS	SA	S	BS
5	40	-	8	5	-

Course Description and Objectives:

This course introduces the mathematical modelling, different methods of analysis and design of nonlinear systems. The objective of the course is to understand the concept of state variable analysis, controllability and observability, and applying them for stability analysis techniques.

Course Outcomes:

The student will be able to:

- formulate state space model of physical systems.
- model non linear control systems.
- analyze stability status of non linear systems.
- design controllers for nonlinear systems..

SKILLS:

- ✓ *Model any nonlinear system (Electrical, Mechanical, Electro-mechanical).*
- ✓ *Analyze nonlinear systems using describing function and phase plane technique.*
- ✓ *Analyze stability using lyapunov method.*
- ✓ *Design state feedback controller for the given specifications.*
- ✓ *Design state observer for the given specifications.*

ACTIVITIES:

- *Model any non linear system in state variable form*
- *Analyze the stability status of any nonlinear control system*
- *Design state feedback controller for DC and AC motors*

UNIT - 1 **L-10**

STATE SPACE ANALYSIS: State space representation, Solution of state equation, State transition matrix, Canonical forms – Controllable, Observable and jordan canonical forms.

CONTROLLABILITY AND OBSERVABILITY : Tests for controllability and observability for continuous time systems.

UNIT - 2 **L-8**

DESCRIBING FUNCTION ANALYSIS: Introduction to nonlinear systems, Types of nonlinearities, Describing functions, Describing function analysis of nonlinear control systems.

UNIT - 3 **L-8**

PHASE-PLANE ANALYSIS: Introduction to phase-plane analysis, Method of isoclines for constructing trajectories, Singular points, Phase-plane analysis of nonlinear control systems.

UNIT - 4 **L-10**

STABILITY ANALYSIS: 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 - 5 **L-9**

MODAL CONTROL: Effect of state feedback on controllability and observability, Design of state feedback control through pole placement, Full order observer and reduced order observer.

LABORATORY EXPERIMENTS

LIST OF EXPERIMENTS Total hours: 30

1. Time response analysis of non linear system using MATLAB.
2. Study of characteristics of of non linearities.
3. State space modeling of DC generator.
4. Describing function analysis of non linear system using MATLAB.
5. Phase-plane analysis of non linear system using MATLAB.
6. Lyapunov stability analysis of non linear system using MATLAB.
7. Design of state feedback controller and simulation for DC motor using MATLAB.
8. Design of state feedback controller and simulation for AC motor using MATLAB.
9. Design of state observer and simulation for DC motor using MATLAB.
10. Design of state observer and simulation for AC motor using MATLAB.

TEXT BOOKS:

1. M. Gopal, " Modern Control System Theory", New Age International Publishers, 3rd edition, 2005.
2. Katsuhiko Ogata, " Modern Control Engineering " ,5 th edition, Prentice Hall of India Private Ltd., New Delhi, 2010.

REFERENCE BOOKS:

1. I. J. Nagrath and M. Gopal, "Control Systems Engineering", 2nd edition, New Age International (P) Limited, 2010.
2. Benjamin C Kuo, " Automatic Control system ", 1st edition, Prentice Hall of India Private Ltd., New Delhi, 2009.
3. Stainslaw H. Zak, "Systems and Control" , 1st edition, Oxford Press, 2003.

16EE355 UTILIZATION OF ELECTRICAL ENERGY

Hours Per Week :

L	T	P	C
3	1	-	4

Total Hours :

L	T	P
45	15	-

WA/RA	SSH/HSH	CS	SA	S	BS
5	40	-	8	5	5

Course Description and Objectives:

This course introduces the fundamentals of electrical drives, illumination, electric heating, welding and traction systems. The objective of the course is to provide an opportunity to study varieties of electric drives and their application to electrical traction systems. It also deals with types of lamps, lightning schemes, light control methods, electrical welding techniques and heating methods employed in industry.

Course Outcomes:

The student will be able to:

- analyze heating and cooling curves of electrical drives.
- understand the heating and welding practices in industries.
- design the lightning control and lighting schemes for a working area.
- calculate the specific energy consumption in traction systems.

SKILLS:

- ✓ *Design simple cooling system for motor, for any given application.*
- ✓ *Design heating element for given application.*
- ✓ *Design lighting scheme for given working area.*
- ✓ *Analyze existing traction systems in nearby railway station.*

ACTIVITIES:

- *Suggest a drive for lifts, electric hammers, punching machine.*
- *Design of heating element for ovens and water immersion heaters.*
- *Design and implementation of appropriate lighting scheme for industries and organizations.*
- *Design and testing of simple electric locomotive*

UNIT – 1 **L-9, T-3**

UTILIZATION AND CONTROL OF ELECTRIC DRIVES : Introduction, Factors governing selection of electric motors, Type of electric drives - Starting and running characteristics, Speed control and temperature rise; Choice of motor rating, Control devices for industrial motors, Motors for particular services, Load equalization.

UNIT – 2 **L-9, T-3**

ELECTRIC HEATING AND ELECTRIC WELDING : Introduction, Methods of heat transfer, Classification of electric heating methods - 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 – 3 **L-8, T-3**

ILLUMINATION ENGINEERING : Introduction, Terms used in illumination, Laws of illumination, Polar curves, Photometry, Integrating sphere, Sources of light - MV and SV lamps, Tungsten filament lamps and fluorescent lamps; Basic principles of light control, Types of lighting schemes, Flood lighting, Methods of lighting calculations.

UNIT – 4 **L-10, T-3**

TRACTION SYSTEMS : Introduction, Different systems of traction, Systems of electric traction, Systems of track electrification. General features of traction motor, Operating characteristics of D.C. motors and three phase induction motor, Methods of electric braking - Plugging, Rheostatic braking and regenerative braking.

UNIT – 5 **L-9, T-3**

TRAIN MOVEMENT AND ENERGY CONSUMPTION : Mechanics of train movement, Typical 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 and coefficient of adhesion.

TEXT BOOKS:

1. E. Openshaw Taylor, “Utilisation of Electric Energy”, 1st edition., Orient Longman, 2006.
2. Partab, “Art & Science of Utilization of electrical Energy”, 3rd edition, Dhanpat Rai & Sons, 2006.

REFERENCE BOOKS:

1. N.V. Suryanarayana, “Utilization of Electrical Power including Electric drives and Electric traction”, 1st edition, New Age International (P) Limited Publishers, 1994.
2. C.L. Wadhwa, “Generation, Distribution and Utilization of electrical Energy”, 3rd edition, New Age International (P) Limited Publishers, 2010.

16EE356 ENERGY AUDIT, CONSERVATION AND MANAGEMENT

Hours Per Week :

L	T	P	C
3	1	-	4

Total Hours :

L	T	P
45	15	-

WA/RA	SSH/HSH	CS	SA	S	BS
5	40	-	8	5	-

Course Description and Objectives:

This course deals with audit, conservation and management of electrical energy. The objective of the course is to introduce the concepts of energy efficient lighting, space heating and ventilation. This also deals with co-generation, tri-generation and waste heat recovery techniques.

Course Outcomes:

The student will be able to:

- understand energy conservation principles.
- analyze energy conservation in thermal systems.
- analyze energy conservation in electrical systems.
- apply basic concepts of energy management.

SKILLS:

- ✓ *Implement the energy conservation measures for various equipment.*
- ✓ *Analyze different lighting schemes.*
- ✓ *Design a capacitor bank for an energy utility.*
- ✓ *Perform energy audit for an energy utility.*

ACTIVITIES:

- *Survey the air–conditioning systems in VFSTRU to implement energy conservation measures.*
- *Survey the VFSTRU to modify the existing lighting schemes.*
- *Design the capacitor bank for improving the power factor of VFSTRU .*
- *Energy auditing of different blocks in VFSTRU.*

UNIT - 1 **L-9, T-3**

BASIC PRINCIPLES OF ENERGY MANAGEMENT : Energy scenario, Energy Management, Strategies, Energy conservation, Energy audit, Types of audit, Sankey diagrams, Load profiles, Energy conservation schemes and energy saving potential, Energy Instruments, Watt-hour meter, Data loggers, Thermocouples, Pyrometers, Lux meters, Tong testers, Power analyzer.

UNIT - 2 **L-9, T-3**

CO-GENERATION, TRI-GENERATION AND WASTE ENERGY RECOVERY: Co-generation and tri-generation, Need, Application, Advantages, Classification and saving potential, Waste heat recovery - Concept of conversion efficiency, Energy waste, Waste heat recovery classification, Advantages and applications, Commercially viable waste heat recovery devices.

UNIT - 3 **L-10, T-3**

ENERGY EFFICIENT LIGHTING : Modification of existing systems, Replacement of existing systems, Priorities, Definition of terms and units, luminous efficiency, Polar curve, Calculation of illumination level, Illumination of inclined surface to beam, Luminance or brightness, Types of lamps, Types of lighting, Electric light fittings (luminaries), Flood lighting, White light LED and conducting polymers, Energy conservation measures.

UNIT - 4 **L-9, T-3**

ENERGY EFFICIENCY IN ELECTRICAL APPLIANCES: Power factor, Causes of low p.f., Methods of Improving p.f. - Static Capacitors, Synchronous condensers phase advancer; Most economical p.f. for constant KW load and constant KVA type loads, Numerical problems, Location of improvement, Location of capacitors, p.f. with non-linear loads, Effect of harmonics on p.f., Motor controllers, Energy efficient motors (basic concepts), Load scheduling and shifting, Demand side management.

UNIT - 5 **L-8, T-3**

ENERGY EFFICIENCY IN SPACE HEATING AND VENTILATION: Ventilation, Air-conditioning (HVAC) and Water heating, Heating of buildings, Transfer of heat, Space heating methods, Insulation, Cooling load, Electric water heating systems, Energy conservation methods.

TEXT BOOKS:

1. W. R. Murphy & F. McKay Butter wort, “Energy management”, 1st edition, Elsevier publications. 2012.
2. John. C. Andreas, “Energy efficient electric motors”, 2nd edition, Marcel Inc Ltd., 1995.

REFERENCE BOOKS:

1. S C Tripathy, “Electric Energy Utilization and Conservation”, 1st edition, Tata Mc-Graw Hill Publishing company Ltd., New Delhi.
2. Paul o’ Callaghan, “Energy management”, 1st edition, Mc-Graw Hill Book Company, 1998
3. V.K Mehta and Rohit Mehta, “Principles of Power Systems”, 1st edition, S.Chand & Company Ltd., New Delhi, 2009.
4. Reay, D.A., “Industrial energy conservation”, 1st edition, Pergamon Press, 2003.
5. White, L. C., “Industrial Energy Management and Utilization”, 1st edition, Hemisphere Publishers, 2002.
6. Beggs, Clive, “Energy – Management, Supply and Conservation”, 2nd edition, Taylor and Francis, 2009.
7. Smith, C.B., Energy “Management Principles”, 1st edition, Pergamon Press, 2006.

16EE457 ENERGY ECONOMICS

Hours Per Week :

L	T	P	C
3	1	-	4

Total Hours :

L	T	P
45	15	-

WA/RA	SSH/HSH	CS	SA	S	BS
5	40	-	8	5	-

Course Description and Objectives:

This course deals with the economic concepts and theories related to the supply and utilization of energy resources and technologies at various levels - economy, firm and individual. The objective of the course is to introduce economic tools, empirical data for economic analysis in the energy systems domain to support and influence decision making in the context of resource planning and energy efficiency to take economically sound decisicions.

Course Outcomes:

The student will be able to:

- apply basics of energy economics to day to day life.
- analyze economic analysis of energy systems.
- compare different alternative technologies.
- understand the various depreciation methods.

SKILLS:

- ✓ *Compare economic and energy parameter of India with other countries.*
- ✓ *Perform make or buy decision.*
- ✓ *Compare various available alternatives.*
- ✓ *Perform replacement and maintenance analysis.*
- ✓ *Perform life cycle analysis of a product.*

ACTIVITIES:

- *Compare economic and energy parameters of India with other countries.*
- *Case study on make or buy decision (Eg: water coolers in VFSTRU)*
- *Case study on economical comparison of solar PV generation and diesel power generation.*
- *Case study on replacement and maintenance of ACs, UPS etc., from VFSTRU.*
- *Life cycle analysis of solar panel.*

UNIT - 1 **L-10, T-3**

ENERGY AND ECONOMICS: Role and significance of renewable energy sources for sustainable economic development and social transformation, Energy and GDP, GNP and its dynamics, Energy sources and overall energy demand and availability, Energy consumption in various sectors and its changing pattern, Exponential increase in energy consumption and projected future demands, Energy security, Energy consumption and its impact on environmental climatic change, Introduction to economics - Flow in an economy, Law of supply and demand, Concept of engineering economics, Engineering efficiency, Economic efficiency, Scope of energy economics; Element of costs - Marginal cost, Marginal revenue, Sunk cost, Opportunity cost; Break-even analysis and V-ratio.

UNIT - 2 **L-9, T-3**

VALUE ENGINEERING: Make or buy decision, Value engineering – Function, Aims, Value engineering procedure; Interest formulae and their applications, Time value of money - Single payment compound amount factor, Single payment present worth factor, Equal payment series sinking fund factor, Equal payment series payment present worth factor, Equal payment series capital recovery factor, Uniform gradient series annual equivalent factor, Effective interest rate and examples.

UNIT - 3 **L-9, T-3**

CASH FLOW : Methods of comparison of alternatives – Present worth method (Revenue dominated cash flow diagram), Future worth method (Revenue dominated cash flow diagram, Cost dominated cash flow diagram), Annual equivalent method (Revenue dominated cash flow diagram, Cost dominated cash flow diagram), Rate of return method and examples; Unit cost of power generation from different sources, Payback period, NPV, IRR and cost benefit analysis and life cycle costing.

UNIT - 4 **L-8, T-3**

REPLACEMENT AND MAINTENANCE ANALYSIS : Types of maintenance, Types of replacement problem, Determination of economic life of an asset, Replacement of an asset with a new asset, Capital recovery with return and concept of challenger and defender, Simple probabilistic model for items which fail completely.

UNIT - 5 **L-9, T-3**

DEPRECIATION : Introduction, Straight line method of depreciation, Declining balance method of depreciation, Sum of the years digits method of depreciation, Sinking fund method of depreciation / Annuity method of depreciation, Service output method of depreciation, Evaluation of public alternatives - Introduction, Inflation adjusted decisions, Procedure to adjust inflation, Examples on comparison of alternatives and determination of economic life of asset.

TEXT BOOKS:

1. Panneer Selvam. R, “Engineering Economics”, 1st edition, Prentice Hall of India Ltd, New Delhi, 2001.
2. Subhes C.Bhattacharyya., “Energy Economics”, 1st edition, Springer, 2011.

REFERENCE BOOKS:

1. Chan S.Park, “Contemporary Engineering Economics”, 1st edition, Prentice Hall of India, 2002.
2. Aswathnarayana U, “Green energy: Technology, Economics and policy”, 1st edition, CRC press, 2010.
3. Truett & Truett, “ Managerial economics- Analysis, Problems & Cases “ Wiley India, 8th edition 2004.
4. Suma Damodaran, “Managerial Economics”, 1st edition, Oxford University press, 2006.

16EE458 DIGITAL CONTROL SYSTEMS

Hours Per Week :

L	T	P	C
3	-	2	4

Total Hours :

L	T	P
45	-	30

WA/RA	SSH/HSH	CS	SA	S	BS
5	40	-	8	5	-

Course Description and Objectives:

This course deals with mathematical modelling of digital systems, different methods of analysis and design of physical systems in discrete domain. The objective of the course is to introduce A/D and D/A conversion, Z-Transform and stability analysis methods of digital control system.

Course Outcomes:

The student will be able to:

- apply A/D and D/A conversion techniques.
- analyse the stability status of a digital control system.
- design digital controller for any process.

SKILLS:

- ✓ *Model any physical system in discrete domain.*
- ✓ *Determine overall pulse transfer function of a system using Z-transformation technique.*
- ✓ *Determine design specifications in discrete time for any system.*
- ✓ *Analyze digital system stability using Jury's criterion.*
- ✓ *Design digital PID controller.*

ACTIVITIES:

- *Analyze the stability status of digital control system*
- *Design a fire alarm circuit using IC 555*
- *Design a digital PID controller using op-amps for DC and AC motors.*
- *Design a street light controller using LDR*
- *Design a digital position controller*
- *Design a temperature controlled DC fan using thermistor*

UNIT - 1 **L-10**

SAMPLE THEORY AND CONVERTERS : Review of sampling theory, Shannon's sampling theorems, Sampled Data Control system, Digital to Analog conversion, Analog to Digital conversion - Ramp type A/D, Dual slope A/D, Successive approximation A/D; A/D and D/A converters, Reconstruction, Zero order hold.

UNIT - 2 **L-9**

SYSTEM RESPONSE : Review of Z and Inverse Z transform, Response of sampled data systems to step and ramp inputs, Steady state errors, Z domain equivalent and modified Z transform.

UNIT - 3 **L-9**

FUNCTION REALIZATION: Pulse transformation function by direct, Cascade and parallel realization, Sampled data model for continuous system, Controllability and observability, Design of state feedback and output feedback control.

UNIT - 4 **L-8**

STABILITY OF DIGITAL CONTROL SYSTEMS : Stability studies, Bilinear transformation, Jury's stability test, Digital quantization, State sequences for sampled data systems, Solutions.

UNIT - 5 **L-9**

DIGITAL CONTROL DESIGN: The digital control design with digital controller with bilinear transformation, Digital PID controller, Design with deadbeat response, Pole placement through state feedback.

LABORATORY EXPERIMENTS

LIST OF EXPERIMENTS Total hours: 30

1. Study of A/D and D/A converters.
2. Study of Shannon's sampling theorem.
3. Study of Z and Inverse Z transform using MATLAB.
4. Derivation of Pulse transfer function of any continuous time control system.
5. Stability analysis of discrete time system using Jurys method.
6. Discrete time domain analysis using MATLAB.
7. Discrete time error analysis using MATLAB.
8. Design of digital PID controller and simulation using MATLAB.
9. Stability analysis of discrete time system using MATLAB.
10. State space model for pulsel transfer function using MATLAB – Verification.

TEXT BOOKS:

1. K. Ogata, "Discrete Time Control Systems", Prentice-hall of India, 2nd edition, New Delhi, 2008.
2. Gopal M, "Digital Control and State variable Methods", 1st edition, Tata Mc-Graw Hill, New Delhi, 2003.

REFERENCE BOOKS:

1. Gene F. Franklin, J. David Powell, "Digital control of dynamic systems", 1st edition, Pearson Education Limited, New Delhi, 2002.
2. Richard C. Dorf, Robert H. Bishop, "Modern control systems," 1st edition, Pearson Education inc, New Delhi, 2008.