ELECTRICAL AND ELECTRONICS ENGINEERING

LIST OF COURSES

S.No	Course Code	Course Name	L:T:P	Credit
1	18EE1001	Basic Electrical Engineering	3:1:0	4
2	18EE1002	Basic Electrical Engineering Laboratory	0:0:2	1
3	18EE1003	Basic Electrical and Electronics Engineering	3:1:0	4
4	18EE1004	Basic Electrical and Electronics Engineering Laboratory	0:0:2	1
5	18EE1005	Electrical Workshop Practices	1:0:4	3
6	18EE2001	Electrical Circuit Analysis	3:1:0	4
7	18EE2002	Network Theory	3:0:0	3
8	18EE2003	Analog Electronic Circuits	3:0:0	3
9	18EE2004	Analog Electronic Circuits Laboratory	0:0:3	1.5
10	18EE2005	Electromagnetic Fields	3:1:0	4
11	18EE2006	Electrical Machines – I	3:0:0	3
12	18EE2007	Electrical Machines - I Laboratory	0:0:2	1
13	18EE2008	Electrical Machines – II	3:0:0	3
14	18EE2009	Electrical Machines – II Laboratory	0:0:2	1
15	18EE2010	Power Electronics	3:0:0	3
16	18EE2011	Power Electronics Laboratory	0:0:2	1
17	18EE2012	Power Systems – I	3:0:0	3
18	18EE2013	Power Systems – I Laboratory	0:0:2	1
19	18EE2014	Power Systems – II	3:0:0	3
20	18EE2015	Power Systems – II Laboratory	0:0:2	1
21	18EE2016	Wind and Solar Energy Systems	3:0:0	3
22	18EE2017	Wind and Solar Energy Laboratory	0:0:2	1
23	18EE2018	Industrial Mechatronics	3:0:0	3
24	18EE2019	Electric Machines and Drives	3:0:0	3
25	18EE2020	Electric Machines and Drives Laboratory	0:0:2	1
26	18EE2021	Electrical Machines and Power Systems	3:0:0	3
27	18EE3001	Energy Engineering	3:0:0	3
28	18EE3002	Photovoltaic Systems	3:0:0	3
29	18EE3003	Energy Management and Audit	3:0:0	3
30	18EE3004	Wind Energy	3:0:0	3
31	18EE3005	Solar Energy Laboratory	0:0:4	2
32	18EE3006	Electric Drives Laboratory for Renewable Energy	0:0:4	2
33	18EE3007	Wind Energy Laboratory	0:0:4	2
34	18EE3008	Power Engineering Simulation Laboratory	0:0:4	2
35	18EE3009	Solar Thermal Energy Conversion	3:0:0	3
36	18EE3010	Materials for Solar Power	3:0:0	3
37	18EE3011	Solar Cell and Module Technology	3:0:0	3
38	18EE3012	Grid Converters for Solar and Wind Power Systems	3:0:0	3
39	18EE3013	Biomass Energy	3:0:0	3
40	18EE3014	Waste to Energy Conversion	3:0:0	3
41	18EE3015	Oceanic Energy	3:0:0	3
42	18EE3016	Data Mining for Renewable Energy Systems	3:0:0	3
43	18EE3017	Power Conversion and Control of Wind Energy Systems	3:0:0	3
44	18EE3018	Power Quality Issues and Mitigation	3:0:0	3
45	18EE3019	Distributed Generation and Micro grid	3:0:0	3

46	18EE3020	Cyber Physical Systems Approach To Smart Grid	3:0:0	3
47	18EE3021	Smart Power Grid Renewable Energy Systems	3:0:0	3
48	18EE3022	Electric and Hybrid Vehicles	3:0:0	3
49	18EE3023	Disaster Management	3:0:0	0

18EE1001	Basic Electrical Engineering	L	T	P	C
		3	1	0	4

Course Objectives:

1. To impart the basic knowledge about the DC, AC and Magnetic circuits.
2. To comprehend the working of various Electrical Machines.
3. To know about various power converters and electrical installations.

Course Outcomes:

At the end of this course students will demonstrate the ability to

1. Describe the basic terminologies of DC, AC circuits.
2. Define the basic concepts of Magnetic circuits and transformers.
3. Predict and analyze the behavior of any circuits.
4. Identify the type of electrical machine used for required application.
5. Classify various means of power conversion methodologies.
6. Plan electrical wiring, earthing for house hold and commercial purposes.

Module 1: DC Circuits (10 hours)

Electrical circuit elements (R, L and C), voltage and current sources, Kirchoff's laws, analysis of simple circuits with DE excitation. Superposition, Thevenin and Norton Theorems, Time-domain analysis of first-order RL and RC circuits.

Module 2: AC Circuits (12 hours)

Representation of sinusoidal waveforms, peak and RMS values, phasor representation, real power, reactive power, apparent power, power factor. Analysis of single-phase AC circuits consisting of R, L, C, RL, RC, RLC combinations (series and parallel), resonance. Three phase balanced circuits, voltage and current relations in star and delta connections. Introduction to Three phase system.

Module 3: Magnetic Circuits & Transformers (8 hours)

Magnetic materials, B-H characteristics, Basics of ideal and practical transformer, equivalent circuit, losses in transformers, regulation and efficiency. Auto-transformer and three-phase transformer connections.

Module 4: Electrical Machines (10 hours)

Construction, working principle, types and applications of DC Generator, DC Motor, Three phase & Single-Phase Induction Motor, Synchronous Generator, Stepper Motor and Servo Motor.

Module 5: Introduction to Android Platform (11 hours)

Introduction to Android platform – UI widgets – UI managers – different devices &drawables – Intents & fragments – styles and themes – data storages – Asynctask – Broadcast receiver notification and GCM – applications

Module 6: Electrical Installations (9 hours)

Components of LT Switchgear: Switch Fuse Unit (SFU), MCB, ELCB, MCCB, Types of Wires and Cables, Earthing. Types of Batteries, Important Characteristics for Batteries. Elementary calculations for energy consumption, power factor improvement and battery backup

Text Books:

1. Kothari D. P, NagrathI. J., "Basic Electrical Engineering", Tata McGraw Hill, 2010.
2. Kulshreshtha D. C., "Basic Electrical Engineering", McGraw Hill, 2011

Reference Books

1. L. S. Bobrow, "Fundamentals of Electrical Engineering", Oxford University Press, 2011.
2. E. Hughes, "Electrical and Electronics Technology", Pearson, 2010.
3. Vincent Del Toro, "Electrical Engineering Fundamentals", Prentice Hall India, 2nd Edition, 2013.

4. Bhattacharya. S. K, “Basic Electrical and Electronics Engineering”, Pearson Education, New Delhi, 2011.
5. https://www.unanth.com/online-course/learn-to-develop-an-android-app-in-10-hours

18EE1002	Basic Electrical Engineering Laboratory	L	T	P	C
		0	0	2	1

Co-requisite: 18EE1001 Basic Electrical Engineering

Course Objectives:

1. To learn the basic safety of electrical engineering and measuring instruments.
2. To know the working of various AC, DC Circuits and Electrical Machines.
3. To be familiar with various power converters and electrical installations.

Course Outcomes

At the end of this course students will demonstrate the ability to

1. Get an exposure to common electrical components and their ratings.
2. Make electrical connections by wires of appropriate ratings.
3. Understand the usage of common electrical measuring instruments.
4. Understand the basic characteristics of transformers and electrical machines.
5. Get an exposure to the working of Switchgears.
6. Get an exposure to use of Android and projects with android.

Description:

The laboratory will demonstrate the student about the certain basic concepts in electrical engineering.

List of experiments:

1. Study of basic safety precautions; Introduction and use of measuring instruments – voltmeter, ammeter, multi-meter, oscilloscope. Real-life resistors, capacitors and inductors.
2. Measuring the steady-state and transient time-response of R-L, R-C, and R-L-C circuits to a step change in voltage (transient may be observed on a storage oscilloscope).
3. Sinusoidal steady state response of R-L, and R-C circuits – impedance calculation and verification.
4. Stair case wiring, Fluorescent tube light wiring, Comparison of LED and CFL wiring.
5. Observation of phase differences between current and voltage, Resonance in R-L-C circuits.
6. Demonstration of cut-out sections of machines: DC machine, Induction machine, Synchronous machine and single-phase induction machine.
7. Android / Arduino based Projects.
8. Torque Speed Characteristic of separately excited DC motor.
9. Torque-Slip Characteristic of an Induction motor.
10. Study of Components of LT switchgear.

18EE1003	Basic Electrical and Electronics Engineering	L	T	P	C
		3	1	0	4

Course Objective

1. To impart knowledge on the fundamental laws of electrical circuits and the different components and functions of electrical machines.
2. To impart knowledge on electrical measurements and wiring.
3. To impart knowledge on the principles of digital electronics and fundamentals of electron devices.

Course Outcome

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

1. Define the parameters, illustrate the behavior and solve a given electric circuits.
2. Name the parts, explain the operation and select a suitable electrical machine for an application.

3. Explain the measurement of both electrical and non-electrical parameters with modern sensors and select a suitable sensor for an application.
4. Plan electrical wiring, earthing for house hold and commercial purposes.
5. Explain the characteristics of electron devices.
6. Explain the operation of a digital circuit.

Module 1: Basic Circuits (10 hours)

Fundamental laws of electric circuits - Current and Voltage sources - Source Transformation - Resistive Circuits: Series and Parallel, Voltage and Current Division – Kirchoff's Voltage and Current law – Star – Delta transformation – Capacitance – Inductance – Power and Power factor - Single Phase and Three Phase Balanced circuits.

Module 2: Electrical Machines (10 hours)

Construction - Principle of operation - Characteristics - Applications of DC Generators, DC Motors, Single Phase and Three Phase Induction Motor, Synchronous Generator and Motor, Stepper Motor, Servomotor

Module 3: Electrical Measurements (10 hours)

Measurement of Voltage – Current – Power – Energy – Power factor - Temperature Sensor – Pressure Sensor – Force Sensor – Load cell - Anemometer – Fire Sensor – Smoke Detector – Concentration of CO_2 and CO – Electronic nose -Data Loggers

Module 4: Electrical Installations (10 hours)

Components of LT Switchgear: Switch Fuse Unit (SFU), MCB, ELCB – Types of Wiring and Wiring Accessories – House Wiring – Industrial Wiring – Earthing – PCB fabrication - Batteries – Characteristics – Energy consumption calculations – Power factor improvement – Battery Backup

Module 5: Electron Devices (8 hours)

Introduction - Characteristics of PN Junction diode - Zener Effect - Zener Diode and its Characteristics – Photo Diode – Light Emitting Diode (LED) - Bipolar Junction Transistor - CB, CE, CC Configurations and characteristics – Field Effect Transistor (FET) – MOSFET

Module 6: Digital Electronics (12 hours)

Binary Number System-Boolean Algebra theorems, Digital Circuits, Introduction to sequential circuits, Flip flops, Registers and counters, A/D and D/A Conversion.

Text Book:

1. Kothari D. P., Nagrath I. J., "Basic Electrical and Electronics Engineering", Tata McGraw Hill, 2017.

Reference Books:

1. Edward Hughes, "Electrical and Electronics Technology", Pearson Education India, 10^{th} Edition, 2010.
2. Muthusubramanian R &Salivahanan S, "Basic Electrical and Electronics Engineering", McGraw Hill India Limited, New Delhi, 2014.
3. Bhattacharya. S. K, "Basic Electrical and Electronics Engineering", Pearson Education, New Delhi, 2011.
4. Jegathesan. V, Vinoth Kumar. K., Saravanakumar. R, "Basic Electrical & Electronics Engineering", Wiley India Private Limited, New Delhi, 2011.

		L	T	P	C
18EE1004	**Basic Electrical and Electronics Engineering Laboratory**	0	0	2	1

Co-requisite: 18EE1003 Basic Electrical and Electronics Engineering

Course Objective:

1. To impart practical knowledge on basics of Electrical Engineering.
2. To impart practical knowledge on basics of Electronics Engineering.
3. To impart knowledge on selection of electrical and electronic components.

Course Outcomes:

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

1. Verify the basic laws of an electric circuit.
2. Demonstrate the working of an Electrical Machine and compute the performance factors of the same.
3. Measure the electrical parameters and select suitable sensors for an application.
4. Perform domestic and industrial wiring
5. Verify the characteristics of Electronic Devices.
6. Construct a digital circuit.

Description:

The laboratory will demonstrate the student about the certain concept in electrical and electronics engineering.

List of Experiments (Any Eight from the list)

1. Verification of Kirchoff's Voltage Law and Kirchoff's Current Law
2. Measurement of Power, Energy and Power Factor
3. Load characteristics of a DC Shunt Motor
4. Study of sensors
5. Domestic Wiring
6. Industrial Wiring
7. PCB Fabrication
8. Identification, Specification and Testing of Active Devices (Diodes, BJT, MOSFET)
9. Study and operation of Digital Multimeter, Signal Generator, Regulated Power Supply and Cathode Ray Oscilloscope
10. Characteristics of PN Diode and Zener Diode
11. Half Wave and Full Wave Rectifier
12. Control of MOSFET with IC741 OP-AMP
13. Square Wave Generation using IC 555 Timer
14. Study of Logic Gates
15. Study of Flip Flops

		L	T	P	C
18EE1005	**Electrical Workshop Practices**	1	0	4	3

Course Objective:

1. To impart practical knowledge on control and troubleshooting of electrical gadgets.
2. To impart practical knowledge on PCB fabrication.
3. To impart knowledge on fitting, welding and electrical wiring.

Course Outcomes:

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

1. Identify and understand importance of control circuits of various electrical equipment.
2. Understand the basic construction and operation of various laboratory experiments.
3. Develop basic PCB layout design.
4. Perform basic maintenance and troubleshooting of household equipment, energy savings etc.
5. Understand the use of various welding and fitting practices.
6. Understand the basics of electrical wiring.

Description:

The laboratory will demonstrate the student about the concepts of electrical workshop practices.

List of Experiments (Any twelve from the list)

1. Study of simple electrical circuit diagrams and wiring
2. Study of electrical connection of basic electrical equipment

3. Study of handling of all measuring instruments and Oscilloscope (Multimeter, Wattmeter, Clamp meter, ammeter, voltmeter, CRO, DSO etc)
4. Study of Electrical Cables, HRC Fuse, MCB. simple relay and Contactors
5. Study of Drilling/Grinding/Winding Machines
6. Assembling and Identification of Various parts, wiring, tracing of various controls, electronic circuits of Mixer/Vacuum Cleaner/Drier
7. Troubleshooting of Electric Motors
8. Study of control circuit of UPS
9. Study of control circuit of Home Inverter and solar inverters
10. Earthing
11. Fault Identification of Control Switches and in Semi-automatic Washing Machine
12. Measurement of Insulation resistance and earth resistance using Meggar
13. PCB layout design using software.
14. PCB fabrication, Components soldering and Trouble shooting
15. Simple exercises on Fitting
16. Simple Exercises on Welding

		L	T	P	C
18EE2001	**Electrical Circuit Analysis**	3	1	0	4

Course Objectives:
1. To impart basic knowledge about electric circuits and networks to the students.
2. To develop in students the ability to analyze various types of electric circuits and networks.
3. To make the students understand the various network theorems and its usage in analyzing the circuits and networks

Course Outcome:
At the end of the course students will be able to
1. Name the various circuit elements, explain the behavior of circuit elements and circuits and analyze the circuits using KVL, KCL, Mesh analysis and Nodal analysis techniques.
2. State various network theorems, explain it and use it for solving the problems of electric circuits and networks.
3. Relate first order and second order differential equations to electric circuits and networks, explain it, solve it for obtaining the transient responses of RL, RC and RLC networks and categorize RLC Networks
4. Describe fundamental concepts used in single phase and three phase AC circuits and coupled circuits, explain these concepts, and solve problems pertaining to these circuits.
5. Explain the Laplace transform technique, transformed networks and resonance in electric circuits, use the Laplace transform technique for transforming a network to S domain and analyzing it, and examine the behavior of resonant circuits and assess the performance of tuned coupled circuits.
6. Calculate the network parameters, explain the network parameters and identify(analyze) the network parameters for a two-port network and construct interconnected networks.

Module 1- Mesh and Nodal Analysis (7 hours)
Analysis with dependent voltage source and current sources. Node and Mesh analysis. Concept of duality and dual networks

Module 2 -Network Theorems (10 hours)
Superposition theorem, Thevinin’s theorem, Norton’s theorem, Maximum power transfer theorem, Reciprocity theorem, Compensation Theorem.

Module 3 -Solution of First Order and Second Order Networks (8 hours)
Solution of first order and second order differential equation for series and parallel R-L, R-C and R-L-C networks. Initial and final conditions in network elements. Forced and free responses, Time constants, Steady state and transient state responses.

Module 4- Sinusoidal Steady State Analysis (11 hours)
Representation of Sine function as a rotating phasor, phasor diagrams, impedances and admittances. AC circuit analysis, Effective or RMS value, Average power and complex power. Three phase circuits-. Coupled circuits- Dot convention in coupled circuits, Ideal transformer.
Module 5 -Electric Circuit Analysis Using Laplace Transform (9 hours)
Review of Laplace Transform. Analysis of Electric Circuits using Laplace transform for standard inputs, Convolution integral, Inverse Laplace transform, Transformed network with initial condition. Transfer function representation. Poles and zeros. Frequency response (Magnitude and phase plot). Series and parallel resonances.
Module6 -Two port network and Network Functions (15 hours)
Two port networks, terminal pairs, Relationship of two port variables, Impedance parameters, Admittance parameters, Transmission parameter and Hybrid Parameters. Interconnection of two port networks.

Text Books

1. William H. Hayt Jr, Jack E. Kemmerly and Steven M. Durbin, "Engineering Circuits Analysis", Tata McGraw Hill Publishing Company Limited, New Delhi, 8thEdition, 2013.
2. Sudhakar A., Shyammohan S Palli, "Circuits & Networks: Analysis and Synthesis", Tata McGraw Hill Publishing Company Limited, New Delhi, 3rd Edition, 2006.

Reference Books:

1. Joseph A. Edminister, Mahmood Nahri, "Electric Circuits", Schaum's series, Tata McGraw-Hill Publishing Company Limited, New Delhi, 2010.
2. Van Valkenburg M.E., "Network Analysis", Pearson Education India, 3rd Edition, 2015.
3. Roy Choudhuri D., "Networks and Systems", New Age International Private Limited, 2nd Edition, 2013.
4. Alexander C.K., SadikuM.N.O., "Fundamentals of Electric Circuits", McGraw Hill Education Series, New York, 5th Edition, 2013
5. Murthy K.V.V., Kamath M.S., "Basic Circuit Analysis", Jaico Publications, 1st Edition, 2002.

18EE2002	Network Theory	L	T	P	C
		3	0	0	3

Course Objectives:
1. To impart knowledge on solving circuits using basic laws and network theorems.
2. To apply mathematical methods such as Fourier series, Fourier transform and Laplace transforms to solve network and circuits problems.
3. To analyze two port networks, three phase circuits and to educate on designing the filters.

Course Outcomes:
At the end of this course students will demonstrate the ability to
1. Understand basics electrical circuits with nodal and mesh analysis.
2. Apply the various electrical network theorems to analyze the circuits and networks.
3. Analyze three phase circuits.
4. Apply Laplace Transform for steady state and transient analysis.
5. Analyze the frequency domain techniques.
6. Determine different network functions and Design filter circuits to satisfy design specifications.

Module 1: Network Solution methods (5 hours)
Kirchhoff's Laws, Current Division rule and voltage division rule, Node and Mesh Analysis, Matrix approach of network containing voltage and current sources, source transformation, Wye -Delta Transformation.
Module 2: Network theorems (8 hours)
Superposition, Thevenin's, Norton's, Maximum power Transfer, Reciprocity, Compensation and Tellegen's theorem as applied to A.C. Circuits, Duals and duality.

Module 3: Steady State analysis (7 hours)
Steady state sinusoidal analysis using phasors of RLC circuits, Three-phase unbalanced circuit and power calculation; steady state response of a network to non-sinusoidal periodic inputs, power factor, effective values, Fourier transform and continuous spectra.
Module 4: Network solutions using Laplace Transforms (7 hours)
Laplace transforms and properties: Partial fractions, singularity functions, waveform synthesis, analysis of RC, RL, and RLC networks with and without initial conditions with Laplace transforms evaluation of initial conditions, convolution theorem.
Module 5: Transient Analysis and Resonance (7 hours)
Transient behavior of simple RLC circuits, concept of complex frequency, Driving points and transfer functions, poles and zeros of admittance function, their properties, sinusoidal response from pole-zero locations. Behaviors of series and parallel resonant circuits,
Module 6: Two port Network, Resonance, Network Graphs and Filters (11 hours)
Two four port network and interconnections, Network Graphs – Tie-set and Cut-set matrix, Introduction to band pass, low pass, high pass and band reject filters.

Text Books

1. William H. Hayt, “Engineering Circuit Analysis” 8th Edition, McGraw-Hill Education, 2013.
2. Sudhakar A., Shyammohan S Palli, “Circuits & Networks: Analysis and Synthesis”, Tata McGraw Hill Publishing Company Limited, New Delhi, 3rd Edition, 2006.

Reference Books

1. Joseph A. Edminister, Mahmood Nahri, “Electric Circuits”, Schaum’s series, Tata McGraw-Hill Publishing Company Limited, New Delhi, 2010.
2. Van Valkenburg M.E., “Network Analysis”, Pearson Education India, 3rdEdition, 2015.
3. Roy Choudhuri D., “Networks and Systems”, New Age International Private Limited, 2ndEdition, 2013.
4. Alexander C.K., Sadiku M.N.O., “Fundamentals of Electric Circuits”, McGraw Hill Education Series, New York, 5thEdition, 2013
5. Murthy K.V.V., Kamath M.S., “Basic Circuit Analysis”, Jaico Publications, 1st Edition, 2002.

18EE2003	Analog Electronic Circuits	L	T	P	C
		3	0	0	3

Course Objectives:
1. To provide students with strong basics in different Electronic devices
2. To provide students with strong foundation in designing circuits
3. To develop confidence in designing circuits using op-amps

Course Outcomes:
At the end of the course, the student will be able to
1. Explain the characteristics and applications of electronic devices such as diode, BJTs, MOSFETs and op-amp
2. Compare various biasing methods for the BJT and MOSFET amplifiers
3. Construct BJT and MOSFET based amplifier circuits with various configurations.
4. Calculate the small signal modelling parameters for a given equivalent circuit.
5. Explain the characteristics of op-amp.
6. Construct op-amp based circuits for linear and nonlinear applications

Module 1: Diode circuits (5 hours)
P-N junction diode - Ideal and Practical Diode - I-V characteristics of a diode; source protection of diode-review of half-wave and full-wave rectifiers, Zener diodes, clamping and clipping circuits

Module 2: BJT circuits (8 hours)
Structure and I-V characteristics of a BJT; BJT as a switch. BJT as an amplifier: small-signal model, biasing circuits, current mirror; common-emitter, common-base and common- collector amplifiers; Small signal equivalent circuits, high-frequency equivalent circuits
Module 3: MOSFET circuits (7 hours)
MOSFET structure and I-V characteristics. MOSFET as a switch. MOSFET as an amplifier: small-signal model and biasing circuits, common-source, common-gate and common-drain amplifiers; small signal equivalent circuits - gain, input and output impedances, trans- conductance, high frequency equivalent circuit
Module 4: Differential, multi-stage and operational amplifiers (8 hours)
Differential amplifier; power amplifier; direct coupled multi-stage amplifier; internal structure of an operational amplifier, ideal op-amp, non-idealities in an op-amp (Output offset voltage, input bias current, input offset current, slew rate, gain bandwidth product)
Module 5: Linear applications of op-amp (9 hours)
Idealized analysis of op-amp circuits. Inverting and non-inverting amplifier, differential amplifier, instrumentation amplifier, integrator, active filter, P, PI and PID controllers and lead/lag compensator using an op-amp, voltage regulator, oscillators (Wein bridge and phase shift). Analog to Digital Conversion.
Module 6: Non-Linear applications of op-amp (8 hours)
Hysteretic Comparator - Zero Crossing Detector, Square-wave and triangular-wave generators. Precision rectifier, peak detector, Monoshot.

Text Books:
1. A. S. Sedra and K. C. Smith, "Microelectronic Circuits", New York, Oxford University Press, 5th Edition 2004
2. J. V. Wait, L. P. Huelsman and G. A. Korn, "Introduction to Operational Amplifier theory and applications", McGraw Hill U. S., 1992.

Reference Books:
1. J. Millman and A. Grabel, "Microelectronics", McGraw Hill Education, 2nd Edition,2001.
2. P. Horowitz and W. Hill, "The Art of Electronics", Cambridge University Press, 3rd Edition, 2015.
3. P. R. Gray, R. G. Meyer and S. Lewis, "Analysis and Design of Analog Integrated Circuits", John Wiley & Sons, 5th Edition, 2009.
4. Robert Boylestad and Louis Nashelsky, "Electronic Devices and Circuit Theory" 11th Edition, 2013
5. Millman&Halkias, "Electronic Devices & Circuits", Tata McGraw Hill, 3rd Edition, 2010
6. David. A. Bell, "Electronic Devices & Circuits ", Oxford University Press, 5th Edition 2010.

18EE2004	Analog Electronic Circuits Laboratory	L	T	P	C
		0	0	3	1.5

Co-requisite: 18EE2004 Analog Electronics

Course Objectives:
1. To impart knowledge on various electron devices.
2. To impart knowledge on various BJT circuits.
3. To impart knowledge on linear IC circuits.

Course Outcomes:
At the end of the semester the students are able to
1. Acquire a basic knowledge in solid state electronics including diodes, MOSFET, BJT, and operational amplifier.
2. Design and analyze analog electronic circuits using discrete components
3. Observe the amplitude and frequency responses of common amplification circuits.

4. Construct various analog circuits to compare experimental results in the laboratory with theoretical analysis.
5. Design Op-Amp based Oscillator circuit.
6. Design linear and nonlinear application of Op-Amp.

List of Experiments:

1. Diode Characteristics
2. Rectifier Circuits
3. Clipping and clamping circuits
4. Zener diode
5. Characteristics of BJT
6. Transistor DC biasing circuits
7. The Common Emitter Amplifier
8. The common Base amplifier
9. The emitter Follower
10. Amplifier Frequency Response
11. JFET Characteristic
12. Common Source amplifier
13. Instrumentation Amplifier using Op-Amp
14. RC Phase Shift Oscillators using Op-Amp
15. PID controller using Op-Amp
16. Signal generation using Op-Amp

		L	T	P	C
18EE2005	**Electromagnetic Fields**	3	1	0	4

Course Objectives:

1. To give an introduction on the coordinate system and vector algebra
2. To impart knowledge on electromagnetic field distribution for various configurations.
3. To give a brief description on the basics of electromagnetic waves.

Course Outcomes:

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

1. Express the concept of vector calculus and to learn about the scalar and vector fields.
2. Solve static electric field problems using coordinate systems
3. Examine the magnetic field concepts and solve problems using the coordinate systems
4. Relate the property of magnetic materials and examine the effect of force on it.
5. Explain faradays law of electromagnetic induction and Maxwell's equation for time varying fields.
6. Illustrate the wave equation and its parameters for a conductor, dielectic and magnetic medium.

Module 1: **Review of Vector Calculus (8 hours)**

Vector algebra-addition, subtraction, components of vectors, scalar and vector multiplications, triple products, three orthogonal coordinate systems (rectangular, cylindrical and spherical). Vector calculus-differentiation, partial differentiation, integration, vector operator del, gradient, divergence and curl; integral theorems of vectors. Conversion of a vector from one coordinate system to another.

Module 2: Static Electric Field (8 hours)

Coulomb's law, Electric field intensity, Electrical field due to point charges. Line, Surface and Volume charge distributions. Gauss law and its applications. Absolute Electric potential, potential difference, Calculation of potential differences for different configurations. Electric dipole, Electrostatic Energy and Energy density. Current and current density, Ohms Law in Point form, Continuity of current, Boundary conditions of perfect dielectric materials. Permittivity of dielectric materials, Capacitance, Capacitance of a two-wire line, Poisson's equation, Laplace's equation, Solution of Laplace and Poisson's equation, Application of Laplace's and Poisson's equations.

Module 3: Static Magnetic Fields (6 hours)
Biot-Savart Law, Ampere Law, Magnetic flux and magnetic flux density, Scalar and Vector Magnetic potentials. Steady magnetic fields produced by current carrying conductors.
Module 4: Magnetic Forces, Materials and Inductance (9 Hours)
Force on a moving charge, Force on a differential current element, Force between differential current elements, Nature of magnetic materials, Magnetization and permeability, Magnetic boundary conditions, Magnetic circuits, inductances and mutual inductances.
Module 5: Time Varying Fields and Maxwell's Equations (9 Hours)
Faraday's law for Electromagnetic induction, Displacement current, Point form of Maxwell's equation, Integral form of Maxwell's equations, Motional Electromotive forces. Boundary
Conditions.
Module 6: Electromagnetic Waves (12 Hours)
Derivation of Wave Equation, Uniform Plane Waves, Maxwell's equation in Phasor form, Wave equation in Phasor form, Plane waves in free space and in a homogenous material. Wave equation for a conducting medium, Plane waves in lossy dielectrics, Propagation in good conductors, Skin effect. Poynting theorem-Concepts of EMI and Definitions, Classification of EMI, Units of Parameters, Examples of EMI, Sources of EMI,EMI coupling modes - CM and DM.

Text Books:

1. William H.Hayt Jr., John A.Buck, "Engineering Electro Magnetics", Tata McGraw- Hill Education India Private Limited, New Delhi, ,8th Edition 2014.
2. Joseph Edminister; MamoodNahvi, "Schaum's outline of electromagnetic", McGraw Hill, NewYork, 2014.

Reference Books:

1. Clayton R.Paul, Keith W.Whites, Syed A. Nasar, "Introduction to Electromagnetic Fields", Tata McGraw Hill Publishing Company Ltd., New Delhi, 2008.
2. Bhag Singh Guru, Huseyin R. Hiziroglu, "Electromagnetic Field Theory Fundamentals", Cambridge University Press, UK, 2004.
3. M. N. O. Sadiku, "Elements of Electromagnetics", Oxford University Publication, 2014.
4. A. Pramanik, "Electromagnetism - Theory and applications", PHI Learning Pvt. Ltd, New Delhi, 2009.
5. A. Pramanik, "Electromagnetism-Problems with solution", Prentice Hall India, 2012.
6. Prasad Kodali, "Engineering Electromagnetic Compatibility–Principles, Measurements, and Technologies", IEEE press, 2001.

		L	T	P	C
18EE2006	**Electrical Machines - I**	3	0	0	3

Course Objectives:
1. To introduce the concept of rotating machines and the principle of electromechanical energy conversion.
2. To explain the generation of D.C. voltages by using different type of generators and study their performance.
3. To study the characteristics and testing methods of electrical machines, starting and methods of speed control.

Course Outcomes:
At the end of the course, the student will be able to
1. Summarize the concepts of magnetic circuits.
2. Explain the concept of electromagnetic force.
3. Illustrate the operation of DC Machines.
4. Identify the differences in operation of different DC machine configurations.

5. Examine single phase and three phase transformers circuits.
6. Outline the working of autotransformers.

Module 1: Magnetic fields and magnetic circuits (6 Hours)
Review of magnetic circuits - MMF, flux, reluctance, inductance; review of Ampere Law and Biot Savart Law; Visualization of magnetic fields produced by a bar magnet and a current carrying coil - through air and through a combination of iron and air; influence of highly permeable materials on the magnetic flux lines.

Module 2: Electromagnetic force and torque (9 Hours)
B-H curve of magnetic materials; flux-linkage vs current characteristic of magnetic circuits; linear and nonlinear magnetic circuits; energy stored in the magnetic circuit; force as a partial derivative of stored energy with respect to position of a moving element; torque as a partial derivative of stored energy with respect to angular position of a rotating element. Examples - galvanometer coil, relay contact, lifting magnet, rotating element with eccentricity or saliency

Module 3: DC Machines (8 Hours)
Basic construction of a DC machine, magnetic structure - stator yoke, stator poles, pole-faces or shoes, air gap and armature core, visualization of magnetic field produced by the field winding excitation with armature winding open, air gap flux density distribution, flux per pole, induced EMF in an armature coil. Armature winding and commutation – Elementary armature coil and commutator, lap and wave windings, construction of commutator, linear commutation Derivation of back EMF equation, armature MMF wave, derivation of torque equation, armature reaction, air gap flux density distribution with armature reaction.

Module 4: DC machine - motoring and generation (10 Hours)
Armature circuit equation for motoring and generation, Types of field excitations – separately excited, shunt and series. Open circuit characteristic of separately excited DC generator, back EMF with armature reaction, voltage build-up in a shunt generator, critical field resistance and critical speed. V-I characteristics and torque-speed characteristics of separately excited, shunt and series motors. Speed control through armature voltage. Losses, load testing and back-to-back testing of DC machines – DC alternator in Automotives

Module 5: Transformers (6 Hours)
Principle, construction and operation of single-phase transformers, equivalent circuit, phasor diagram, voltage regulation, losses and efficiency Testing - open circuit and short circuit tests, polarity test, back-to-back test, separation of hysteresis and eddy current losses Three-phase transformer - construction, types of connection and their comparative features, Parallel operation of single-phase and three-phase transformers

Module 6: Transformers in Power System (6 Hours)
Autotransformers - construction, principle, applications and comparison with two winding transformer, Magnetizing current, - Three Phase transformer - Phase conversion - Scott connection, three-phase to six-phase conversion, Tap-changing transformers - No-load and on-load tap-changing of transformers, Three-winding transformers. Cooling of transformers – voltage regulators

Text Book:

1. Kothari. D. P, Nagrath. I. J, “Electric Machines”, Tata McGraw- Hill Education India Private Limited, New Delhi, 4th Edition, 2010.
2. Vincent Del Toro, “Basic Electrical Machines”, Pearson Education Incorporation, New Delhi, 2016.

Reference Books:

1. A. E. Fitzgerald and C. Kingsley, "Electric Machinery”, New York, McGraw Hill Education, 2013.
2. A. E. Clayton and N. N. Hancock, “Performance and design of DC machines”, CBS Publishers, 2004.
3. M. G. Say, “Performance and design of AC machines”, CBS Publishers, 2002.
4. P. S. Bimbhra, “Electrical Machinery”, Khanna Publishers, 2011.

18EE2007	Electrical Machines – I Laboratory	L T P C 0 0 2 1

Co-requisite: 18EE2005 Electrical Machines – I

Course Objective

1. The ability to conduct testing and experimental procedures on different types of Electrical machines.
2. A chance to practice different types of wiring and devices connections.
3. The capability to analyze the operation of electric machines under different loading Conditions.

Course Outcome:

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

1. Infer the operation of DC Shunt Generator under different loading conditions.
2. Examine the load characteristics of Series DC motors.
3. Calculate the losses of DC motors and Generator
4. Discriminate the concept of efficiency and the short circuit impedance of a transformer from no-load test, winding resistance, short circuit test, and load test.
5. Calculate the efficiency and separation of losses in transformer.
6. distinguish the braking mechanism of DC machines

Description:

The laboratory will demonstrate the student about the operation and performance analysis of a DC Machines and Transformers.

List of Experiments

1. Load Characteristics of Separately Excited DC Generator.
2. Load Characteristics of DC Compound Generator.
3. Load Test on DC Shunt Motor.
4. Load Test on DC Series Motor.
5. Load Test on Single Phase Transformer.
6. Speed Control of DC Shunt Motor.
7. Swinburne's Test.
8. Sumpner's Test on Single Phase Transformer
9. Open Circuit and Short Circuit of Single Phase Transformer.
10. Electric Braking of DC Shunt Motor

18EE2008	Electrical Machines - II	L T P C 3 0 0 3

Course Objectives:

1. To impart knowledge on the constructional features and magnetic field pattern of AC rotating Machines.
2. To impart knowledge on the working and control of asynchronous AC Machines.
3. To impart knowledge on the working and control of a Synchronous AC machines.

Course Outcomes:

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

1. List the parts and explain the construction details of an AC Machine
2. Describe the magnetic field pattern and compute the MMF of an AC machine when excited.
3. Analyze the effect of parameter variation on torque of Induction Motor and Identify suitable starting, speed control and braking methods for Induction Motor.
4. Discuss the operation of various types of Single phase induction motor.
5. Determine the voltage regulation of an Alternator or predetermine the efficiency of an AC rotating machine and Inspect the synchronized operation of an Alternator with an Infinite bus bar.

6. Explain the working of a Synchronous motor and demonstrate the effect of DC excitation on the performance of the motor.

Module 1: Fundamentals of AC machine windings (8 Hours)
Physical arrangement of windings in stator and cylindrical rotor; slots for windings; single- turn coil - active portion and overhang; full-pitch coils, concentrated winding, distributed winding, winding axis, 3D visualization of the above winding types, Air-gap MMF distribution with fixed current through winding - concentrated and distributed, Sinusoidally distributed winding, winding distribution factor

Module 2: Pulsating and revolving magnetic fields (4 Hours)
Constant magnetic field, pulsating magnetic field - alternating current in windings with spatial displacement, Magnetic field produced by a single winding - fixed current and alternating current - Pulsating fields produced by spatially displaced windings, Windings spatially shifted by 90°, Addition of pulsating magnetic fields, three windings spatially shifted by 120° (carrying three-phase balanced currents), revolving magnetic field.

Module 3: Induction Machines (12 Hours)
Construction, Types (squirrel cage and slip-ring), Torque Slip Characteristics, Starting and Maximum Torque. Equivalent circuit. Phasor Diagram, Losses and Efficiency. Effect of parameter variation on torque speed characteristics (variation of rotor and stator resistances, stator voltage, frequency). Methods of starting, braking and speed control for induction motors. Generator operation. Self-excitation. Doubly-Fed Induction Machines.

Module 4: Fractional HP Motor (6 Hours)
Principle of operation – Double revolving field theory – Types of Single Phase Induction Motor – Stepper Motor – Universal Motor – Synchronous Reluctance Motor – Hysteresis Motor.

Module 5: Synchronous Generator (10 Hours)
Types - Constructional features – three phase windings – Winding factors – EMF equation – Armature reaction – Voltage regulation – Predetermination of regulation by Synchronous Impedance – Ampere Turn and Potier reactance methods - Load characteristics – Power expression – Parallel operation – Synchronizing Current and Synchronizing power – Salient Pole Synchronous Machine – operation of Salient Pole Generator and Motor - Slip Test

Module 6: Synchronous Motor (5 Hours)
Principle of operation – Methods of starting – Phasor diagrams – V-curves and Inverted V-curves - Power/Power-angle relations – Synchronous Condensers – Hunting and methods of Suppression.

Text Books:

1. Kothari D.P., Nagrath I.J., "Electrical Machines", Tata McGraw Hill Education India Private Limited, New Delhi, 3rd Edition, 2004.
2. Vincent Del Toro, "Basic Electrical Machines", Pearson Education Incorporation, New Delhi, 2016.

Reference Books:

1. Alexander, S. Langsdorf, "Theory of Alternating Current Machinery", Tata McGraw Hill Education India Private Limited, New Delhi, 2nd Edition, 2009.
2. Gupta, B.R., Vandana, Singhal, "Fundamentals of Electric Machines", New Age International Publishers Limited, New Delhi, 2nd Edition, 2002.
3. Arthur Eugene Fitzgerald, Charles Kingsley, Stephen D. Umans, "Electric Machinery", McGraw Hill Professional Series, New York, 6th Edition, 2002.
4. Murugesh Kumar, K, "Induction and Synchronous Machines", Vikas Publishing House Limited, New Delhi, 4th Reprint, 2009.

18EE2009	Electrical Machines – II Laboratory	L 0	T 0	P 2	C 1

Co-requisite: 18EE2008 Electrical Machines - II

Course Objective:

1. To prepare students to understand, demonstrate and analyze the concepts of Induction Motor.
2. To prepare students to understand, demonstrate and analyze the concepts of Synchronous Motor.
3. To prepare students to understand, demonstrate and analyze the concepts of Synchronous Machine.

Course Outcomes:

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

1. Recall the working principle and various parts of Induction and Synchronous Machines.
2. Conduct brake test on Induction and Synchronous Machines.
3. Conduct a suitable test to determine the system parameters of Synchronous Machine.
4. Evaluate the performance factors of Induction and Synchronous Machines.
5. Predict the performance factors of Induction and Synchronous Machines.
6. Perform synchronization of alternator with infinite bus-bar.

Description:

The laboratory will demonstrate the student about the operation and performance analysis of an AC Machines.

List of Experiments (Any Eight from the list)

1. Load Test on Three Phase Squirrel Caged Induction Motor.
2. Load Test on Three Phase Slip Ring Induction Motor.
3. Speed Control of Three Phase Slip Ring Induction Motor.
4. No-load and Blocked Rotor test on Three Phase Induction Motor.
5. Separation of No-load losses of Three Phase Induction Motor.
6. Star-Delta starter of Three Phase Induction Motor.
7. Load Test on Single Phase Induction Motor.
8. No load and blocked rotor test on Single Phase Induction motor.
9. Voltage Regulation of Three Phase Alternator by EMF and MMF method.
10. Load Test on Three Phase Alternator.
11. Synchronization of Alternator with Infinite Bus-bar.
12. V and Inverted V curve of Three Phase Synchronous Motor.
13. Determination of X_d and X_q of a salient pole synchronous machine from slip test.
14. Determination of sub-transient reactance of salient pole synchronous machine.
15. Determination of sequence impedances of salient pole synchronous machine.

18EE2010	Power Electronics	L 3	T 0	P 0	C 3

Course Objectives:

1. Study the Static and Dynamic characteristics of Power Semiconductor Devices.
2. Understand the operation of power electronic converters and its control strategies of various power converters.
3. Study the design parameters for control circuitry requirement of various converters.

Course Outcomes:

At the end of this course students will be able to

1. Understand the switching characteristics of power devices and select a suitable power device for power conversion.
2. Design a power converter with criteria (power, efficiency, ripple voltage and current, harmonic distortions, power factor).
3. Implement and verify the performance characteristics of power converters.

4. Interpret terminal characteristics of the components for designing the circuitry for power converters.
5. Estimate the required converters for renewable based applications.
6. Assess the quality of power by analyzing the factors such as harmonics, ripples, etc.,

Module1: Power switching devices (7 hours)
Introduction to switching concepts, Static and Switching characteristics of Power Diode, Thyristor (SCR), Power BJT, Power MOSFET, IGBT and Thyristor (SCR); Brief introduction to power devices viz. GTO, TRIAC, MOS controlled thyristor (MCT) and Power Integrated Circuit(PIC), Concept of fast recovery and schottky diodes, freewheeling feedback diodes and snubber circuits.
Module2: AC to DC Converters (7 hours)
Controlled rectifiers: Single Phase semi and fully controlled converters with R, RL Load, Analysis of load voltage, load current, ripple factor – Introduction to Three phase semi and fully Controlled Converters- Dual Converters – Gate triggering methods for rectifiers - Practical design of Converter
Module 3: AC to AC Converters (6 hours)
Single Phase half and full Wave controller with R and RL load, Estimation of RMS load voltage, current and input power factor, Introduction to Three phase AC voltage controllers, Single phase Cyclo-converters, Gate pulse generation for AC regulator using TRIAC / DIAC.
Module 4: DC to DC Converters (7 hours)
Control strategies: TRC and CLC, Principle of step up and step-down operation, Analysis of Type A chopper with estimation of duty ratio, load voltage and load current, Two and Four Quadrant DC choppers – Pulse generation / triggering circuit for chopper circuits.
Module 5: DC to AC Converters (10 hours)
Single-phase inverters: Principle of operation of full bridge square wave, quasi-square wave, Driver circuits for inverters, Three phase bridge inverters (180° & 120° Modes), Voltage control methods, Harmonic reduction methods, Sinusoidal PWM Technique for pulse generation, Basics of Single phase Series Inverter and Current source inverters – Practical design of Inverter
Module 6: Recent Trends and Applications (8Hours)
Advanced converters: Introduction to Zeta and Super lift luo converter and Comparison of Multilevel Inverters, Applications: UPS, SMPS, HVDC systems, Induction heating – Power electronics for Renewable Energy, Rectifier based DC Motor Drive, Inverter based AC Motor Drive.

Text Books:

1. Rashid. M.H., “Power Electronics – Circuits, Devices and Applications”, Pearson Education Incorportion, New Delhi, 3rd Edition, 2014.
2. Ned Mohan, Undeland and Robbins, “Power Electronics – Converters, Applications and Design”, Wiley India Pvt. Ltd., New Delhi, 2010.

Reference Books:

1. EricksonR.W., MaksimovicD.,“Fundamentals of Power Electronics”, Springer Science & Business Media, 2nd Edition, 2001.
2. UmanandL., “Power Electronics: Essentials and Applications”, WileyIndia,2009.
3. Joseph Vithayathil, “Power Electronics – Principles and Applications”, Tata McGraw-Hill Limited, New Delhi, Indian Edition, 2017.
4. Bhimbra P. S., “Power Electronics”, Khanna Publishers, New Delhi, 2015.

18EE2011	Power Electronics Laboratory	L 0	T 0	P 2	C 1

Co-requisite: 18EE2010 Power Electronics

Course Objectives:

1. To understand the operating performance of Power Electronic Devices.
2. To study the various power electronics circuits, gating methods.
3. To learn the various simulation tools to analyze the power converter.

Course Outcomes:

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

1. Analyze the static and switching characteristics of Power Devices
2. Test and verify the design of Power Converters.
3. Develop control circuits for controlling the power converters.
4. Use the Data Sheets for the selection of power rating of the device.
5. Design suitable power, control and isolation circuits for an application.
6. Model a power converter using simulation packages such as MATLAB, PSIM & MULTISIM.

Description:

The laboratory will demonstrate the student about the operation and performance analysis of Power Devices, Power Converters and Drives.

List of Experiments

1. Characteristics of MOSFET, IGBT, SCR and TRIAC
2. Single Phase Semi & Full Converter with R & R – L Load
3. Three Phase Half Wave Converter with R & R – L Load
4. MOSFET based DC Chopper with DC Motor Load
5. Single Phase AC Voltage Controller with R & R – L Load
6. Single Phase Cyclo-converter with R & R – L Load
7. Single Phase Series Inverter with R & R – L Load
8. Three Phase Static Inverter with Induction Motor Load
9. Switched Mode Power Supply / DC Regulated Power Supply
10. Simulation of Power Electronic Circuits using MATLAB / Simulink
11. Simulation of Power Electronic Circuits using PSIM
12. Simulation of Power Electronic Circuits using MULTISIM
13. Various triggering methods for Power Devices
14. Microcontroller / DSP based triggering methods.

18EE2012	Power Systems - I	L 3	T 0	P 0	C 3

Course Objectives:

1. To perform steady state analysis and fault studies for a power system of any size and also to explore the nuances of estimation of different states of a power system.
2. To make the students familiar with the theoretical basis for various forms of over voltages such as lighting strokes, surges, switching transients etc.
3. To make the students familiar about distribution networks.

Course Outcome:

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

1. Investigate the state of a power system of any size and be in a position to analyze a practical system both under steady state and fault conditions.
2. Do calculation in transmission lines, select the protective components, planning and analysis
3. Mathematically model the various over voltages and analyze different situations. They will be aware of the preliminary design aspects of protection equipment needed.

4. Analyze the electromagnetic and electromechanical phenomena taking place around the synchronous generator.
5. Analyze the various electrical faults and use of switchgears.
6. Explain the various structures and configurations of a Microgrids.

Module 1: Basic Concepts (4 hours)

Evolution of Power Systems and Present-Day Scenario. Structure of a power system: Bulk Power Grids and Micro-grids. Generation: Conventional and Renewable Energy Sources. Distributed Energy Resources. Energy Storage. Transmission and Distribution Systems: Line diagrams, transmission and distribution voltage levels and topologies (meshed and radial systems). Synchronous Grids and Asynchronous (DC) interconnections. Review of Three-phase systems. Analysis of simple three phase circuits. Power Transfer in AC circuits and Reactive Power.

Module 2: Power System Components (10 hours)

Overhead Transmission Lines and Cables: Electrical and Magnetic Fields around conductors, Corona. Parameters of lines and cables. Capacitance and Inductance calculations for simple configurations. Travelling wave Equations. Sinusoidal Steady state representation of Lines: Short, medium and long lines. Power Transfer, Voltage profile and Reactive Power. Characteristics of transmission lines. Surge Impedance Loading. Series and Shunt Compensation of transmission lines.

Module 3: Synchronous Machines (5 hours)

Synchronous Machines: Steady-state performance characteristics. Operation when connected to infinite bus. Real and Reactive Power Capability Curve of generators. Typical waveform under balanced terminal short circuit conditions – steady state, transient and sub-transient equivalent circuits. Loads: Types, Voltage and Frequency Dependence of Loads. Per unit System and per unit calculations.

Module 4: Over-voltages and Insulation Requirements (4 hours)

Generation of Over-voltages: Lightning and Switching Surges. Protection against Overvoltages, Insulation Coordination. Propagation of Surges. Voltages produced by traveling surges. Bewley Diagrams.

Module 5: Fault Analysis and Protection Systems (13 hours)

Method of Symmetrical Components (positive, negative and zero sequences). Balanced and Unbalanced Faults. Representation of generators, lines and transformers in sequence networks. Computation of Fault Currents. Neutral Grounding.

Relays and Switchgear: Essential qualities of protective relays - over current relays -directional, distance and differential, under frequency, negative sequence relays -static relays - microprocessor based relays, Types of Circuit Breakers. Attributes of Protection schemes, Back-up Protection. Protection schemes (Over-current, directional, distance protection, differential protection) and their application.

Module 6: Distribution Systems (9 hours)

D.C and A.C. distribution - radial and ring main distribution systems, Introduction to Microgrid, Typical structure and configurations of a microgrid, AC and DC microgrids.

Text Books:

1. Wadhwa, C.L., “Electrical Power Systems”, New Age International Publishers Ltd., New Delhi, 6th Edition, 2014.
2. Kothari D. P., Nagrath I. J., “Modern Power System Analysis”, McGraw Hill India Limited, New Delhi, 4th Edition 2014.
3. Mehta, V.K., Rohit Mehta, “Principles of Power Systems”, S. Chand& Company Private Limited, New Delhi, 14th Edition, 2005.

Reference Books:

1. Grainger J., Stevenson W. D., “Power System Analysis”, McGraw Hill Education, Indian Edition, 2017.
2. B. M. Weedy, B. J. Cory, N. Jenkins, J. Ekanayake and G. Strbac, “ElectricPower Systems” , Wiley, 2012.
3. HadiSaadat, “Power System Analysis”, Tata McGraw-Hill Education India Private Limited, New Delhi, 3rd Edition 2010.

4. Gupta, B.R., “Power System Analysis and Design”, S.Chand & Company Limited, New Delhi, 2017.

18EE2013	Power Systems – I Laboratory	L	T	P	C
		0	0	2	1

Course Objectives:
1. To enable the students to understand the transmission line parameters and models in power system.
2. To enable the students to do the computation of per unit and single line diagram.
3. To enable the students to understand the fault analysis in a power system.

Course Outcomes:
At the end of the course, the student will be able to
1. Determine the sequence line parameters such as L and C.
2. Performance study of different transmission line model.
3. Facilitate the modification to be carried out in Per unit and single line diagram.
4. Model various power system components that are adequate for the basic system studies of short-circuit analysis.
5. Analyze the fault current under different fault conditions.
6. Simulate the Microgrid using PSCAD/EMTP

Description:
This laboratory will highlight the students about the basic concepts of a transmission system, fault analysis and microgrid.

List of Experiments:
1. Introduction to MATLAB
2. Computation of Transmission Line Parameters
3. Performance of a Medium Transmission Line Model
4. Per Unit Reactance Diagram
5. Analysis of Symmetrical Faults
6. Analysis of Unsymmetrical Faults Using SIMULINK
7. Symmetrical Components
8. Three Phase Short Circuit Analysis of a Synchronous Machine
9. Construct Single Line Diagram of Power System Using ETAP
10. Simulation of Microgrid using PSCAD/EMTP.

18EE2014	Power Systems – II	L	T	P	C
		3	0	0	3

Course Objectives:
1. To understand the operation of electric power systems.
2. To study the fault, power flow and stability analysis in a power system.
3. To learn the economic operation of power

Course Outcomes:
At the end of the course, the student will be able to
1. Use numerical methods to analyze a power system in steady state.
2. Classify the state of operating equilibrium after being subjected to a physical disturbance
3. Implement the voltage, frequency and power flow control
4. Monitoring and control the transmission and distribution power system.
5. Design various compensator for to control the power system parameters
6. Optimize the operation of power plant

Module 1: Power Flow Analysis (10 hours)
Review of the structure of a Power System and its components. Analysis of Power Flows: Formation of Bus Admittance Matrix. Real and reactive power balance equations at a node. Load and Generator Specifications. Application of numerical methods for solution of nonlinear algebraic equations – Gauss Seidel and Newton-Raphson methods for the solution of the power flow equations. Computational Issues in Large-scale Power Systems.

Module 2: Stability Constraints in synchronous grids (8 hours)
Swing Equations of a synchronous machine connected to an infinite bus. Power angle curve. Description of the phenomena of loss of synchronism in a single-machine infinite bus system following a disturbance like a three-phase fault. Analysis using numerical integration of swing equations (using methods like Forward Euler, Runge-Kutta 4th order methods), as well as the Equal Area Criterion. Impact of stability constraints on Power System Operation.

Module 3: Control of Frequency (6 hours)
Turbines and Speed-Governors, Frequency dependence of loads, Droop Control and Power Sharing. Automatic Generation Control. Generation and absorption of reactive power by various components of a Power System. Excitation System Control in synchronous generators.

Module 4: Control of Voltage (6 hours)
Automatic Voltage Regulators. Shunt Compensators, Static VAR compensators and STATCOMs. Tap Changing Transformers. Power flow control using embedded dc links, phase shifters.

Module 5: Monitoring and Control (8 hours)
Overview of Energy Control Centre Functions: SCADA systems. Phasor Measurement Units and Wide-Area Measurement Systems. State-estimation in distribution system. System Security Assessment. Normal, Alert, Emergency-Contingency Analysis. Preventive Control and Emergency Control-Bi-directional Communication system.

Module 6: **Power System Economics and Management (7 hours)**
Basic Pricing Principles: Generator Cost Curves, Utility Functions, Power Exchanges, Spot Pricing. Electricity Market Models (Vertically Integrated, Purchasing Agency, Whole-sale competition, Retail Competition), Demand Side-management, Transmission and Distributions charges, Ancillary Services. Regulatory framework.

Text Books:

1. HadiSaadat, “Power System Analysis”, Tata McGraw-Hill Education India Private Limited, New Delhi, 3rd Edition 2010.
2. Olle I. Elgerd “Electric Energy Systems Theory: An Introduction”, McGraw-Hill ,2nd Edition, 2017.
3. Gupta, B.R., “Power System Analysis and Design”, S.Chand & Company Limited, New Delhi, 2017.

Reference Books:

1. Nagrath I.J., Kothari D.P., ‘Modern Power System Analysis’, Tata McGraw-Hill, 4th Edition, 2011.
2. Wadhwa C. L., “Electrical Power Systems”, New Age International Private Limited, New Delhi, 6th Edition, 2014.
3. Kundur P., “Power System Stability and Control”, Tata McGraw Hill Education Pvt. Ltd.,New Delhi, 10th reprint 2010.

18EE2015	Power Systems – II Laboratory	L	T	P	C
		0	0	2	1

Co-requisite: 18EE2014 Power Systems - II

Course Objectives
1. To enable the students to understand the load flow and stability analysis in a power system.
2. To learn the economic operation of power system.

3. To understand the structure and functional units of a Smart Grid

Course Outcomes

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

1. Facilitate the modification of the Bus admittance matrix to reflect the network changes.
2. Model various power system components that are adequate for the basic system studies of load flow and stability analysis.
3. Model power-frequency dynamics and reactive power-voltage interaction and Simulate ALFC and AVR
4. Optimize the operation of power plants using computational techniques.
5. Characterize reliability aspects at all stages of the power system.
6. Design the prototype model of the smart grid

Description:

This lab course includes nine experiments to study various aspects of power systems: measurement of the characteristics data of a transmission line and an assessment of its voltage drop and losses; synchronization and steady state operation of a generator connected to an infinite bus system; load characteristics of a synchronous motor and effect of field excitation on reactive power load; effect of voltage and frequency levels on power transmission and effects of various load types on power plants; load flow data preparation and system study; system analysis of symmetrical and unsymmetrical faults; Transient stability data preparation and system study.

<u>List of experiments</u>

1. Formation of Y Bus Matrix By Direct Inspection And Singular Transformation Method
2. Load flow Analysis –MATLAB
3. Load Flow Analysis using ETAB/PSCAD
4. Solving Load Flow Equation By Newton Raphson Method
5. Transient Stability
6. Automatic Voltage Regulator (AVR) and Automatic Load Frequency Control (ALFC)
7. Fault analysis
8. Economic Load Dispatch
9. Power System State Estimation/ Contingency Analysis
10. Smart Grid

		L	T	P	C
18EE2016	**Wind and Solar Energy Systems**	3	0	0	3

Couse Objective:

1. To impart knowledge about wind, solar power and solar thermal power generation
2. To create awareness about the various topologies of wind generators
3. To make the students understand the grid requirements in renewable integration.

Course Outcomes:

At the end of this course, students will demonstrate the ability to

1. Identify the need for technologies pertaining to renewable energy sources in the current energy scenario
2. Describe the basic physics of wind and solar power generation.
3. Outline the power electronic interfaces for wind and solar generation.
4. Illustrate the technologies in Solar PV power generation
5. Interpret the issues related to the grid-integration of solar and wind energy systems
6. Summarize the solar thermal power generation technologies

Module 1: Physics of Wind Power: (5 hours)

History of wind power, Indian and Global statistics, Wind physics, Betz limit, Wind speed statistics-probability distributions, Wind speed and power-cumulative distribution functions.

Module 2: Wind generator topologies: (10 hours)
Review of modern wind turbine technologies, Tip speed ratio, Stall and pitch control, Fixed and Variable speed wind turbines, Induction Generators, Doubly-Fed Induction Generators and their characteristics, Permanent Magnet Synchronous Generators, Power electronic interfaces for wind generators, Wind farm development.
Module 3: The Solar Resource: (6 hours)
Introduction, solar radiation spectra, solar geometry, Earth Sun angles, observer Sun angles, solar day length, Estimation of solar energy availability.
Module 4: Solar photovoltaic: (8 hours)
Technologies-Amorphous, monocrystalline, polycrystalline; V-I characteristics of a PV cell, PV module, array, Power Electronic Converters for Solar Systems, Maximum Power Point Tracking (MPPT) algorithms. Converter Control.
Module 5: Network Integration Issues: (8 hours)
Overview of grid code technical requirements. Fault ride-through for wind farms - real and reactive power regulation, voltage and frequency operating limits, solar PV and wind farm behavior during grid disturbances. Power quality issues. Power system interconnection experiences in the world. Hybrid and isolated operations of solar PV and wind systems.
Module 6: Solar thermal power generation: (8 hours)
An overview of solar-thermal applications, Solar air heaters, Flat plate collectors, concentrating collectors, Thermal energy storage, Solar water heating, Building heating, Solar cooling, Solar thermal power systems, Solar ponds.

Text Books:

1. Ackermann T., “Wind Power in Power Systems”, John Wiley and Sons Ltd., 2nd Edition, 2012.
2. SukhatmeS. P., NayakJ. K., “Solar Energy: Principles of Thermal Collection and Storage”, 3rd Edition, McGraw Hill, 2009.

Reference Books:

1. Masters G. M., “Renewable and Efficient Electric Power Systems”, 2nd Edition, John Wiley and Sons, 2013.
2. Siegfried. H., Waddington R., “Grid Integration of Wind Energy Conversion Systems”, 2nd Edition, John Wiley and Sons Ltd., 2006.
3. Tiwari G.N., Ghosal M.K., “Renewable Energy Applications”, Narosa Publications, 2004.
4. Duffie J.A., Beckman W.A., “Solar Engineering of Thermal Processes”, 4thEdition, John Wiley & Sons, 2013.

18EE2017	Wind and Solar Energy Laboratory	L	T	P	C
		0	0	2	1

Co-requisite: 18EE2016 Wind and Solar Energy Systems
Course Objective:
1. To prepare students to understand, learn and analyze the different concepts of wind and solar energy technologies.
2. To prepare the students about the standards to be followed for wind and solar energy technologies.
3. To prepare the students the various applications pertaining to wind and solar technologies.

Course Outcomes:
At the end of the course, the students will be able to
1. Interpret solar PV characteristics and design a solar PV system.
2. Conduct performance tests on solar PV panel and other applications.
3. Simulate stand-alone solar and wind energy systems.
4. Assess and predict the wind and solar resource potential.
5. Evaluate the performance of a wind turbine generating system.

6. Estimate the wind turbine characteristics.

Description:
The laboratory will demonstrate the student about the design, performance analysis and simulation of solar PV and wind energy conversion systems.

List of Experiments:
1. Study & Design of solar PV system for domestic application PVsyst
2. Characteristics of solar PV panel
3. Effects of temperature on solar panel performance
4. Performance of solar water heater (solar-thermal conversion) as per BIS standards
5. Simulation of stand- alone solar PV system
6. Charge-discharge characteristics of battery connected to solar PV system
7. Solar energy forecasting
8. Evaluation of power coefficient of a wind turbine
9. Evaluation of charge controller efficiency in a wind turbine generating system
10. Estimation of wind turbine power curve.
11. Simulation of variable pitch wind turbine.
12. Wind resource assessment

18EE2018	Industrial Mechatronics	L	T	P	C
		3	0	0	3

Course Objectives:
1. To make the students understand the concepts of mechatronics.
2. To impart knowledge in elements of mechatronics systems
3. To introduce the concept of different interfacing used in industry

Course Outcomes:
At the end of the course, the students will be able to
1. Summarize and select the appropriate control elements and actuators for an application.
2. Interface microcontrollers through external circuit interface to a variety of sensors and actuators.
3. Design and control various drives and motors for various process applications.
4. Propose simple Hydraulic and Pneumatic circuits for automation.
5. Engineer mechanical systems with precision and accuracy
6. Review the working skills for carrying out (understanding, planning, and executing) innovation projects, developing mechatronics industrial products.

Module 1: Introduction to Mechatronics and elements (8 hours)
Definition of mechatronics, Mechatronics in manufacturing, products and design, Review of fundamentals of electronics, Role of mechatronics in automation, manufacturing and product development; Control Elements and Actuators: On/off push buttons, control relays, thermal over load relays, contactors, selector switches, solid state switches, Mechanical actuators, Computational Elements and Controllers, block and functional diagrams controllers for robotics and CNC, linear and rotary

Module 2: Microprocessors, microcontrollers and interfacing (8 hours)
Introduction, programming and applications, introduction to PLC, simple programs for process control application based on relay ladder logic-Supervisory Control and Data Acquisition Systems (SCADA) and Human Machine Interface (HMI); Interfacing Systems, TCP/IP, MAP/TOP;

Module 3: Drives and mechanisms of an automated system (8 hours)
Drives: stepper motors, servo drives. Ball screws, linear motion bearings, cams, systems controlled by camshafts, electronic cams, indexing mechanisms, tool magazines, and transfer systems.

Module 4: Hydraulic system (7 hours)
Hydraulic systems: flow, pressure and direction control valves, actuators, and supporting elements, hydraulic power packs, pumps, Design of hydraulic circuits.

Module 5: Pneumatic system (7 hours)
Pneumatics: production, distribution and conditioning of compressed air, system components and graphic representations, design of systems.
Module 6: Industrial mechatronics (7 Hours)
Application of Mechatronic Systems: Introduction to factory automation and integration, design of simple Mechatronics systems, Case studies based on the application of mechatronics in manufacturing, autotronics, bionics and avionics. CNC technology and Robotics CNC machines and part programming, Industrial Robotics.

Text Books

1. Cetinkunt, S., “Mechatronics”, John wiley, 2007.
2. HMT ltd. Mechatronics, Tata Mcgraw-Hill, New Delhi, 1988

Reference Books

1. J Stenersons, “Fundamentals of Programmable Logic Controllers Sensors and Communications”, Prentice Hall, 2004.
2. Kuttan K K, “Introduction to Mechatronics”, Oxford University Press, 2007.
3. D. G. Alciatore and M. B. Histand, “Introduction to Mechatronics and Measurement Systems”, McGraw Hill, NY, 2007.
4. Bolton W, “Mechatronics”, Pearson Education Asia, New Delhi, 2004.

18EE2019	Electrical Machines and Drives	L	T	P	C
		3	0	0	3

Course Objective
1. To impart knowledge on the performance characteristics, speed control and starting methods of DC and AC motors.
2. To impart knowledge on the basic of selection of drive for a given application.
3. To impart knowledge on the concept of controlling the speed of DC and AC motor using Solid state converters.

Course Outcomes
At the end of the course, the student will be able to
1. Explain the operating principles of DC and AC motors.
2. Explain the various method of speed control of DC and AC motors.
3. Describe the factors for selection of drive, various load pattern and determine their power rating.
4. Discuss the working of various power semiconductor devices.
5. Demonstrate the working of various power converters and inverters.
6. Apply and Analyze the control of DC and AC motors with solid state power converters and inverters.

Module 1: Electric Motors (10 hours)
Constructional details – Principle of operation – Performance characteristics of DC Motor, Single Phase Induction Motor, Three Phase Induction Motor, Synchronous Motor, Universal Motor, Stepper Motors and Reluctance Motors
Module 2: Speed Control and Starting (8 hours)
Speed control of D.C. motors – Ward – Leonard system – Electrical Braking – Starting methods - Three phase induction motors – Starting methods – Electrical braking – Speed Control methods – Slip Power Recovery Scheme
Module 3: Electric Drives (7 hours)
Types of Electrical Drives – Selection & factors influencing the selection – heating and cooling curves – loading condition – Classes of duty – determination of Power rating – Load equalization

Module 4: Power Semiconductor Devices (5 hours)
Basic structure and operation of SCR, static and dynamic switching characteristics – MOSFET - general switching characteristics - IGBT - static and dynamic switching characteristics.
Module 5: Converters and Inverters (7 hours)
Introduction - Controlled Converters – two pulse converter - three pulse converter – Chopper – Types of Chopper – Inverter – Voltage Source Inverter – Current Source Inverter – Cycloconverter
Module 6: Solid State Speed Control (8 hours)
Advantages of Solid State Control - Control of DC Drives using Converters – Choppers – Control of Three Phase Induction Motors using Stator Voltage Control – V/F Control and Slip Power Recovery Schemes using Inverters and AC power regulators.

Text Book
1. Gopal K. Dubey, "Fundamentals of Electric Drives", Narosa Publications, New Delhi, 2nd Edition, 2002.

Reference Books
1. Pillai S.K., "A First course on Electrical Drives", New Age International Private Limited, New Delhi, 1991.
2. Vedam Subrahmanyam, "Electric Drives: Concept and Application", Tata McGraw-Hill Education, 2nd Edition, 2011.
3. Bhattacharya, "Electrical Machines", Tata McGraw Hill Education, 2008.
4. Kothari D.P., Nagrath I.J., "Electrical Machines", Tata McGraw Hill Education India Private Limited, New Delhi, 3rd Edition, 2004.
5. Sen P.C., "Principles of Electrical Machines and Power Electronics", John Wiley Publications Private Limited, 3rd Edition, 2013.

18EE2020	Electrical Machines and Drives Laboratory	L	T	P	C
		0	0	2	1

Co-requisite: 18EE2019 Electrical Machines and Drives
Course Objective:
1. To prepare the students to understand, demonstrate and analyze the concepts of DC and AC Motors.
2. To prepare the students to understand, demonstrate and analyze the concepts of DC Drive.
3. To prepare the students to understand, demonstrate and analyze the concepts of AC Drive.

Course Outcomes:
At the end of the course, the students will be able to
1. Recall the working principle and various parts of DC and AC Motors.
2. Conduct the suitable method for speed control of DC and AC motors.
3. Observe the switching characteristics of Power Semiconductor Devices
4. Perform the control of Induction Motor with Solid state converters.
5. Perform the Control of DC Motor with Solid State converters.
6. Perform the Control of Synchronous Motor with Solid state converter.

Description:
The laboratory will demonstrate the student about the operation and control of DC and AC Motor with Solid state converters.
List of Experiments (Any Eight from the list)
1. Speed Control of DC Shunt Motor
2. Speed Control of Three Phase Squirrel Cage Induction Motor
3. Speed Control of Three Phase Slip Ring Induction Motor
4. Switching Characteristics of Power Semiconductor Devices (SCR, MOSFET, IGBT)
5. Chopper Fed DC Drive
6. Three Phase Converter Fed DC Drive

7. Control of Induction Motor with AC Voltage Regulator
8. Voltage Control of Voltage Source Inverter Fed AC Drive
9. V/F control of AC Drive
10. Cycloconverter Fed Synchronous Motor Drive

18EE2021	Electrical Machines and Power Systems	L	T	P	C
		3	0	0	3

Course Objectives:

1. To impart knowledge on the construction and working of a DC Machines.
2. To impart knowledge on the construction and working of a AC Machines.
3. To impart knowledge on the basics of a Power system.

Course Outcomes:

At the end of this course, students will demonstrate the ability to

1. Outline the characteristics of DC and AC machines.
2. Validate their usage for specific applications
3. Summarize on starting, speed control and braking techniques in DC and AC motors.
4. Exemplify the equivalent circuit of transformer and induction motor, regulation, losses and efficiency, load test on transformers.
5. Explain the operation of electric power system, EHVAC and EHVDC transmission systems
6. Understand the basic structure of electric power system

Module 1: Introduction to DC Machines: (8 Hours)

Electromechanical energy conversion - Rotating machines - Driving and opposing torque – Faradays law – Generator mode and Motor mode - Constructional details of DC Machines – EMF equation – Methods of excitation – Self and separately excited Shunt generator

Module 2: DC Motors: (8 Hours)

Principle of operation of DC Motor – Back emf and torque equation – Characteristics of DC series and shunt motors Starting of DC Motors, Need for Starters - Speed control and Braking of DC motors (Voltage Control & Dynamic Braking Only)–Principle of Brushless DC motors - Direct Drive High Torque Motors.

Module 3: Transformers: (8 Hours)

Constructional Details – Principle of Operation – EMF Equation – Transformation ratio – Transformer on no load –Parameters referred to HV/LV windings – Equivalent circuit – Dot Convention - Transformer on load – Regulation - Losses and efficiency - Load test – Three phase transformers connections – Introduction to Current and Potential Transformers –Applications of Transformer in Robotics and Automation.

Module 4: Induction motors: (8 Hours)

Construction – Types – Principle of operation of three phase induction motors – Speed Torque characteristics- Equivalent circuit - Starting and Speed control – Single-phase induction motors (only qualitative analysis). - Introduction to Linear induction motor – PMTIM – Applications.

Module 5: Synchronous and Special Machines: (8 Hours)

Construction of Synchronous machines - Types – Induced emf – Working principles of Brushless alternators – Stepper motor - Servomotor – Universal motor -. Applications – rating and duty cycle -Sizing of Motor for an Industrial application

Module 6: Introduction to Power System: (5 Hours)

Structure of electric power systems – Generation, transmission, sub-transmission and distribution systems - EHVAC and EHVDC transmission systems – Substation layout. (Concepts only).

Text Books:

1. Kothari. D. P, Nagrath. I. J, “Electric Machines”, Tata McGraw- Hill Education India Private Limited, New Delhi, 4^{th} Edition, 2010.
2. V. K. Mehta and Rohit Mehta, “Principles of Power System”, S.Chand and Company Ltd, 2003.

Reference Books:

1. Vincent Del Toro, "Electrical Machines and Power Systems", Prentice Hall Limited, 1985.
2. Haruhiko Asada, Kamal Youeef-Toumi, "Direct-Drive Robots Theory and Practice", The MIT Press, Cambridge, 1987.
3. AE Fitzgerald, Charles Kingsley, Stephen.D.Umans, "Electric Machinery", Tata McGraw Hill publishing Company Ltd, 2003.
4. JB Gupta, "Theory and Performance of Electrical Machines", S.K.Kataria and Sons, 2002.

18EE3001	Energy Engineering	L	T	P	C
		3	0	0	3

Course Objective

1. To create environment-friendly and energy-efficient buildings
2. To deal with actively harnessing renewable natural resources like solar energy and utilizing materials that cause the least possible damage to the global commons – water, soil, forests and air.
3. To deal with global and Indian energy scenario.

Course Outcome

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

1. Express the basic definitions and units of energy and the role of energy in economic development
2. Narrate the national and Global energy scenario for Conventional and nonconventional energy sources
3. Illustrate the various renewable energy systems, performance and issues related to grid connections.
4. Effectively manage the energy requirements by understanding the pollutions in the power plants along with its control.
5. Solve the environmental issues regarding the energy sources and its utilization in energy
6. Outline on the evolution of Smart Grids and risks to the Smart Grid and its protective measures.

Module 1: Introduction to Energy: (8 hours)

Definition and Units of energy, power, Forms of energy, Conservation of energy, Energy flow diagram to the earth. Conventional and nonconventional energy sources- Origin of fossil fuels,time scale of fossil fuels, Renewable Energy Resources, Role of energy in economic development and social transformation. Commercial and non-commercial forms of energy, energy consumption pattern and its variation as a function of time.

Module 2: National and Global Energy Scenario: (8 hours)

Energy resources available in India, urban and rural energy consumption, nuclear energy - promise and future, energy as a factor limiting growth, need for use of new and renewable energy sources. Energy consumption in various sectors, projected energy consumption for the future, exponential increase in energy consumption, energy resources, coal, oil, natural gas, nuclear power and hydroelectricity, impact of exponential rise in energy consumption on global economy, future energy options.

Module 3 :Solar And Wind Energy: (8 hours)

Solar radiation at the earth's surface ,solar radiation measurements ,estimation of average solar radiation ,solar thermal flat plate collectors ,concentrating collectors ,solar thermal applications ,heating, cooling, desalination, drying, cooking, etc , principle of photovoltaic conversion of solar energy, types of solar cells - Photovoltaic applications: battery charger, domestic lighting, street lighting, water pumping etc- Nature of the wind , power in the wind ,factors influencing wind , wind data and energy estimation , wind speed monitoring , wind resource assessment , Betz limit , site selection .

Module 4: Other Renewable Energy Systems : (7 hours)

Introduction and overview of solar, wind, bio-mass, geothermal, oceanic energy systems. Hydrogen and Fuel cells, types, scope, stand-alone power generations, Issues related to grid, connections, Global and National Policies.

Module 5: Environmental Impact: (7 hours) Kyoto protocol- Environmental degradation due to energy production and utilization, Primary and secondary pollution, air, thermal and water pollution, depletion of ozone layer, global warming, biological damage due to environmental degradation. Pollution due to thermal power station and their control. Pollution due to nuclear power generation, radioactive waste and its disposal. Effect of hydroelectric power stations on ecology and environment.

Module 6: Smart Grid Evolution: (7 hours)

Electric grid operation - evolution of Smart Grids, electric system design and operation, technical and tariff changes - integration between utilities and Regional Transmission Organizations. Smart Grid components and description, Smart grid metering, demand response, governmental regulation, network standards, network integration, loan guarantees, consumer privacy -Risks to the Smart Grid - protective measures.

Reference Books

1. Vaclav Smil, Energy: A Beginner's Guide, One world Publications, Oxford, 2017.
2. Stuart Borlase, "Smart Grids: Infrastructure, Technology, and Solutions" Taylor and Francis, Boca Raton,2016.
3. Narendra Jadhav, Rajiv Ranjan, SujanHajra, "Re-Emerging India - A Global Perceptive", The ICFAI University Press, Hyderabad, 2005.
4. Eric Jeffs, "Green energy: sustainable electricity supply with low environmental impact" CRC Press,USA, 2017.
5. Kishore V. V .N., "Renewable Energy Engineering And Technology Principles and Practice", Earthscan,Publications Ltd, UK, 2009.

18EE3002	Photovoltaic Systems	L	T	P	C
		3	0	0	3

Course Objectives:

1. To provide necessary knowledge about the modeling, design and analysis of various PV systems
2. To show that PV is an economically viable, environmentally sustainable alternative to the world's energy supplies.
3. To understand the power conditioning of PV system's power output.

Course Outcome

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

1. Explain basics of solar photovoltaic systems.
2. Identify the feasibility of PV systems as an alternative to the fossil fuels
3. Design efficient stand alone and grid connected PV power systems
4. Analyze the structure, materials and operation of solar cells, PV modules, and arrays.
5. Differentiate the characteristics of the solar cell under local climatic working conditions.
6. Apply the concept to design PV systems for various applications.

Module 1: Photovoltaic Basics: (6 Hours)

Structure and working of Solar Cells-Types, Electrical properties and Behavior of Solar Cells -Cell properties and design- PV Cell Interconnection and Module Fabrication -PV Modules and arrays -Basics of Load Estimation.

Module 2: Manufacturing of PV Cells & Design of PV Systems: (8 Hours)

Commercial solar cells - Production process of single crystalline silicon cells, multi crystalline silicon cells, amorphous silicon, cadmium telluride, copper indium gallium diselenide cells. Design of solar PV systems and cost estimation. Case study of design of solar PV lantern, standalone PV system - Home lighting and other appliances, solar water pumping systems.

Module 3: Classification of PV Systems: (7 Hours)

Classification - Central Power Station System, Distributed PV System, Standalone PV system, Grid Interactive PV System, small system for consumer applications, Hybrid solar PV system, Concentrator solar photovoltaic.

Module 4: PV System Components: (8 Hours)
System components - PV arrays, inverters, batteries, charge controls, net power meters, PV array installation, operation, costs, reliability.
Module 5: Inverters for PV Systems: (8 Hours)
Inverter control topologies for stand-alone and grid-connected operation-Analysis of inverter at fundamental frequency and at switching frequency-Feasible operating region of inverter at different power factors for grid connected systems and stand-alone PV systems.
Module 6: PV System Applications: (8 Hours)
Building-integrated photovoltaic units, grid -interacting central power stations, stand- alone devices for distributed power supply in remote and rural areas, solar cars, aircraft, space solar power satellites. Socio-economic and environmental merits of photovoltaic systems.

Reference Books:

1. C.S. Solanki: Solar Photovotaics–Fundamentals, Technologies and Applications, PHI Learning Pvt. Ltd., 2011.
2. John R. Balfour, Michael L. Shaw, Sharlave Jarosek "Introduction to Photovoltaics", Jones& Bartlett Publishers, Burlington, 2011.
3. Chetan Singh Solanki., Solar Photovoltaic: "Fundamentals, Technologies and Application", PHI Learning Pvt., Ltd., 2009.
4. Partain .L.D, Fraas L.M., " Solar Cells and Their Applications", 2nd edition, Wiley, 2010.
5. Sukhatme .S.P, Nayak .J.K, " Solar Energy", Tata McGraw Hill Education Private Limited, New Delhi, 2010.

18EE3003	Energy Management and Audit	L	T	P	C
		3	0	0	3

Course Objective
1. To understand various energy management techniques
2. To understand energy auditing techniques
3. To understand the importance of energy conservation

Course Outcome
At the end of the course, the students will be able to
1. Demonstrate an understanding of energy management and audit approaches.
2. Differentiate energy auditing methods and the implementation procedures.
3. Analyze the energy requirement for domestic and industrial application.
4. Apply energy conservation act on transportation and agriculture sectors.
5. Design the economic financial model for energy in an industry.
6. Examine the economic and financial management for an energy model.

Module 1: Energy Management and Audit: (8 hours)
Energy management: concepts, energy demand and supply, economic analysis, duties and responsibilities of energy managers. Energy conservation: concepts, energy conservation in – household, transportation, agricultural and industrial sectors, lighting- Energy Conservation act. Energy Audit: Definition – needs–types-approaches; energy costs, bench marking, energy performance, matching energy supply to requirement, fuel and energy substitution, energy audit instruments, duties and responsibilities of energy auditors- Energy policy.
Module 2: Energy Efficiency in Thermal Utilities: (12 hours)
Boilers: Types, Combustion in boilers, Performances evaluation, Analysis of losses, Feed water treatment, Blow down, Energy conservation opportunities. Steam System: Properties of steam, Assessment of steam distribution losses, Steam leakages, and trapping, Condensate and flash steam recovery system, Identifying opportunities for energy savings. Furnaces: Classification, General fuel economy measures in furnaces, Excess air, Heat distribution, Temperature control, Draft control, Waste heat recovery. Insulation and

Refractories: Insulation-types and application, Economic thickness of insulation, Heat savings and application criteria, Refractory-types, selection and application of refractories, Heat loss. Need for cogeneration, principle of cogeneration, Technical options of cogeneration, and prime movers of cogenerations.

Module 3: Energy Efficiency in Electrical Utilities: (7 hours)

Electrical System: Electricity billing, Load management and Maximum Demand Control, Power factor improvement. Electric Motors: Types, losses in induction motors, motor efficiency, factors affecting the motor performance, rewinding and motor replacement issues. Lighting system: Light source, Choice of lighting, Luminance requirements and Energy conservation measures.

Module 4: Energy Action Planning: (6 hours)

Key elements, force field analysis, energy policy- purpose, perspective, contents, formulation, ratification; location of energy management, top management support, energy manager-accountability, motivation-information system strategies- marketing and communicating- training and planning-Case Studies of 4 to 6 Successful Energy Management in Industries.

Module 5: Monitoring and Targeting: (6 hours)

Defining – elements, data and information analysis; techniques, energy consumption, production, cumulative sum of differences, energy service companies, energy management information Systems-Star Labeling for Electrical appliances. Role of BEE in star labeling.

Module 6: Economic Analysis and Financial Management: (6 hours)

Objectives, Investment needs, appraisal and criteria, sources of funds. Simple pay-back period, Return on investment (ROI), Net Present value (NPV), Internal Rate of Return (IRR), and Annualized cost, Time value of money, Cash flows, Discounting, Inflation Risk and sensitivity analysis, financing options. Pros and cons of the common methods of analysis.

Reference Books

1. 1.Steve Doty, Wayne C. Turner, "Energy Management Handbook" Fairmont Press, Lilburn, 2009.
2. Barney L. Capehart, Wayne C. Turner, William J. Kennedy, "Guide to Energy Management", Fairmont Press, Lilburn, 2008.
3. Clive Beggs, "Energy: Management, Supply and Conservation" Butterworth-Heinemann Publications, Oxford, 2009
4. Albert Thumann, William J. Younger, Terry Niehus, "Handbook of Energy Audits" Fairmont Press, Lilburn, 2010.
5. MoncefKrarti, "Energy Audit of Building Systems: An Engineering Approach" Taylor & Francis, Boca Raton, 2010.
6. Guide books for National Certification Examination for Energy Manager / Energy Auditors Book-General Aspects (available online)
7. Guide books for National Certification Examination for Energy Manager / Energy Auditors Book-2, Electrical Utilities (available online)
8. Guide books for National Certification Examination for Energy Manager / Energy Auditors Book-3, Electrical Utilities (available online)

18EE3004	Wind Energy	L	T	P	C
		3	0	0	3

Course Objectives:

1. To gain detailed understanding of the issues associated with the development of wind energy for electrical energy supply
2. To study the aerodynamic design of wind turbines
3. To understand the issues of location and grid connection of wind energy power plants

Course Outcomes:

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

1. Outline the various wind turbine topologies and conversion technologies
2. Estimate the cost involved and other economic aspects of wind energy system
3. Assess the wind resource in a given geographical location
4. Select the appropriate blade design parameters
5. Categorize the different kinds of generators used in wind energy system
6. Explain grid interconnection strategy and hybridization of wind energy system

Module 1: Wind Energy System and Economics: (7 Hours)

Introduction – Power contained in the wind – Principal wind turbine components – Wind turbine materials – Machine elements – Wind turbine topologies – Wind turbine power curve - Economic assessment of wind energy systems – Capital costs – Operation and maintenance cost – Value of wind energy – Economic analysis methods

Module 2: Wind Characteristics: (7 Hours)

General characteristics of wind resource – Characteristics of atmospheric boundary layer - Wind data analysis and resource estimation – Wind turbine energy production estimates - Regional wind resource assessment

Module 3: Wind Resources and Impacts: (7 Hours)

Wind prediction and forecasting – Wind measurement and instrumentation – Wind turbine siting – Installation and operation issues – Wind farms – Off shore wind energy - Environmental impacts of wind energy systems.

Module 4: Aerodynamics of Wind Turbines: (8 Hours)

Introduction – One-dimensional momentum theory and the Betz Limit – Ideal horizontal axis wind turbine with wake rotation – Airfoils and general concepts of aerodynamics –Momentum theory and blade element theory – Blade shape for ideal rotor without wake rotation– Blade shape for optimum rotor with wake rotation – Generalized rotor design procedure

Module 5: Electrical Aspects of Wind Turbines: (8 Hours)

Electrical machines as applied to wind turbines: DFIG, PMSG – Fixed speed and variable speed operation– Stand-alone configurations – Transmission and distribution network interfaces – Power converters for wind technology – Active power control – Reactive power control – Wind farm power quality - Ancillary electrical equipment.

Module 6: Wind Turbine Control, Grid Integration and Hybrid Power Systems: (8 Hours)

Overview of wind turbine control system – Grid connected turbine operation – Supervisory control – Dynamic control theory and implementation – Wind turbines and wind farms in electrical grid - Distributed generation – Hybrid power system – Energy storage.

Reference Books:

1. Manwell, J.F., McGowan, J.G. and Rogers A.L., “Wind Energy Explained – Theory, design and application”, John Wiley & Sons, UK, 2009.
2. Heier, S., “Grid Integration of Wind Energy Conversion Systems”, John Wiley & Sons, Chichester, 2nd Edition, 2006.
3. Burton, T., Jenkins N., Sharpe, D. and Bossanyi, E., “Wind Energy Handbook”, John Wiley & Sons, Chichester, 2nd Edition, 2011.
4. Ackermann, T., “Wind power in power systems “, John Wiley& Sons, Chichester 2006.
5. Olimpo Anaya-Lara, Nick Jenkins, JanakaEkanayake, Phill Cartwright, Michael Hughes, “Wind Energy Generation: Modelling and Control, John Wiley& Sons, Chichester 2009.

		L	T	P	C
18EE3005	**Solar Energy Laboratory**	0	0	4	2

Co-requisite: 18EE3002 Photovoltaic Systems

Course Objective

1. To learn the characteristics of PV array and calculate the charge carrier life time of PV cell.

2. To understand the algorithms for efficient and optimal power tracking of PV modules.
3. To have practical experience on SAPV and Grid tied PV systems

Course Outcome

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

1. Identify the characteristics of the PV modules and the charge carrier lifetime.
2. Locate the faulty modules of the PV array.
3. Apply the Maximum power point tracking procedure in solar PV systems.
4. Analyze the performance of PV modules at different environmental conditions and inclination angle.
5. Setup the standalone PV system and calculate its efficiency.
6. Evaluate the performance of grid tied PV system with linear and non-linear load condition.

LIST OF EXPERIMENTS

1. Characteristics of PV Panel
2. Characteristics of PV panel under series and parallel combination
3. Solar energy Measurement
4. Estimating the effect of sun tracking on Energy Generation of solar PV Modules
5. Study of shadow effect on the PV panel
6. Carrier Lifetime Measurements for a Solar Cell
7. Perturb and observe MPPT Algorithm
8. Efficiency measurement of Standalone Solar PV System
9. Observation of current waveforms for linear and non linear loads and calculations in a Grid tied solar PV system
10. Solar Cell Simulation Using Personal Computer One Dimension (PC - 1D) Simulator

		L	T	P	C
18EE3006	**Electric Drives Laboratory for Renewable Energy**	0	0	4	2

Course Objective:

1. To prepare the students to understand, demonstrate and analyze the role of Electric Drives for Renewable Energy Systems.

Course Outcomes:

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

1. Understand the working of Modern Power Converters (Multilevel Inverter and Matrix Converter).
2. Apply the usage of modern power converters for PV systems.
3. Apply the usage of modern power converters for Wind Energy systems.
4. Select and apply suitable control for Wind Energy System.
5. Understand the use of special machine for Wind Energy System.
6. Use suitable algorithms for design of control for renewable energy system.

Description:

The laboratory will demonstrate the student about the role of various converters and electric drives for renewable energy systems.

List of Experiments (Any Eight from the list)

1. Multilevel Inverter with RLE Load
2. Matrix Converter with RLE Load
3. Control of 8/6 SRM Drive
4. Multilevel Inverter in transformerless PV Systems
5. Matrix Converter for Photovoltaic systems
6. Generator side converter control of Wind Energy System
7. Load side converter control of Wind Energy System
8. Matrix converter for Wind Energy Systems
9. Multilevel Inverter for Wind Energy Systems

10. Simulation of Variable Speed Wind turbine with Permanent Magnet Synchronous Generator.

18EE3007	Wind Energy Laboratory	L 0	T 0	P 4	C 2

Co-requisite: 18EE3004 Wind Energy

Course Objectives:
1. To study the various wind power forecasting techniques.
2. To learn the control algorithm for maximum power operation.
3. To know the impact of blade geometry in wind energy system.

Course Outcomes:

At the end of the course, the student will be able to
1. Assess and predict the wind resources at a given site.
2. Simulate the model of a wind power system
3. Implement suitable controller to track maximum wind power.
4. Experimentally determine the power coefficient of wind turbine energy system
5. Analyze the power quality of wind turbine energy system with AC and DC loads
6. Evaluate the pressure distribution across an airfoil at different angles of attack

List of Experiments:
1. ANN based wind energy forecasting
2. Fuzzy logic-based wind energy forecasting
3. Modeling of wind turbine power curve
4. Simulation of variable pitch wind turbine
5. Simulation of PMSG based wind turbine system using PSIM
6. Maximum power tracking in wind energy system
7. Evaluation of power coefficient and tip speed ratio of a wind turbine
8. Power analysis of wind energy system with AC and DC loads
9. Flow visualization over symmetric and cambered airfoils
10. Pressure distribution on a cambered airfoil at different angles of attack.

18EE3008	Power Engineering Simulation Laboratory	L 0	T 0	P 4	C 2

Course Objective:
1. To understand the usage of MATLAB / SIMULINK for simulating Power Electronic Circuits.
2. To understand the usage of PSIM / Pspice for simulating Power Electronic Circuits.
3. To understand the usage of PSCAD / EMTDC for simulating Power Electronic Circuits.

Course Outcome:

At the end of the course, the student will be able to
1. Analyze the performance characteristics of Power Devices and Power converters.
2. Select and compare appropriate simulation tool for the required applications.
3. Develop mathematical model for the system.
4. Use the various functional blocks in the simulation packages for the problems specified.
5. Design and simulate any power electronic circuits.
6. Propose and investigate the performance of the model developed.

LIST OF EXPERIMENTS:
1. Simulation of AC Voltage Controller Using MATLAB / SIMULINK
2. Simulation of Induction Motor Drive Using MATLAB/SIMULINK
3. Simulation of Multilevel Inverter Using MATLAB/SIMULINK
4. Simulation of AC Voltage Controller Using MATLAB
5. Simulation of Single Phase Rectifier Using MATLAB
6. Simulation of Buck-Boost Converter Using PSIM

7. Simulation of ZVS and ZCS Resonant Converters using PSIM
8. Simulation of Three-Phase PWM Inverter using PSIM
9. Simulate and Compare the output of a Single Phase Half Wave Rectifier using Thermal Module Devices of PSIM
10. Simulation of Speed Control of DC Motor using SIM-Coupler
11. Fault Analysis of AC Power System using PSCAD / EMTDC
12. Simulation of Class E Resonant Inverter using Pspice

18EE3009	Solar Thermal Energy Conversion	L	T	P	C
		3	0	0	3

Course Objectives:
1. To provide a comprehensive engineering basics for solar thermal system and its design.
2. To understand the different technologies of solar thermal systems.
3. To get know about the different types of solar heating & cooling.

Course Outcome: The student will be able to
1. Describe the radiative properties and the purpose of selective surfaces in solar thermal energy harvesting.
2. Choose the right type of solar collector for an application.
3. Model a solar thermal system using simulation tools.
4. Estimate the thermal load requirement and suggest a suitable energy storage system.
5. Demonstrate how solar thermal energy is useful in providing comfortable living experience by water heating, space heating and cooling processes.
6. Discover new ways of utilizing the solar thermal energy.

Module 1: Radiative properties and characteristics of materials: (8 Hours)
Thermal radiation fundamentals - Reflection from ideal specular, ideal diffuse and real surfaces - Selective Surfaces: Ideal coating characteristics, Types and applications - Anti-reflective coating - Reflecting Surfaces and transparent materials – Solar radiation – Instruments for measuring solar radiation and sunshine.

Module 2: Solar collectors: (8 Hours)
Solar Collectors & its Classification - Stationary Collectors - Flat Plate Collectors: Liquid Flat Plate Collectors, Air flat-plate Collectors - Compound parabolic collectors - Evacuated tube collectors - Sun tracking concentrating collectors: Parabolic trough collectors, Linear Fresnel reflector, Parabolic dish reflector, Heliostat field collector - Comparison of various designs - Testing methods.

Module 3: Modeling and analysis of solar collectors : (7 Hours)
Thermal analysis of collectors - Flat-plate collectors performance, Concentrating collectors performance - Performance of solar collectors - Modelling of solar systems - TRNSYS simulation program, F-Chart method and program, Artificial neural networks in solar energy systems modelling and prediction - Limitations of simulations - Economic analysis.

Module 4: Solar thermal energy storage: (7 Hours)
Solar Process loads and solar collector output – Energy storage in solar process systems - Classification - Sensible storage: Water storage, Packed Pebble storage, Storage Walls - Latent heat storage - Thermo-chemical storage – Battery Storage - Design of storage system.

Module 5: Solar heating and cooling applications: (8 Hours)
Solar water heating systems - Thermosyphon systems, Integrated collector storage systems, Direct circulation systems, Indirect water heating systems, Air systems - Solar space heating and cooling - Space heating and service hot water, Air systems, Water systems, Heat pump systems - Cooling requirements of buildings – Solar Refrigeration – Adsorption units, Absorption units - Solar Desiccant cooling.

Module 6: Solar Thermal applications: (7 Hours) Industrial Process heat – Solar Desalination system – Solar thermal Power system – Solar furnaces – Solar Pond – Solar Cooker – Photovoltaic Thermal(PV/T) collector – Types – Energy balance equations – Modeling.

Reference Books

1. Duffie J.A., Beckman W.A., Solar Engineering of Thermal Processes, John Wiley & Sons, New York, 2013.
2. Kalogirou S. A., "Solar thermal collectors and applications," Progress in Energy and Combustion Science, Elsevier Journal, Vol. 30, pp. 231–295, 2004.
3. Yogi Goswami D., Frank Kreith, "Energy Conversion", CRC Press, New York, 2007.
4. "ASHRAE Handbook Authors and Revisers Guide", ASHRAE Inc., Atlanta, 2007.
5. Yogi Goswami D., Frank Kreith, "Principles of Solar Engineering", 3rd Edition, CRC Press, 2015.

18EE3010	Materials for Solar Power	L	T	P	C
		3	0	0	3

Course Objective

1. Understand the physics of solar cell.
2. Study the different materials used in manufacturing process.
3. Know the technology of manufacturing solar cell.

Course Outcome

At the end of the course students will able to

1. Explain the physical theory of solar cells.
2. Use characterization techniques to measure solar cell properties
3. Describe the operating principles of various types of crystalline solar cells structures.
4. Develop a printed solar cell.
5. Connect nanotechnology for the preparation of solar cell
6. Prepare the thin film solar cells.

Module 1: Fundamental Physical Limits to Photovoltaic Conversion : (6 Hours)

Introduction, PN junction, Thermodynamic Limits, Limitations of Classical devices, multi junction, two level system model, Fundamental Limits of Some High-Efficiency Concepts, Quantum theory of solar cells.

Module 2: Solar Grade Silicon: (7 Hours)

History and Applications of Silicon Physical Properties of Silicon Relevant to Photovoltaics, Chemical Properties Relevant to Photovoltaics, Health Factors, Production of Metallurgical Grade Silicon, Requirements of Silicon for Crystalline Solar Cells

Module 3: Physical Characterization of Photovoltaic Materials: (8 Hours)

Needs of characterization, X-Ray Techniques-X-Ray Diffraction Grazing-Incidence X-Ray Diffraction Electron Microscopy Methods, and Spectroscopy Methods X-Ray Photoelectron Spectroscopy, Secondary Ion Mass Spectrometry, Rutherford Backscattering Spectrometry, Raman Spectroscopy, UV-VIS-NIR Spectroscopy.

Module 4: Crystalline Solar Cell: (8 Hours)

Homo-Hetro junction solar cell, multi junction solar cells, thin film solar cells, CIGS, Kesterites. cell processing Screen-Printed Cells, Buried-Contact and Laser Doped, Selective-Emitter Solar Cells, HIT Cell, Rear-Contact Cell PERL Solar Cell.

Module 5: Printed Solar Cells: (8 Hours)

Materials morphology-Organic Semiconductors Control of Morphology in BHJ Solar Cells Monitoring Morphology, Interfaces in Organic Photovoltaic, Tandem Technology, Electrode Requirements for Organic Solar Cells-Materials for Transparent Electrodes, Materials for Non transparent Electrodes, Production of Organic Solar Cells.

Module 6: Third-Generation Solar Cells: (8 Hours)

Introduction, Multiple-Energy-Level Approaches, Tandem Cells, Multiple-Exciton Generation (MEG) Intermediate-Band Solar Cells (IBSC), Modification of the Solar Spectrum- Downconversion, QE >1 Upconversion of Below-Bandgap Photons,Thermal Approaches, Nonreciprocal Devices, Quantum Antennae – Light as a Wave.

Reference Books

1. Arthur Willoughby, “Solar Cell Materials: Developing Technologies”, John Wiley and Sons, 2010.
2. William D. Callister, Jr, “Materials Science and Engineering: An Introduction”, John Wiley, New York, 2010.
3. Srinivasan, “Engg Materials and Metallurgy”, Tata McGraw-Hill Education Limited, 2nd Edition, 2010.
4. Jenny Nelson, “The Physics of Solar Cells” Imperial College Press, 2003.
5. Tom Markvart, “Solar Cells: Materials, Manufacture and Operation” Elsevier, USA, 2nd Edition, 2013.

18EE3011	Solar Cell and Module Technology	L	T	P	C
		3	0	0	3

Course Objectives

1. To study the fundamentals of solar cells
2. To learn the manufacturing processes of different types of solar cells
3. To study the performance of solar PV systems

Course Outcomes

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

1. Describe the physics of PV cells.
2. Report the uniqueness of different PV cells.
3. Explain the manufacturing processes of silicon and different types of solar cells
4. illustrate the making of different crystalline solar cells and evaluate its performance in a PV system.
5. illustrate the making of organic solar cells and evaluate its performance in a PV system.
6. Demonstrate an appropriate calibration technique for a solar cell while evaluating the PV system performance

Module 1: Introduction: (8 hours)

Physical principles of solar irradiation and solar cell fundamentals-properties of semiconductors-PN Junction diode electrostatics-Solar cell operation - Efficiency and band gap-spectral response-parasitic resistance effects.

Module 2: Solar Cells-Types: (5 hours)

Physical and chemical principles of materials used in solar cells of various kinds: CIGS, CIS and other inorganic thin film solar cells, multijunction solar cells, nanoparticles and quantum dots solar cells, organic and hybrid solar cells.

Module 3: Manufacturing of Silicon: (8 hours)

Production of metallurgical grade silicon production of semiconductor grade silicon-requirements of silicon for crystalline solar cells-routs to solar grade silicon-Bulk crystal growth and

Module 4: Manufacturing of Crystalline Solar Cells: (8 hours)

PV-Crystalline silicon solar cells -Manufacturing process- Crystalline silicon photovoltaic modules - Thin film silicon solar cells - Amorphous silicon solar cells.

Module 5: Preparation of Organic Solar Cells: (8 hours)

Dye sensitized and Organic solar cells - Organic Electronic Materials – fabrication - Rating, quantum solar cells. Application of nano technology in solar cells.

Module 6: PV performance and calibration methods: (8 hours)

PV Performance - Current versus voltage measurements, Primary reference cell calibration methods - spectral responsibility measurements - Module qualification and certification.

Reference Books:

1. Antonio Luque, Steven Hegedus, “Hand book of Photovoltaic Science and Engineering”, John Wiley& Sons Ltd, England, 2011.
2. Larry D. Partain, “Solar Cells and Their Applications”, John Wiley & Sons Ltd, England, 2010.

3. Tom Markvart, "Solar Cells: Materials, Manufacture and Operation", Elsevier, USA, 2nd Edition, 2013.
4. JefPoortmans, Vladimir Arkhipov, "Thin Film Solar Cells: Fabrication, Characterization and Applications", John Wiley & Sons, 2006
5. Arvind Shah, "Thin-Film Silicon Solar Cells", 1st Edition, CRC Press 2010.
6. Chetan Singh Solanki, "Solar Photovoltaics: Fundamentals, Technologies and Applications" PHI Learning Private Ltd, 3rd Edition, 2015.

18EE3012	Grid Converters for Photovoltaic and Wind Power Systems	L	T	P	C
		3	0	0	3

Course Objectives:

1. To illustrate key concepts about converter structures and grid requirements
2. To enlighten the students about the latest power conversion and control technology in photovoltaic and wind power systems
3. To provide in-depth understanding about grid synchronization

Course Outcomes:

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

1. Outline the need and design of grid converters for PV and wind power system
2. Summarize the different converter structures and the stringent grid requirements
3. Illustrate grid synchronization in single and three-phase power converters
4. Analyze the different islanding detection methods
5. Formulate grid converter control strategies during grid faults
6. Choose the appropriate grid filter design and current control.

Module 1: Inverter and Grid Converter Structures for PV and Wind Turbine Systems: (8 Hours)

Inverter structure derived from H-bridge topology – Inverter structure derived from NPC topology- Three phase PV inverters - WTS power configurations – Grid power converter topologies – WTS control

Module 2: Grid Requirements for PV and Wind Turbine Systems: (8 Hours)

PV: International Regulations – Response to abnormal grid conditions – Power quality – Anti-islanding requirements – WT: Frequency and voltage deviation under normal operation – Active power control in normal operation – Reactive power control in normal operation – Behaviour under grid disturbances – Harmonization of grid codes

Module 3: Grid Synchronization in Single-Phase and Three-Phase Power Converters:(8 Hours)

Grid synchronization techniques for single-phase systems – Phase detection based on In-Quadrature signals – SOGI Frequency Locked Loop - Three-phase voltage vector under grid faults – Synchronous reference frame PLL under unbalanced and distorted grid conditions- Decoupled double synchronous reference frame PLL – Double second order generalized integrated FLL

Module 4: Islanding Detection : (6 Hours)

Introduction – Non-detection zone – Overview of islanding detection methods – Passive islanding detection methods – Active islanding detection methods

Module 5: Grid Converter Control for Wind Turbine System: (7 Hours)

Model of the converter – AC voltage and DC voltage control – Voltage oriented control and direct power control – Stand-alone, micro-grid, droop control and grid supporting

Module 6: Control of Grid Converters under Grid Faults: (8 Hours)

Overview of control techniques for grid-connected converters under unbalanced grid voltage conditions – Control structures for unbalanced current injection – Power control under unbalanced grid conditions – Flexible power control with current limitation

Reference Books:

1. Teodorescu R., Liserre M., Rodriguez P., "Grid Converters for Photovoltaic and Wind Power System", John Wiley & Sons Ltd., UK, 2011.

2. Wu B., Lang Y., Zargari N., Kouro S., “Power Conversion and Control of Wind Energy”, John Wiley & Sons, New Jersey, 2011.
3. Zhong Q.C., Hornik T., “Control of Power Inverters in Renewable Energy and Smart Grid Integration”, John Wiley & Sons, UK, 2013.
4. Gevorkian P., “Large-Scale Solar Power System Design – An Engineering Guide for Grid-Connected Solar Power Generation”, Mc-Graw Hill, New York, 2011.
5. Vittal V., Ayyanar R., “Grid Integration and Dynamic Impact of Wind Energy”, Springer, New York, 2013.

18EE3013	Biomass Energy	L	T	P	C
		3	0	0	3

Course Objectives:
1. classify the biomass resources and biomass conversion processes
2. construct a small size gasifier and biogas plant
3. explain the alcohol production method from biomass

Course Outcomes:

At the end of the course, the students will be able to
1. express the chemical conversion process of biomass in terms of chemical reactions
2. select a biogas plant for a community or village.
3. Show how gasification of biomass is processed in biomass gasifier
4. design a biogas digester and gas holder for the specified load requirements
5. recommend the use of biogas and bio fuels in various applications
6. demonstrate the power generation techniques using biomass waste

Module 1: Energy from Biomass: (7 Hours)

Biomass resources, energy plantation, design and management of energy plantation, advantages of energy plantation, plants proposed for energy plantation, photosynthesis, biomass conversion technologies, thermo chemical conversion, direct combustion, biochemical conversion, biodegradability.

Module 2: Biogas generation: (8 hours)

Classification of biogas plants, biogas generation, anaerobic digestion, floating drum plant, fixed dome type plant, continuous and batch type, Janta biogas plant, DeenBandhu biogas plant, Khadi and Village industries type biogas plant, Ferro-Cement digester biogas plant, biogas from plant wastes, wet and dry fermentation, problem in straw fermentation, pilot plants using plant wastes, community biogas plants, materials used for biogas generation, additives, factors affecting bio-digestion.

Module 3: Bio Gasifier: (7 hours)

Gasification process, gasification of wood, wood gas purification and shift conversion, gasification equipment, use of wood gas in engines, classification of biomass gasifiers, fixed bed gasifier, fluidized bed gasifier, applications of the gasifier, problems in development of gasifiers.

Module 4: Digester design: (8 Hours)

Design based on methane production rate, design based on end user requirements, scaling of biogas plants, digester sizing, methods for maintaining biogas production, problems related to biogas plants, starting a biogas plant, filling a digester for starting, fuel properties of biogas, selection of site for a biogas plant.

Module 5: Utilization of bio fuels and biogas : (8 Hours)

Pyrolysis, types of pyrolysis, alcohol fuels, ethanol production from wood and sugar cane, methanol production, Modification of SI and CI engine, biogas use in stationary power plants, mobile power plants, use of biogas in refrigerators, gas turbines, economic viability of biogas technology, biogas technology scenario in India, purification, scrubbing, compression and storage of biogas, biogas burners.

Module 6: Electricity production from biomass wastes: (7 Hours)

Electricity production from municipal solid wastes, animal wastes, plant residues, pulp and paper industry wastes, distillery waste, high rate digester for industrial waste water treatment.

Reference Books:

1. G.D.Rai, Non Conventional Energy Sources, Khanna publishers, 8th reprint, 2013.
2. Nijaguna, B.T, "Biogas Technology", New Age International Private Ltd, New Delhi, 1st Edition, 2009.
3. N.H.Ravindranath, Hall D.O., "Biomass, Energy and Environment", Oxford University Press, Reprinted Edition, Oxford, 2002.
4. Chawla O.P., "Advances in biogas technology", Publications and Information Division, Indian Council of Agricultural Research, New Delhi, 2009.
5. Mital, K.M,"Biogas Systems: Principles and Applications", New Age International Private Ltd, New Delhi, 1st Edition, 2009.

18EE3014	Waste to Energy Conversion	L	T	P	C
		3	0	0	3

Course Objective

1. To understand the various classification of waste and categorize the waste from which energy can be harvested
2. To analyze different processing techniques, conversion process and treatment of wastes.
3. To understand the product recovery process of waste to energy conversion.

Course Outcomes

The student will be able to

1. Define and Classify different types of waste and its processing techniques.
2. Identify feedstock's characteristics for incineration and choose the utilization schemes for gasification products
3. Analyze the operating conditions of pyrolysis with its end product distribution and compare the briquetting processes.
4. List out the options for management of plastic wastes and recycling through pyrolysis and compare the process involved in removal of unwanted elements from gas
5. Explain the operation of anaerobic digester and compare different product recovery process using fermentation
6. Elaborate on the cultivation of algae and explain the conversion process from algae to biodiesel.

Module 1: Introduction: (7 Hours)

Introduction of wastes - Definition of wastes and their classification - Important quality parameters of different types of wastes - Wastes suitable for energy production - Solid wastes and their classification - Waste water and their classification - Availability of agro based, forest, industrial and municipal solid wastes in India - Availability of waste water in India - Routes for solid wastes management

Module 2: Energy Production from Waste Through Incineration And Gasification: (7 Hours)

Definition and scope for application - Mechanism - Air requirement- Performance factors and staged combustion - Advantages and disadvantages - Preferable feedstock's characteristics for incineration - Process flow sheet - Definition and Basic chemistry of gasification - Gasification reaction schemes and steps- Syngas production, efficiency and factors influencing gasification - Advantages of gasification - Typical process flow sheet and utilization schemes for gasification products - Syngas conditioning and clean up - Gasifier types.

Module 3: Energy Production from Waste Through Pyrolysis: (8 Hours)

Definition of pyrolysis - Mechanism - Types of pyrolysis - Operating conditions and end product distribution - Use of pyrolysis products - Properties of bio oil and need of its upgradation - Catalytic pyrolysis - Pyrolysis reactors- Utilization of pyro char and gases - Densification of solids- Fundamentals of densification - Types of briquetting - Briquetting processes and their comparison - Carbonization process - Carbonization reactor - Briquette characteristics - Application of briquettes - Manual briquette machine

Module 4: Energy Production from Waste Plastics And Gas Clean Up: (7 Hours)
Plastics, their classification and code for recyclable plastics - Plastic types, their monomers and suitability for energy production - Plastic wastes generation and its need for proper management - Pyrolysis reaction mechanism - Pyrolysis process types and their variables - Catalytic pyrolysis - Common steps for converting waste plastics to fuels - Process flow sheet for pyrolysis of waste plastics - Reactors for pyrolysis - Case study - Scrubbers - Gas molecules removal - Absorption - Adsorption methods- Removal of specific gas components like SO2, NOx and CO2

Module 5: Energy Production from Organic Wastes Through Anaerobic Digestion And Fermentation: (8 Hours)
Anaerobic digestion and biogas production - Mechanism of anaerobic digestion - Microorganisms/steps for anaerobic digestion - Pathways for anaerobic digestion - Pretreatment of lignocellulosic biomass and wastes - Two stage digester and process - Impurities in biogas and their impacts - Sludge volume in a digester.- Ethanol production through gasification route - Butanol production from LCB-Production of ethanol from three different feedstocks and pre-processing steps - Production of ethanol from starchy crops (corn) - Production of ethanol from lignocellulosic biomass (LCB) - Pre treatment of lignocellulosic biomass - Detoxification and hydrolysis

Module 6: Cultivation and Energy Production Of Algal Biomass: (8 Hours)
Algal cultivation- Algal metabolism and synthesis of fat and protein - Classification of algae - Lipid content in algal cell - Algal lipids and bio oil quality - Conditions influencing algal lipid quality and quantity - Enhanced lipid accumulation - Reactor systems for cultivation/growth of microalgae - Harvesting of algal biomass- Biodiesel as an important route for energy production from algal biomass - Bio oil production from algal biomass - Conversion of algal oil to biodiesel - Types of conversion process, mechanisms and comparison - Factors affecting biodiesel yield

Reference Books

1. Rogoff, M.J. and Screve, F., "Waste-to-Energy: Technologies and Project Implementation", Elsevier Store,Kindle edition, 2011
2. Young G.C., "Municipal Solid Waste to Energy Conversion processes", John Wiley and Sons, May 2010
3. Harker, J.H. and Backhusrt, J.R., "Fuel and Energy", Academic Press Inc,Feb 1981
4. EL-Halwagi, M.M., "Biogas Technology- Transfer and Diffusion", Elsevier Applied Science. 1986
5. Hall, D.O. and Overeed, R.P.," Biomass - Renewable Energy", John Willy and Sons.2002
6. Gary C. Young, “Municipal Solid Waste to Energy Conversion Processes: Economic, Technical, and Renewable Comparisons”, John Wiley & Sons, 2010.
7. Naomi Klinghoffer,MardoCastaldi,”Waste to Energy Conversion” Woodhead Publishing,15th May 2013.
8. Christian Furedy, Alison Doig, “Recovering Energy from Waste Various Aspects”, Science Publishers, Inc. Enfield (NH) USA, 2002. .
9. Robert Green, “From Waste to Energy”, Cherry Lake Publishing limited, USA, 2009.
10. Dieter D., Angelika S., “Biogas from Waste and Renewable Resources”, Wiley-VCH Verlag GmbH & Company, Germany, 2010.

18EE3015	Oceanic Energy	L	T	P	C
		3	0	0	3

Course Objective
1. To provide necessary knowledge about the basics, design and analysis of two important oceanic energy components i.e., tidal and wave.
2. To make the learner to understand the operation of tidal power plants and wave power plants
3. To impart the basic knowledge about integration of tidal and wave power plants with grid

Course Outcome

The students will able to

1. Get the awareness about the possibilities of power generation from ocean
2. Differentiate tidal power schemes, modes of operation
3. Outline the different models with mathematical expressions
4. Suggest new mechanisms to harvest energy from ocean
5. Calculate the power obtained from the waves
6. Design efficient tidal and wave power plants

Module 1: Introduction to Tidal Energy: (8 Hours)

Historical Development -Tidal phenomenon-Ocean tides -Types of tides -Propagation of tides in estuaries -Coriolis effect -Barrage effects –Tidal power potential and site selection -Hydroelectric versus Tidal-Electric developments-Site potential estimation-Coefficient of the tide-Major factors influencing project economics-Site selection- Management and organization of investigations-Management-Organization-Feasibility studies

Module 2: Tidal Power Schemes, Modes of Operation: (8 Hours)

Single-Basin development, Single-effect mode of operation- Single-basin development, Double-effect mode of operation, Pumping to augment tidal effect, Linked-basin developments - Paired-basin developments - Retiming of tidal energy - Basic data - General physiography of the estuary- Geology

Module 3: Tidal Power Planning and Simulation Models: (8 Hours)

Tides -Waves - Tidal currents - Suspended and mobile sediments – Ecosystem characteristics - Hydraulic and numerical models in feasibility investigations- Hydraulic models- Numerical models for estuaries - Hybrid models - Modeling of barrier effects – Mathematical model for closure activities - Utility system planning and simulation

Module 4: Tidal Power Plants: (8 Hours)

Civil works -Dry versus wet Construction - Design parameters - Caisson design- Dikes- Construction schedules- Electromechanical equipment – Specific requirements for tidal generating equipment- Types of turbines - Generators – Electrical equipment – Transmission-Integration of output with electric utility systems - Absorption of raw tidal energy -Enhancing raw tidal energy output - System considerations

Module 5: Introduction To Wave Energy: (7 Hours)

Wave structure- Wave power calculations- Global wave energy -Wave energy potential- Wave energy technologies- Wave concentration effects- Tapered channel - Oscillating water column- Mighty whale design

Module 6: Wave Power Plants: (6 Hours)

Turbines for wave energy - Ocean wave conversion system-Wave energy power distribution-Grid connection-Wave energy-Environmental impacts.

Reference Books

1. Robert H. Clark, “Elements of Tidal-Electric Engineering”, 1st Edition, Wiley-IEEE Press, USA, 2007.
2. Boyle, “Renewable Energy”, 2nd Edition, Oxford University Press, UK, 2004.
3. Jack Hardisty , “The Analysis of Tidal Stream Power”, Wiley, 1st Edition, UK, 2009
4. Michael E. McCormick, “Ocean Wave Energy Conversion” Dover Publications, 1st Edition, USA, 2009
5. Joao Cruz, Ocean Wave Energy: Current Status and Future Perspectives, Springer, 1st Edition, Berlin, 2010.

18EE3016	Data Mining for Renewable Energy Systems	L	T	P	C
		3	0	0	3

Course Objective

1. To enlighten the student on the basic concepts of data mining.
2. To improve the student competence in the algorithms and learning schemes of data mining.
3. To enable the student to exploit the data mining techniques for research in renewable energy.

Course Outcome

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

1. Understand the importance of data-driven performance optimization of renewable energy system.
2. Exploit the vast data base available in the renewable energy sector and devise ways to make renewable energy a competitive source of supply.
3. Classify and analysis the different type of data
4. Prediction of data with error measures
5. Apply data mining for the prediction of power from renewable energy sources
6. Find the various research opportunities provided by this field.

Module 1: Introduction: (7 hours)

Data Mining – Kinds of Data – Functionalities – Classification – Primitives – Major Issues –Data Preprocessing – Descriptive Data Summarization - Data Cleaning – Data Integration and Transformation - Data Reduction

Module 2: Data Warehouse: An Overview: (7 hours)

Data Warehouse – Multidimensional Data Model – Data Warehouse Architecture – Data Warehouse Implementation – From Data Warehousing to Data Mining. Mining Frequent Patterns, Associations: Basic Concepts and a Road Map – Efficient and Scalable Frequent Item set -Mining Methods- Mining Multilevel Association Rules

Module 3: Classification and Prediction: (7 hours)

Issues regarding classification and prediction - Decision tree Induction - Bayesian Classification – Lazy Learners – Other Classification Methods – Prediction – Accuracy and Error Measures.

Module 4: Cluster Analysis: (8 hours)

Types of Data – Categorization of Major Clustering Methods –Partitioning Methods – Hierarchical Methods. Mining Stream, Time-Series and Sequence Data Mining- Data Streams – Mining Time-series-Data- Mining Sequence Patterns in Transactional Databases.

Module 5: Applications in Solar Energy: (8 hours)

Modeling and Forecasting of Solar Radiation Data - Analyzing Solar Power Plant Performance-Classification Cascades of Overlapping Feature Ensembles for Energy Time Series Data- Evaluation of Forecasting Methods for Very Small-Scale Networks.

Module 6: Applications in Wind Energy: (8 hours)

Application of Data Mining in Wind Power System -Wind Power Prediction- Performance Analysis of Data Mining Techniques for Improving the Accuracy of Wind Power Forecast Combination- Argument Visualization and Narrative Approaches for Collaborative Spatial Decision Making and Knowledge Construction: A Case Study for an Offshore Wind Farm Project.

Reference Books:

1. Jiawei Han, Micheline Kamber, “Data Mining : Concepts and Techniques”, II Edition, Morgan Kaufmann Publishers, San Francisco, 2006
2. Ian Witten, Eibe Frank, “Data Mining: Practical Machine Learning Tools and Techniques”, III Edition, Morgan Kaufmann Publishers, San Francisco 2011.
3. Sumathi S., S. N. Sivanandam, “Introduction to Data Mining and its Applications”, Springer-Verlag Berlin Heidelberg 2006.

4. David Hand, HeikkiMannila, Padhraic Smyth, "Principles of Data Mining", A BradfordBook, The MIT Press, Cambridge, Massachusetts London, England, 2001.
5. Michael J A Berry, Gordon S Linoff, "Data Mining Techniques", II Edition, Wiley India,
6. 2004.
7. Woon, Wei Lee,Aung, Zeyar, Madnick, Stuart (Eds.),"Data Analytics for Renewable Energy Integration", Third ECML PKDD Workshop, DARE 2015, Porto, Portugal, September 11, 2015

18EE3017	Power Conversion and Control of Wind Energy Systems	L	T	P	C
		3	0	0	3

Course Objectives:

1. To understand power conversion in wind energy systems
2. To impart the basics of modeling of generators in wind energy conversion system
3. To introduce the control techniques in different wind energy system configuration

Course Outcomes:

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

1. Model the generators used in wind energy conversion systems
2. Design the power converters in wind energy conversion systems
3. Outline the different wind energy system configurations
4. Analyze the control of squirrel cage induction generators in WECS
5. Explain the control techniques for DFIG based WECS
6. Summarize the control of synchronous generator based WECS

Module 1: Wind Generators and Modeling: (7 Hours)

Introduction – Reference frame transformation – Induction generator models – Synchronous generators

Module 2: Power Converters in Wind Energy Conversion System: (8 Hours)

AC Voltage controllers – Interleaved boost converters – Two-level voltage source converters – Three-level neutral point clamped converters – PWM current source converters – Control of grid-connected inverter

Module 3: Wind Energy System Configurations: (8 Hours)

Fixed speed WECS – Variable speed induction generator WECS – Variable speed synchronous generator WECS – Fixed speed configuration: Operation principle – Grid connection – Reactive power compensation

Module 4: Variable-Speed Wind Energy Systems with Squirrel Cage Induction Generators: (7 Hours)

Direct field-oriented control – Indirect field-oriented control – Direct torque control – Control of current source converter interfaced WECS

Module 5: Doubly Fed Induction Generator based WECS: (7 Hours)

Super and sub-synchronous operation of DFIG – Unity power factor operation of DFIG – Leading and lagging power factor operation – Stator voltage-oriented control of DFIG WECS

Module 6: Variable-Speed Wind Energy Systems with Synchronous Generators: (8 Hours)

System configuration – Control of synchronous generators – SG wind energy system with back-to-back VSC – DC/DC boost converter interfaced SG wind energy system – Reactive power control of SG WECS –Current source converter based SG wind energy system

Reference Books

1. Bin Wu, Yongqiang Lang, NavidZargari, Samir Kouro, "Power Conversion and Control of Wind Energy Systems", IEEE Press, Wiley Publication, 2011
2. Thomas Ackermann, "Wind Power in Power Systems", John Wiley & Sons Ltd., England, 2005.
3. Fernando D. Bianchi, Hernan De Battista, Ricardo J. Mantz, "Wind Turbine Control Systems: Principles, Modelling and Gain Scheduling Design", Springer-Verlag, London, 2007.
4. Olimpo Anaya-Lara, Nick Jenkins, JanakaEkanayake, Phill Cartwright, Mike Hughes, "Wind Energy Generation- Modelling and Control", John Wiley & Sons Ltd., UK, 2009.

5. Siegfried Heier, “Grid Integration of Wind Energy Conversion System”, 2nd Edition, John Wiley & Sons Ltd., England, 2006.

18EE3018	Power Quality Issues and Mitigation	L	T	P	C
		3	0	0	3

Course Objectives:

1. To study the power quality problems in grid connected system and isolated systems.
2. To learn the effects of harmonics on various power system components.
3. To describe various equipment used for power monitoring.

Course Outcome: At the end of the Course, the student would be able to:

1. Recognize the cause and source of power system disturbances.
2. Calculate harmonic voltages and currents by analyzing all types of electrical systems loads and their power quality considerations.
3. Suggest suitable mitigation scheme for some of the power quality issues.
4. Examine the methods of reducing excessive harmonics using advanced modeling technique.
5. Analyze the power quality issues using the Power quality indices.
6. Design load compensators useful for mitigating power quality problems.

Module 1: Overview & Characterization of Electric Power Quality: (7 hours)
Power Quality Issues - Power Quality and Electro Magnetic Compatibility (EMC) Standards- CBEMA & ITI Curves- Short Interruptions- Long Interruptions- End user issues.

Module 2: Voltage Quality: (7 hours)
Voltage Sags—Characterization- voltage sag calculation- Mitigation Methods- Transients and Over Voltage Protection- Utility Capacitor Switching Transients- Utility lightning protection

Module 3: Power Frequency Disturbances (7 hours)
Waveform Distortion- Harmonic sources from commercial loads and industrial loads- Locating Harmonic sources -harmonics Distortion Evaluation- Principles of controlling Harmonics - Active and passive filters-Types.

Module 4: Power Quality Conditioner: (8 hours)
DSTATCOM - Working Principle, Types and Applications - Dynamic Voltage Restorer – Working Principle, Types and Applications - - Unified Power Quality Conditioner (UPQC) - Working Principle, Types and Applications

Module 5: Control Theory for Power Quality Conditioner: (8 hours)
Instantaneous Reactive power theory – Instantaneous symmetrical component theory – SRF theory –DFT theory.

Module 6: Power Quality Monitoring: (8 hours)
Monitoring and diagnostic techniques for various power quality problems – power line disturbance analyzer – quality measurement equipment – harmonic / spectrum analyzer – flicker meters – disturbance analyzer -Planning, Conducting and Analyzing power quality survey.

Reference Books:

1. Bhim Singh, Ambrish Chandra, Kamal Al-Haddad, “Power Quality: Problems and Mitigation Techniques”, Wiley, 2014.
2. Arindam Ghosh, Gerard Ledwich, “Power Quality Enhancement Using Custom Power Devices”, Springer Science, 2012
3. Roger. C. Dugan, Mark. F. McGranagham, Surya Santoso, H.WayneBeaty, “Electrical Power Systems Quality” McGraw Hill, 2003.
4. J. Arrillaga, N.R. Watson, S. Chen, “Power System Quality Assessment”, Wiley, 2011.

5. Eswald.F.Fudis and M.A.S.Masoum, "Power Quality in Power System and Electrical Machines," Elsevier Academic Press, 2013.

18EE3019	Distributed Generation and Micro Grid	L	T	P	C
		3	0	0	3

Course Objective

1. To impart the concept of distributed generation and microgrid
2. To provide knowledge on power architecture, configuration and control strategies for distributed generation
3. To give details of the impacts of distributed resources to the grid and the various issues associated with integrating such resources to the grid

Course Outcome

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

1. Define the concept of distributed generation and Impact of DG on Transmission System
2. Classify the various distributed generation sources and energy storage
3. Outline the general and the power electronic topologies for distributed generation and its interface
4. Describe various distributed generation protection scheme
5. Analyze the power quality issues of distributed generation.
6. Compare the different microgrid architectures and discuss on the risks of the Smart Grid and its protective measures.

Module 1: DG Overview and Technology Trends: (8 hours)

History of Power System-Representation of Power Systems - SLD, PU System - DG - Microgrid - Smart Grid -Power Grid Vs Microgrid - DG Definition - Interface with the Grid -IEEE 1547 Standards - Impact of DG on Distribution System - Impact of DG on Transmission System and Central Generation- DG Advantages & Disadvantages.

Module 2: DG Units: (8 hours)

Microturbines - Reciprocating Engines - Wind Generators - Photovoltaic Generators - Fuel Cells-Combined Heat and Power Generation - Solar Thermal - Small Hydro - hydro kinetic - Geothermal - Oceanic power generation-Energy Storage

Module 3: Power Electronic Interface for DG : (8 hours)

General Topology - Power Electronics Topologies for Microturbines -Power Electronics Topologies for Reciprocating Engines - Power Electronics Topologies for the Wind Energy Systems - Power Electronics Topologies for the PV Systems - Power Electronics Topologies for Fuel Cell Systems -Power Electronics Topologies for the Battery Energy Storage Systems – Charging of Electric Vehicles.

Module 4: DG Protection: (7 hours)

Voltage Regulation- DG Grounding Issue - Transient Response and Fault Behaviors - Reclosing - DC Current Injection - Flicker Concerns - Current Distortion from Power Electronics of DG - Anti-islanding Protection of DG.

Module 5: Power Quality Issues: (7 hours)

Radial Feeder Models and Cases for Voltage Regulation Analysis - Unbalanced Grid- DG Design Considerations to Meet Power Quality Requirements-Power quality issues in microgrids

Module 6: Micro Grids: (7 hours)

Microgrid Definition - Microgrid Architecture - Power Electronic Interfaces (AC to DC & DC to AC) - Power Architecture - distributed and centralized - DC and AC distribution - Controls: distributed, autonomous, and centralized systems - Grid interconnection - Issues, planning. Microgrid communication infrastructure - Modelling and Stability analysis of Microgrid, regulatory standards, Microgrid economics- Case study

Reference Books:

1. N. Jenkins, J.B. Ekanayake and G. Strbac, Distributed Generation, IET, UK,2010
2. Felix A. Farret, M. Godoy Simoes, Integration of Alternative Sources of Energy, Wiley-IEEE Press, John Wiley & Sons Ltd., Canada, 2006
3. Math H. Bollen, Fainan Hassan, Integration of Distributed Generation in the Power System, Wiley-IEEE Press, John Wiley & Sons Ltd., Canada, 2012
4. Nikos Hatziargyriou, Microgrids Architectures and Control, Wiley-IEEE Press John Wiley and Sons Ltd, UK,2014
5. S. Chakraborty, M. G. Simoes, William E.Kramer, Power Electronics for Renewable and Distributed Energy Systems, Springer-Verlag, London 2013
6. Suleiman M. Sharkh, Mohammad A. Abu-Sara, Georgios I. Orfanoudakis, Babar Hussain, Power Electronic Converters for Microgrids, Wiley-IEEE Press John Wiley & Sons Ltd., Singapore, 2014.

18EE3020	Cyber Physical Systems Approach to Smart Grid	L	T	P	C
		3	0	0	3

Course Objectives:

1. To understand the modeling of dynamic behaviors and embedded computing systems.
2. To understand the communication systems in the smart grid.
3. To understand the concepts of modeling, simulation and security in cyber physical systems for Smart Electric Power Grid.

Course Outcomes:

At the end of this course, students will able to

1. understand the concept of the continuous, discrete and hybrid cyber physical systems
2. explain the composition of state machines and concurrent models of computation
3. select the appropriate input and output devices for cyber physical systems
4. summarize the usage of communication system used in smart grid
5. analyze the distributed power generation and transmission system models in cyber physical systems
6. develop an own security model for cyber physical energy systems

Module 1: Modeling Dynamic Behaviors: (7 Hours)

Introduction to Cyber Physical System: Applications, Examples, and Design Process. Continuous Dynamics: Newtonian Mechanics, Actor Models, Properties of Systems and Feedback control. Discrete Dynamics: Discrete Systems, Notion of the State, Finite-State Machines, Behaviors and Traces. Hybrid Systems: Modal Models, Classes of Hybrid Systems. Composition of State Machines: Concurrent composition and Hierarchical State Machines. Concurrent Models of Computation: Structure of Models, Synchronous-Reactive Models, Dataflow and Timed Models for Computation.

Module 2: Embedded Computing Systems: (6 Hours)

Introduction: Hardware Architecture of Embedded Computing Systems. Design: Sensors, Actuators, Embedded Processors, Memory Architectures, Input and Output, Multitasking and Scheduling. Embedded Control Systems: Control, Feedback control and its components. Hardware-Software Codesign, Case Study: FPGA- Based CPU core.

Module 3: Communication Systems: (8 Hours)

Communications: A Key Enabler of the Smart Grid, Communications Requirements for the Smart Grid, Wireless Sensor Network Technology, Powerline Communication. Communication Standards and Protocols, Communications Challenges in the Smart Grid. Communications in the Smart Grid: An Integrated Roadmap.Reliable and Scalable Communication for the Power Grid: Introduction, Micro Grids and Renewables, Distributed Control for Power Grid, Resilient Network Model, Realistic Network Overlay Designs and Monitoring.

Module 4: Cyber-Physical Systems for Distributed Generation: (8 Hours)

Modeling and Simulation of Network Aspects for Distributed Cyber-Physical Energy Systems: Introduction, Modeling Challenges, Modeling Approach, Case Study and discussions. A Service-Oriented, Cyber-Physical Reference Model for Smart Grid: Introduction, Reference Model for Smart Grid, Technological Implications of a Service-Oriented Reference Model for Smart Grid, Case Study. Real Time Modeling and Simulation of Cyber-Power System:Introduction, Modeling and Simulation of Cyber-Power System, Real Time Cyber-Power Test Bed and its applications.

Module 5: Cyber-Physical system for Transmission and communication system: (6 hours)

Cyber Physical Approach to HVDC Grid Control: Multi-terminal HVDC Grids, Communication Control for HVDC Grid, HVDC Grids as Cyber-Physical Systems.Decision-Support Tools for Renewables rich Power Systems: Introduction, Operational Concept, Renewable Generation Forecasting Module, Case Studies and Scheduling Module: Some Initial Explorations.

Module 6: Cyber-Security in Smart Grid: (10 Hours)

Defining Security, Communication Model, Security Functions and Security Threats. Cyber Security of Smart Grid Communications: Introduction, Voltage Control, ICT Architecture, Benchmark Grid and Security Scenarios, Risk Analysis (Qualitative Approach), Risk Levels to Security Standards and Experimental Environment. Cyber-Attacks in the Automatic Generation Control: Introduction, Power System Modeling, Feasibility of AGC attack, Attack Signal Synthesis, Evaluation of Detailed Simulation Environment. Cyber attack Mechanisms and Security Measures: Introduction, Power System State Estimation and Adversary Model, Unobservable State and Topology attack, Attack Impacts on Real-time Grid Operations, Security Measures against Unobservable Attacks.

Text/Reference Books

1. Edward Ashford Lee and SanjitArunkumarSeshia, “Introduction to Embedded Systems: A Cyber-Physical Systems Approach”, Second Edition, MIT Press 2017.
2. Dietmar P.F. Moller, “Guide to Computing Fundamentals in Cyber-Physical Systems: Concepts, Design Methods, and Applications”, Springer International Publishing, Switzerland, 2016.
3. Siddhartha Kumar Khaitan, James D. McCalley, Chen-Ching Liu, “Cyber Physical Systems Approach to Smart Electric Power Grid”, Springer-Verlag Berlin Heidelberg 2015.
4. Stuart Borlase, “Smart Grids: Infrastructure, Technology, and Solutions”, CRC Press, 2013.
5. S. Chakraborty, M. G. Simoes, William E.Kramer, Power Electronics for Renewable and Distributed Energy Systems, Springer-Verlag, London 2013

		L	T	P	C
18EE3021	**Smart Power Grid Renewable Energy Systems**	3	0	0	3

Course Objectives

1. To understand the concepts and design of Smart grid
2. To study the various communication and measurement technologies in smart grid
3. To learn about renewable energy resources and storages integrated with smart grid.

Course Outcomes

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

1. Differentiate the information exchange in traditional grid and smart grid
2. Assess the importance of the information security for smart grid
3. Demonstrate different Smart Grid communication technologies
4. Design the prototype model of the smart grid
5. Evaluate the role of power electronic devices in the network
6. Analyze the grid integration issues of renewable energy sources

Module 1: Introduction to Smart Grid: (8 hours)

Evolution of Electric Grid, Concept - Definitions and Need for Smart Grid - Smart grid drivers - functions, opportunities, challenges and benefits - Difference between conventional & Smart Grid - Concept of

Resilient &Self Healing Grid - Present development & International policies in Smart Grid - Diverse perspectives from experts and global Smart Grid initiatives.

Module 2: Distribution Management System: (8 hours)

Technology Drivers - Smart energy resources – Smart substations - Substation Automation - Feeder Automation - Transmission systems: EMS, FACTS and HVDC – Wide area monitoring - Protection and control - Distribution systems: DMS, Volt/VAR control

Module 3: Smart Grid Communications: (8 hours)

Local Area Network (LAN) - House Area Network (HAN) - Wide Area Network (WAN) - Wide Area Monitoring Systems (WAMS) - Broadband over Power line (BPL) – IP based Protocols - Basics of Web Service and Cloud computing to make Smart Grids smarter - Cyber Security for Smart Grid.

Module 4: Smart Meters and Advanced Metering Infrastructure: (8 hours)

Introduction to Smart Meters - Advanced Metering infrastructure (AMI) drivers and benefits - AMI protocols, standards and initiatives - AMI needs in the smart grid, Phasor Measurement Module (PMU) - Intelligent Electronic Devices(IED) & their application for monitoring & protection.

Module 5: Power Electronics in Smart Grid: (5 hours)

Introduction-Fault current limiting-Shunt Compensation: D-Statcom - Shunt compensator with energy storage - Series compensation - Power Quality Conditioners for Smart Grid - Anti islanding and smart grid protection.

Module 6 - Renewable Energy and Storage: (8 hours)

Renewable Energy Resources-Sustainable Energy Options for the Smart Grid-Penetration and Variability Issues Associated with Sustainable Energy Technology-Demand Response Issues-Electric Vehicles and Plug-in Hybrids-PHEV Technology-Environmental Implications-Storage Technologies-Grid integration issues of renewable energy sources

Reference Books:

1. Stuart Borlase, “Smart Grids: Infrastructure, Technology and Solutions”, CRC Press, Taylor and Francis Group, Boca Raton, 2012.
2. JanakaEkanayake, Nick Jenkins “Smart Grid Technology and applications”, John Wiley & Sons Limited, UK, 2012.
3. Stephen F. Bush, “Smart Grid: Communication-Enabled Intelligence for the Electric Power Grid, Wiley – Blackwell, USA, 2014.
4. Ali Keyhani , “Design of Smart Power Grid Renewable Energy Systems”, John Wiley & Sons, New Jersey, 2011
5. NouredineHadjsaid, Jean-Claude Sabonnadiere, “Smart Grids”, John Wiley & Sons Limited, New Jersey, 2012.
6. James Momoh, “ Smart Grid: Fundamentals of design and analysis ”,John Wiley & sons Inc, IEEE press, 2012.

18EE3022	Electric and Hybrid Vehicles	L	T	P	C
		3	0	0	3

Course Objective

1. To understand the concept of various types of Electric Vehicle Technology.
2. To know about various Electrical propulsion system.
3. To learn designing and mathematical modeling of EHV and drives.

Course Outcome

The students will be able to

1. Realize the need of Hybrid Vehicles and Electric vehicles.
2. State different types of drives used in Electric & Hybrid Vehicles.
3. Use the energy on-board optimally.
4. Understand the merits and demerits of various mathematical models of Electric and hybrid Vehicle.

5. Design the EHV using the mathematical Model.
6. Simulate and observe the behavior of the EHV.

Module 1: Fundamentals of Electric and Hybrid Vehicles: (8 Hours)
Environmental Impact and History of Modern Transportation – Configuration of EV– Performance of Electric Vehicles - Configuration and Types of HEV and its merits and demerits - Fuel Cell Vehicles – Battery – principle and Chemical reaction of Lead acid and Lithium Batteries, Ultra capacitors – Fly Wheels.

Module 2: Electric Propulsion Systems: (8 Hours)
DC Motor Drives Principle and Performance - Induction Motor Drives - Principles – Steady state Performance - Permanent Magnetic Brush-Less DC Motor Drives - Basic Principles of BLDC Motor Drive – SRM - Principles – Steady state Performance –Fundamentals of Regenerative Braking

Module 3: Design Considerations of Electric and Hybrid Vehicles: (8 Hours)
Vehicle Architecture - Tractive Effort - Aerodynamic Considerations - Consideration of Rolling Resistance - Transmission Efficiency- Consideration of Vehicle Mass - Electric Vehicle Chassis and Body Design

Module 4: Modeling of Electric and Hybrid Vehicles: (8 Hours)
Linear, Dynamic Model and reference Model - Modelling Vehicle Acceleration - Modelling Electric Vehicle Range – IC Engine for Hybrid Vehicle Modelling - Battery Modelling – Modelling DC Motor drive and Controller - Induction Motor drive and controller.

Module 5: Applications: (7 Hours)
Case studies- Honda Insight, FCX clarity – Audi A3 E Tron, BMW i8, Chevrolet Spark EV, Mercedes S550, Nissan Leaf, Performance simulation of the GM EV1,

Module 6: Simulation: (6 Hours)
Importing and creating driving cycles, range simulation of the GM EV1 electric car, fuel cell vehicle range Simulation.

Reference Books

1. James Larminie and John Loury, “Electric Vehicle Technology – Explained”, John Wiley & Sons Ltd, 2003.
2. MehrdadEhsani, YiminGao, Sebatien Gay and Ali Emadi, “Modern Electric, Hybrid Electric and Fuel cell vehicles: Fundamentals, Theory and Design”, CRC press, 2004.
3. Ronald K Jurgen, “Electric and Hybrid – Electric Vehicles”, SAE, 2002.
4. Ron Hodkinson and John Fenton, “Light Weight Electric/Hybrid Vehicle Design”, Butterworth – Heinemann, 2001.
5. SerefSoylu, “Electric Vehicles – Modelling and Simulations”, InTech, Croatia, 2011.
6. Haitham Abu-Rub, Atif Iqbal, JaroslawGuzinski , “High Performance Control of AC Drives with Matlab / Simulink Models”, John Wiley, U.K., 2012.

18EE3023	**Disaster Management**	**L**	**T**	**P**	**C**
		3	0	0	3

Course Objective:
1. To provide an exposure to disasters, their significance and types.
2. To gain a preliminary understanding of approaches of Disaster Risk Reduction (DRR)
3. To develop rudimentary ability to respond to their surroundings with potential disaster response in areas where they live, with due sensitivity

Course Outcomes:
The students will be able to
1. Differentiate the types of disasters, causes and their impact on environment and society
2. Assess vulnerability and various methods of risk reduction measures as well as mitigation.
3. Draw the hazard and vulnerability profile of India, Scenarios in the Indian context, Disaster damage assessment and management.

4. Relate between vulnerability, disasters, disaster prevention and risk reduction
5. Understand the institutional processes in the country
6. Analyze and Implement the disaster Management strategies

Module 1: Introduction To Disasters: (9 Hours)
Definition: Disaster, Hazard, Vulnerability, Resilience, Risks – Disasters: Types of disasters – Earthquake, Landslide, Flood, Drought, Fire etc - Classification, Causes, Impacts including social, economic, political, environmental, health, psychosocial, etc.- Global trends in disasters: urban disasters, pandemics, complex emergencies, Climate change- Dos and Don'ts during various types of Disasters.

Modules 2: Approaches To Disaster Risk Reduction (DRR): (9 Hours)
Disaster cycle - Phases, Culture of safety, prevention, mitigation and preparedness community based DRR, Structural- nonstructural measures, Roles and responsibilities of- community, Panchayati Raj Institutions/Urban Local Bodies (PRIs/ULBs), States, Centre, and other stake-holders- State Disaster Management Authority(SDMA) – Early Warning System.

Module 3: Inter-Relationship Between Disasters and Development: (9 Hours)
Factors affecting Vulnerabilities, differential impacts, impact of Development projects such as dams, embankments, changes in Land-use etc.- Climate Change Adaptation- IPCC Scenario and Scenarios in the context of India - Relevance of indigenous knowledge, appropriate technology and local resources.

Module 4: Disaster Risk Management in India: (9 Hours)
Hazard and Vulnerability profile of India, Components of Disaster Relief: Water, Food, Sanitation, Shelter, Health, Waste Management- Response and Preparedness, Disaster Management Act and Policy - Role of GIS and Information Technology components in preparedness, Risk Assessment, Response and Recovery Phases of Disaster – Disaster Damage Assessment.

Module 5: Disaster Management: Applications: (5 Hours)
Landslide Hazard Zonation: Case Studies, Earthquake Vulnerability Assessment of Buildings and Infrastructure: Case Studies, Drought Assessment: Case Studies, Coastal Flooding: Storm Surge Assessment, Floods: Fluvial and Pluvial Flooding:

Module 6: Case Studies and Field Works: (4 Hours)
Case Studies; Forest Fire: Case Studies, Man Made disasters: Case Studies, Space Based Inputs for Disaster Mitigation and Management and field works related to disaster management.

Reference Books:

1. Singhal J.P. "Disaster Management", Laxmi Publications, 2010. ISBN-10: 9380386427 ISBN-13: 978-9380386423
2. Tushar Bhattacharya, "Disaster Science and Management", McGraw Hill India Education Pvt.Ltd., 2012. **ISBN-10:** 1259007367, **ISBN-13:** 978-1259007361
3. Gupta Anil K, Sreeja S. Nair. Environmental Knowledge for Disaster Risk Management, NIDM, New Delhi, 2011
4. KapurAnu Vulnerable India: A Geographical Study of Disasters, IIAS and Sage Publishers, New Delhi, 2010.
5. PardeepSahni, Madhavimalalgoda and ariyabandu, "Disaster risk reduction in south asia", PHI
6. Amitasinvhal, "Understanding earthquake disasters" TMH, 2010.
7. Govt. of India: Disaster Management.

LIST OF COURSES

S.No	Course Code	Name of the Course	Credits
1	17EE1001	Basic Electrical Engineering	3:0:0
2	17EE2001	Electric Circuits and Networks	3:1:0
3	17EE2002	Electromagnetic Fields	3:1:0
4	17EE2003	DC Machines and Transformers	3:1:0
5	17EE2004	Induction and Synchronous Machines	3:1:0
6	17EE2005	Electrical Machine Design	3:1:0
7	17EE2006	Power Electronics	3:0:0
8	17EE2007	Transmission and Distribution	3:1:0
9	17EE2008	Power System Analysis	3:1:0
10	17EE2009	Power System Protection and Switchgear	3:0:0
11	17EE2010	DC Machines and Transformer Laboratory	0:0:1
12	17EE2011	AC Machines Laboratory	0:0:2
13	17EE2012	Power Electronics Laboratory	0:0:2
14	17EE2013	Computer Aided Power System Analysis Laboratory	0:0:2
15	17EE2014	Design Laboratory	0:0:1
16	17EE2015	Electrical Measurements and Control System Laboratory	0:0:1
17	17EE2016	Computer Aided Graphics for Electrical Engineers	0:0:2
18	17EE2017	Electron Devices and Electronic Circuits Laboratory	0:0:2
19	17EE2018	Electric Drives and Control	3:0:0
20	17EE2019	Special Electrical Machines	3:0:0
21	17EE2020	Automotive Electronics	3:0:0
22	17EE2021	Switched Mode Power Supplies	3:0:0
23	17EE2022	Energy Systems	3:0:0
24	17EE2023	Power System Stability	3:0:0
25	17EE2024	Power System Operation and Control	3:0:0
26	17EE2025	High Voltage Engineering	3:0:0
27	17EE2026	HVDC and FACTS	3:0:0
28	17EE2027	Renewable Energy – I	3:0:0
29	17EE2028	Renewable Energy – II	3:0:0
30	17EE2029	Smart Grid	3:0:0
31	17EE2030	Power Quality	3:0:0
32	17EE2031	Testing and Installation of Power System Apparatus	3:0:0
33	17EE2032	Power Electronics for Renewable Energy	3:0:0
34	17EE2033	Energy Storage in Power Systems	3:0:0
35	17EE2034	Microgrids	3:0:0
36	17EE2035	Power System Optimization	3:0:0
37	17EE2036	Substation Design	3:0:0
38	17EE2037	Testing and Commissioning of Electrical Equipment	3:0:0
39	17EE2038	Electrical Estimation and Costing	3:0:0
40	17EE2039	Illumination Engineering	3:0:0
41	17EE2040	Building Automation	3:0:0
42	17EE2041	Fundamentals of Electrical Safety	3:0:0
43	17EE2042	Basics of Electric and Hybrid Vehicle	3:0:0
44	17EE2043	Industrial Electronics	3:0:0
45	17EE2044	Electronics in Agricultural Automation	3:0:0
46	17EE2045	Green Electronics	3:0:0
47	17EE2046	FEM Analysis Laboratory	0:0:2
48	17EE2047	Smart Grid Laboratory	0:0:1
49	17EE2048	Power Electronics Application to Renewable Energy Laboratory	0:0:2
50	17EE2049	Electric Drives and Control Laboratory	0:0:1
51	17EE2050	Electrical Machines	3:1:0

52	17EE3001	Power Semiconductor Devices	3:0:0
53	17EE3002	Power Converter Analysis - I	3:0:0
54	17EE3003	Power Converter Analysis - II	3:0:0
55	17EE3004	Solid State DC Drives	3:0:0
56	17EE3005	Solid State AC Drives	3:0:0
57	17EE3006	Generalized Theory of Electrical Machines	3:0:0
58	17EE3007	Special Machines and Controllers	3:0:0
59	17EE3008	DSP Based Control of Power Converters and Drives	3:0:0
60	17EE3009	Power Electronics Laboratory	3:0:0
61	17EE3010	Advanced Electric Drives and Control Laboratory	3:0:0
62	17EE3011	Energy Engineering	3:0:0
63	17EE3012	Energy Management and Audit	3:0:0
64	17EE3013	Hydrogen and Fuel Cells	3:0:0
65	17EE3014	Photovoltaic Systems	3:0:0
66	17EE3015	Power Electronic Circuits	3:0:0
67	17EE3016	Wind Energy	3:0:0
68	17EE3017	PV System Design and Installation	3:0:0
69	17EE3018	Solar Tracking Systems Control	3:0:0
70	17EE3019	Solar Energy Laboratory	0:0:1
71	17EE3020	Wind Energy Laboratory	0:0:1
72	17EE3021	Power Engineering Simulation Laboratory	0:0:1
73	17EE3022	Power Quality Issue and Mitigation	3:0:0
74	17EE3023	Simulation of Power Electronic Systems	3:0:0
75	17EE3024	Soft Computing Techniques	3:0:0
76	17EE3025	Electric and Hybrid Vehicles	3:0:0
77	17EE3026	EV Energy Sources and Energy Recovery	3:0:0
78	17EE3027	HEV Power Management	3:0:0
79	17EE3028	Switched Mode Power Converters	3:0:0
80	17EE3029	Power Electronics in Wind and Solar Power Conversion	3:0:0
81	17EE3030	Modeling of Power Converters	3:0:0
82	17EE3031	Neuro-Fuzzy Controllers for Electric Drives	3:0:0
83	17EE3032	Advanced Control of Electric Drives	3:0:0
84	17EE3033	HVDC Transmission	3:0:0
85	17EE3034	Distributed Generation and Microgrid	3:0:0
86	17EE3035	Flexible AC Transmission Systems	3:0:0
87	17EE3036	Power System Planning and Reliability	3:0:0
88	17EE3037	Smart Grid Technologies	3:0:0
89	17EE3038	Materials for Solar Power	3:0:0
90	17EE3039	Solar Energy Forecasting	3:0:0
91	17EE3040	Solar Cell and Module Technology	3:0:0
92	17EE3041	Optimal Control of Wind Energy Systems	3:0:0
93	17EE3042	Wind Resource Assessment and Forecasting	3:0:0
94	17EE3043	Advanced Control for Induction Generators	3:0:0
95	17EE3044	Grid Converters for Wind Power Systems	3:0:0
96	17EE3045	Data Mining for Renewable Energy Systems	3:0:0
97	17EE3046	Policy and Regulatory Aspects for Renewable Power Generation	3:0:0
98	17EE3047	Oceanic Energy	3:0:0
99	17EE3048	Geothermal Energy	3:0:0
100	17EE3049	Energy Modelling, Economics and Project Management	3:0:0
101	17EE3050	Waste to Energy Conversion	3:0:0
102	17EE3051	Turbines for Renewable Energy Systems	3:0:0
103	17EE3052	Solar Thermal Energy Conversion	3:0:0
104	17EE3053	Biomass Energy	3:0:0

17EE1001 BASIC ELECTRICAL ENGINEERING

Credits: 3:0:0

Course Objectives

- To impart the basic knowledge about the DC, AC and Magnetic circuits.
- To understand the working of various Electrical Machines.
- To know about various measuring instruments and house wiring.

Course Outcomes

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

- Define the basic terminologies of DC, AC and Magnetic circuits.
- Predict and analyze the behavior of any circuits.
- Identify the type of electrical machine used for required application.
- Classify various means of power generation.
- Employ appropriate measuring instruments for the specific applications.
- Plan electrical wiring, earthing for house hold and commercial purposes.

Unit I - BASICS OF DC AND AC CIRCUITS: Electrical Quantities and Definitions - Circuit Elements - Current and Voltage sources - Source Transformation - Ohm's Law and Kirchhoff's laws - Resistive Circuits: Series and Parallel, Voltage and Current Division - AC Circuits: Generation of Alternating EMF - Alternating Quantities - Expression for Average, RMS, Form factor and Peak factor Values - Introduction to Three phase system.

Unit II - BASICS OF MAGNETIC CIRCUITS: Magnetic Materials - Magnetic Quantities: Magnetic flux, flux density, reluctance, permeance - magnetic circuits - Comparison magnetic and electric circuit - Laws of Electromagnetic induction – Induced emf - Self and Mutual inductance - Coupling co-efficient.

Unit III - BASICS OF POWER SYSTEM: Sources of Electrical Energy: Thermal and Nuclear power generating station – Transmission and Distribution: Types, Components, Comparison of OHL and UGC - Renewable Energy: Hydro, Solar and Wind Power Generation - Electricity Tariff and Energy saving methods.

Unit IV - BASICS OF ELECTRICAL MACHINES: Working principle, operation, and applications of DC Generator - DC Motor - Transformer - Three phase induction motor - Single phase induction motor - Alternator - Servo motor - Stepper motor.

Unit V - BASICS OF INSTRUMENTATION AND DOMESTIC WIRING: Instruments: Classification - Torques Mechanism for deflecting type instruments - Moving iron/ coil and Induction Type Instruments - Smart Energy Meter - Sensors & its Types - Wiring and Earthing: Wiring materials and accessories - Types of wiring - Fluorescent lamp and Stair case wiring - Basics of Earthing - Comparison of CFL / LED.

Text Books:

1. D P Kothari and I J Nagrath, "Basic Electrical & Electronics Engineering", McGraw Hill India Limited, New Delhi, 2014.
2. Muthusubramanian R & Salivahanan S, "Basic Electrical and Electronics Engineering", McGraw Hill India Limited, New Delhi, 2014.

Reference Books:

1. Bhattacharya. S. K, "Basic Electrical and Electronics Engineering", Pearson Education, New Delhi, 2011.
2. Jegathesan. V, Vinoth Kumar. K and Saravanakumar. R, "Basic Electrical & Electronics Engineering", Wiley India Private Limited, New Delhi, 2011.
3. Smarajit Ghosh, "Fundamentals of Electrical and Electronics Engineering", Prentice Hall of India, 2nd Edition, New Delhi, 2010.

17EE2001- ELECTRIC CIRCUITS AND NETWORKS

Credits 3:1:0
Pre-requisite: 17MA2003 Mathematical Transforms

Course Objectives

- To develop the ability to apply the basic laws and theorems and to analyze a DC and AC electric circuit.
- To use mathematical methods such as Laplace transform and some linear algebra techniques and differential equations to solve circuit problems.
- To analyze three phase circuits

Course Outcomes

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

- Identify the circuit elements and different types of circuits.
- Understand the various circuit analysis techniques.
- Apply the various techniques to analyze the electric circuits and networks
- Analyze the problems of electric circuits and networks for the possible solutions.
- Assess the behavior of various electric circuits and the technique used to analyze it.
- Design circuits which satisfy certain design specifications.

Unit I - BASICS OF CIRCUIT ANALYSIS: Circuit elements-Resistors- Inductors- Capacitors- Independent and dependent voltage source-Independent and dependent current source - Basic circuit laws- Ohm's law- Kirchhoff's voltage law- Kirchhoff's Current law, Resistors in series and parallel, Star-Delta and Delta-Star conversions, Network Reduction, Source Transformation, Current Division and Voltage Division Rules, Coplanar circuits - Mesh and Loop - Mesh Analysis - Super Mesh analysis, Nodes- Node voltage analysis- Super nodal analysis – PSPICE simulation

Unit II - NETWORK THEOREMS: Superposition theorem - Thevenin's theorem - Norton's theorem - Maximum power transfer theorem - Reciprocity Theorem and Millman's theorem – PSPICE simulation

Unit III - RESONANCE, COUPLED CIRCUITS AND THREE PHASE CIRCUITS: Resonance in series RLC circuits- Resonance in parallel RLC circuits- Bandwidth - Quality factor, Coupled Circuits- Dot rule- Analysis of coupled circuits, Single tuned and double tuned circuits – PSPICE simulation

Three phase circuits- Analysis of balanced and unbalanced star networks- Analysis of balanced and unbalanced delta networks- Power measurement using two wattmeter method.

Unit IV - TWO PORT NETWORKS: Network functions of two port network- Poles and Zeros- Open loop impedance parameters-Short circuit admittance parameters-Hybrid parameters - Transmission Parameters- Image parameters- Design of passive filters-low pass- high pass

Unit V - TRANSIENT RESPONSE: Transient response in RL, RC and RLC circuits with DC input- Transient response in RL, RC and RLC circuits with sinusoidal input – PSPICE simulation

Text Books

1. William H. Hayt Jr, Jack E. Kemmerly, Steven M. Durbin, "Engineering Circuits Analysis", Tata McGraw Hill Publishing Company Limited, New Delhi, 6th Edition, 2011.
2. Joseph A. Edminister, Mahmood Nahri, "Electric Circuits", Schaum's series, Tata McGraw-Hill Publishing Company Limited, New Delhi, 2010.

Reference Books

1. Sudhakar A., Shyam Mohan S.P., "Circuits, Network Analysis and Synthesis", Tata McGraw Hill Publishing Company Limited, New Delhi, 2014.
2. Kuo F.F., "Network Analysis and Synthesis", Wiley India Private Limited, New Delhi, 2nd Edition, 2006.
3. Chakrabati A, "Circuits Theory (Analysis and Synthesis)", Dhanpath Rai & Sons, New Delhi, 2008.
4. Charles K. Alexander, Matthew N.O. Sadiku, "Fundamentals of Electric Circuits", McGraw Hill Education Series, 5th Edition, 2013.

17EE2002 ELECTROMAGNETIC FIELDS

Credits: 3:1:0
Pre-requisite: 17MA2001 Vector Calculus and Complex Analysis

Course Objectives

- To understand the concept of charge, current and fields.
- To gain knowledge on electromagnetic field distribution for various configurations.
- To know the basics of electromagnetic waves.

Course Outcomes

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

- Solve the Electro Magnetic Field problems.
- Calculate and plot electromagnetic field distribution for various configurations.
- Explain the concept of EM waves and their propagation through various medium.
- Illustrate how materials affect electric and magnetic fields
- Interpret the relation between the fields under time varying situations
- Review the principles of propagation of uniform plane waves.

Unit I - ELECTROSTATICS-1: Introduction to Co-ordinate System – Rectangular – Cylindrical and Spherical Co-ordinate System – Introduction to line, Surface and Volume Integrals – Definition of Curl, Divergence and Gradient – Meaning of Stokes theorem and Divergence theorem Coulomb's Law in Vector Form – Definition of Electric Field Intensity –Electric Field due to an infinite uniformly charged sheet - Relationship between potential and electric field – Potential due to infinite uniformly charged line – Potential due to electrical dipole – Electric Flux Density – Gauss Law – Proof of Gauss Law – Applications.
Unit II - ELECTROSTATICS -2: Poisson's and Laplace's equation – Electric Polarization-Nature of dielectric materials- Definition of Capacitance – Capacitance of various geometries using Laplace's equation– Electrostatic energy and energy density – Boundary conditions for electric fields — simple examples– Applications.
Unit III – MAGNETOSTATICS: Biot-Savart Law in vector form – Magnetic Field intensity due to a finite and infinite current carrying conductor – Magnetic field intensity due to a circular and rectangular current carrying conductor – Ampere's circuital law – Magnetic field due to Coaxial cable. Magnetic flux density – The Lorentz force equation – Force and Torque on a current carrying conductor – Magnetic moment – Magnetic Vector Potential–Definition of Inductance – Inductance of loops and solenoids – Definition of mutual inductance – Applications.
Unit IV - ELECTRO DYNAMIC FIELD: Current density– point form of ohm's law –Displacement current – Faraday's law Transformer EMF and Motional EMF–Eddy currents –Maxwell's four equations in integral form and differential form.
Unit V – ELECTROMAGNETICWAVES: Derivation of Wave Equation – Uniform Plane Waves – Maxwell's equation in Phasor form – Wave equation in Phasor form – Plane waves in free space and in a homogenous material–Wave equation for a conducting medium – Plane waves in lossy dielectrics –Propagation in good conductors – Skin effect– Poynting Theorem and Poynting Vector.

Text Books:

1. William H.Hayt Jr., John A.Buck, "Engineering Electro Magnetics", Tata McGraw- Hill Education India Private Limited, New Delhi, 8th Edition 2014.
2. Joseph Edminister; Mamood Nahvi, "Schaum's outline of electromagnetic", McGraw Hill, New York, 2014.

Reference Books:

1. John D. Kraus & Flesh , "ElectroMagnetics with Applications", Tata McGraw- Hill, New Delhi, ,5th Edition,2010.
2. Clayton R.Paul, Keith W.Whites, Syed A. Nasar, "Introduction to Electromagnetic Fields", Tata McGraw Hill Publishing Company Ltd., New Delhi, 2008.
3. Bhag Singh Guru, Huseyin R. Hiziroglu, "Electromagnetic Field Theory Fundamentals", Cambridge University Press, UK, 2004.

17EE2003 DC MACHINES AND TRANSFORMERS

Credits: 3:1:0

Course Objectives

- To understand the generation of D.C. voltages by using different types of generators and study their performance.
- To study the working principles of Transformers and their load characteristics.
- To understand the various testing methods

Course Outcomes

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

- Distinguish different types DC machines.
- Interpret the various types of speed control methods
- Estimate the various losses taking place in D.C. machines and transformers.
- Describe on constructional details of different type of transformers, working principle and its performance
- Test the different testing methods of electrical machines to arrive at its performance.
- Explain the parallel operation of DC machine and Transformers

Unit I - DC GENERATORS: Constructional features of a DC machines – Principle of operation – EMF equation – Types of DC Generator - methods of excitation – no load and load characteristics of DC generators –armature reaction and commutation – interpoles - Compensating windings - Parallel operation of DC generators

Unit II - DC MOTORS: Principles of operation - back EMF – torque equation –Types of DC Motor- Characteristics of DC motors – starting – speed control – Braking- Applications

Unit III - TESTING OF DC MACHINES: Losses and efficiency – Testing of DC machines- Brake test, Swinburne's and Hopkinson's test

Unit IV – TRANSFORMERS: Principles of operation – constructional features of single phase and three phase transformers – EMF equation – transformer on no load and load – effects of resistance and leakage reactance of the windings – phasor diagram – Auto transformer – comparison with two winding transformers – three phase transformers connections – Tertiary winding

Unit V - TESTING OF TRANSFORMERS: Equivalent circuit – regulation-losses and efficiency – all day efficiency – testing – polarity test – open circuit and short circuit test – Sumpner's test – Parallel operation of transformers.

Text Books:

1. Kothari D.P., Nagrath I.J., "Electric Machines", Tata McGraw- Hill Education India Private Limited, New Delhi, 4th Edition, 2010.
2. Murugesh Kumar, K., "DC Machines and Transformers", Vikas Publishing House Private Limited., New Delhi, 2nd Edition, 2004.

Reference Books:

1. Arthur Eugene Fitzgerald, Charles Kingsley Jr, Stephen D. Umans, "Electric machinery", Mc Graw – Hill Professional Series, New York, 6th Edition, 2002.
2. Cotton, H., "Advanced Electrical Technology", A.H Wheeler and Company Publications, London, 2011.
3. Rajput R.K., "Direct Current Machines", Lakshmi Publications, New Delhi, 4th Edition, 2007.

17EE2004 INDUCTION AND SYNCHRONOUS MACHINES

Credit: 3:1:0

Pre-requisite: 17EE2003 DC Machines and Transformers

Course Objectives:

- To gain knowledge on the concepts of AC rotating Machines.
- To know about the control techniques of AC rotating Machines.
- To understand the operation of a Synchronous machine with an Infinite bus bar.

Course Outcomes:

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

- Explain the construction and working principle of Induction and Synchronous Machines.
- Identify suitable starting, speed control and braking methods for Induction Motor and Synchronous Motor.

- Analyze the performance of the Induction and Synchronous Machine under various operating conditions.
- Inspect the synchronized operation of an Alternator with an Infinite bus bar.
- Determine the voltage regulation of an Alternator or predetermine the efficiency of a AC rotating machine.
- Choose a suitable Induction and Synchronous Machines for an application.

Unit I - THREE-PHASE INDUCTION MOTOR: Principle of Operation – Construction and types of Rotor – Torque equation – Torque-Slip characteristics – Maximum torque – Equivalent circuit – Phasor diagram – Circle diagram - Starters – Speed control – Crawling and Cogging – Electrical Braking – Double Cage Induction Motor – Induction Generator

Unit II - FRACTIONAL KILOWATT MOTOR Principle of operation – Double revolving field theory – Equivalent circuit – Performance calculations – Methods of self-starting – Types of Single Phase Induction Motor – Stepper Motor – Universal Motor – Synchronous Reluctance Motor – Hysteresis Motor.

Unit III - SYNCHRONOUS MACHINES Types - Constructional features – three phase windings – Winding factors – EMF equation – Armature reaction – Voltage regulation – Predetermination of regulation by Synchronous Impedance – Ampere Turn and Potier reactance methods - Load characteristics – Power expression – Parallel operation – Synchronizing Current and Synchronizing power – Salient Pole Synchronous Machine – operation of Salient Pole Generator and Motor - Slip Test

Unit IV - SYNCHRONOUS MOTOR Principle of operation – Methods of starting – Phasor diagrams – V-curves and Inverted V-curves - Power/Power-angle relations – Synchronous Condensers – Hunting and methods of Suppression.

Unit V - APPLICATIONS OF AC MACHINES Wind turbine with Doubly Fed Induction Generator (DFIG) & Permanent Magnet Synchronous Generator(PMSG) – Pump for irrigation and sewage plants – Power Factor improvement using Synchronous Motor – Motor Coil winding machine using stepper motor – Hybrid Electric Vehicle

Text Books:

1. Arthur Eugene Fitzgerald, Charles Kingsley, Stephen D. Umans, “Electric Machinery”, McGraw Hill Professional Series, New York, 6th Edition, 2002.
2. Murugesh Kumar, K, “Induction and Synchronous Machines”, Vikas Publishing House Limited, New Delhi, 4th Reprint, 2009.

Reference Books:

1. Alexander, S. Langsdorf, “Theory of Alternating Current Machinery”, Tata McGraw Hill Education India Private Limited, New Delhi, 2nd Edition, 2009.
2. Kothari D.P., Nagrath I.J., “Electrical Machines”, Tata McGraw Hill Education India Private Limited, New Delhi, 3rd Edition, 2004.
3. Gupta, B.R., Vandana, Singhal, “Fundamentals of Electric Machines”, New Age International Publishers Limited, New Delhi, 2nd Edition, 2002.

17EE2005 ELECTRICAL MACHINE DESIGN

Credits 3:1:0

Pre-requisite: 17EE2003 DC Machines and Transformers
17EE2004 Induction and Synchronous Machines

Course Objectives

- To gain knowledge on the design aspects of Electrical Machines.
- To study the design procedure of DC and AC machines.
- To know the analysis of electrical machines.

Course Outcomes

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

- Recognize the importance of magnetic and electric loadings
- Explain the design of main dimensions of DC and AC rotating machines.
- Calculate the system parameters for proper design of field coils and armature coils and DC and AC rotating machines.
- Select a proper winding design of armature coils and deduce the values of armature design parameters of DC and AC rotating machines.

- Design a transformer and its cooling systems.
- Predetermine the performances of the DC, AC rotating machines and transformers from the design data.

Unit I - GENERAL ASPECTS Major considerations – Limitations - Main dimension- Output equation - Choice of specific electric and magnetic loadings - Separation of D and L for rotating machines - Conducting, insulating and magnetic materials used in electrical apparatus – Thermal considerations - MMF for air gap - Effects of slots, ventilating ducts and saliency - MMF for teeth -Total MMF calculation - Leakage reactance calculation

Unit II - DC MACHINES Armature winding -output equation-Choice of specific loadings-Choice of poles-design of conductors, winding, slot, air gap, field poles and field coils, commutator and brush-Predetermination of efficiency, temperature rise and open circuit characteristics from design data (qualitative treatment only)

Unit III – TRANSFORMERS Output equation-Design of core and coils for single phase and three phase transformers-Design of tank and cooling tubes-Predetermination of circuit parameters, magnetizing current, losses, efficiency, temperature rise and regulation from design data (qualitative treatment only)

Unit IV - THREE PHASE INDUCTION MACHINES Output equation-Choice of specific loadings-Design of stator-Design of squirrel cage and slip ring rotors-Stator and rotor winding designs - Predetermination of circuit parameters, magnetizing current, efficiency and temperature rise from design data (qualitative treatment only).

Unit V - SYNCHRONOUS MACHINES Output equations – choice of Electrical and Magnetic Loading – Design of salient pole machines – Short circuit ratio – shape of pole face – Armature design – Armature parameters – Estimation of air gap length – Design of rotor –Design of damper winding – Determination of full load field mmf – Design of field winding – Design of turbo alternators – Rotor design.

Text Books:

1. Sawhney, A.K., “A Course in Electrical Machine Design”, Dhanpat Rai & Sons, New Delhi, 2016.
2. Sen, S.K., “Principles of Electrical Machine Designs with Computer Programs”, Oxford and IBH Publishing Company Private Ltd., New Delhi, 2ndEdition, 2009.

Reference Books:

1. A.Shanmugasundaram, G.Gangadharan, R.Palani “Electrical Machine Design Data Book”, New Age International Pvt. Ltd., New Delhi, Reprint 2007.
2. Deshpande M.V., “Design and Testing of Electrical Machines”, Prentice Hall India, New Delhi, 3rd Edition, 2009.
3. Agarwal R.K., “Principles of Electrical Machine Design”, S.K.Kataria and Sons, Delhi, 2002.
4. Mittle V.N., Mittle A., “Design of Electrical Machines”, Standard Publications and Distributors, Delhi, 2002.

17EE2006 POWER ELECTRONICS

Credits: 3:0:0

Course Objectives:

- Study the Static and Dynamic characteristics of Power Semiconductor Devices.
- Understand the operation of power electronic converters and its control strategies of various power converters.
- Study the design parameters for control circuitry requirement of various converters.

Course Outcomes:

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

- Identify to use the solid-state power devices for the control, conversion, and Protection of electrical energy.
- Design a power converter with criteria (power, efficiency, ripple voltage and current, harmonic distortions, power factor).
- Implement and verify the performance characteristics of power converters
- Interpret terminal characteristics of the components for designing the circuitry for power converters.
- Estimate the required converters for renewable based applications.
- Assess the quality of power by analyzing the factors such as harmonics, ripples, etc.,

Unit I - POWER SEMICONDUCTOR DEVICES: Introduction to switching concepts - Static and Dynamic characteristics: Power Diodes - Power BJT - Power MOSFET – IGBT - Thyristor family: SCRs – TRIAC – GTO – IGCT – MCT - Protection circuits – Series and parallel connections.
Unit II - AC - DC CONVERTERS: Controlled rectifiers: Single Phase semi and fully controlled converters with R, RL Load -Estimation of average load voltage and average load current – Introduction to Three phase halfwave, semi and fully Controlled Converters- Dual Converters – Gate triggering methods for rectifiers.
Unit III - AC - AC AND DC - DC CONVERTERS: AC- AC Converter - Single Phase half and full Wave controller with R and RL load – Estimation of RMS load voltage, current and input power factor – Three phase AC voltage controllers - Single phase Cyclo-converters – Gate pulse generation for AC regulators. DC TO DC Converter**:** Control strategies - Principle of step up and step down operation – Analysis of single quadrant DC chopper – Estimation of average load voltage and load current for Continuous current operation – Two and Four Quadrant DC choppers – Pulse generation for chopper circuits
Unit IV - DC - AC CONVERTERS: Single phase and Three phase bridge inverters – Voltage control methods - Harmonic reduction – Single phase Series Inverters – Basics of Current source inverters – PWM Techniques for pulse generation.
Unit V - RECENT TRENDS AND APPLICATIONS IN POWER ELECTRONICS: Advanced converters: Introduction to Zeta converter - Super lift luo converter - Multilevel Inverters. Applications: UPS – SMPS - HVDC systems - Tap changing of Transformers – Induction heating – Power electronics for Solar and Wind Power.

Text Books:

1. Rashid. M.H., "Power Electronics – Circuits, Devices and Applications", Pearson Education Incorportion, New Delhi, 3rd Edition, 2014.
2. Ned Mohan, Undeland and Robbins, "Power Electronics – Converters, Applications and Design,", Wiley India Pvt. Ltd., New Delhi, 2010.

Reference Books:

1. Philip T. Krein, "Elements of Power Electronics", Oxford University Press, Inc., New York, 2008.
2. Joseph Vithayathil, "Power Electronics – Principles and Applications", Tata McGraw-Hill Edition, New Delhi, 2010.
3. Dr. P. S. Bhimbra, "Power Electronics", Khanna Publishers, New Delhi, 2015.

17EE2007 TRANSMISSION AND DISTRIBUTION

Credits 3:1:0

Course Objectives

- To learn the usage of passive elements in various Power Transmission and Distribution Systems.
- To understand the factors affecting Insulators.
- To know the structure of Distribution System.

Course Outcomes

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

- Match the load with various generation units in different location.
- Design the transmission line by calculating resistance, inductance and capacitance of the transmission lines.
- Understand the selection of insulators and cables.
- Design the appropriate distribution system.
- Evaluate the performance of the transmission and distribution system with mathematical calculations.
- Interpret the various transmission concepts.

Unit I - INTRODUCTION AND VARIOUS LOAD FACTORS: Basic structure of power system- demand of electrical system – base load- peak load-controlling power balance between generator and load-advantages of interconnected system
Unit II - TRANSMISSION LINE PARAMETERS: Evaluation of Transmission line parameters- types of conductors- representation of transmission line-inductance calculation of single/three phase lines- concept of GMD and GMR- transposition of lines- bundled conductors- capacitance calculation of single/three phase lines
Unit III - ANALYSIS OF TRANSMISSION LINES: Analysis of transmission lines – representation, short/medium/long transmission lines- nominal T/π network- ABCD parameters- surge impedance- skin effect-proximity effect- Ferranti effect.

Unit IV - ANALYSIS OF INSULATORS AND CABLES: Insulators for overhead transmission lines - Insulated cables – capacitance of single/three core cable- dielectric loss

Unit V - DISTRIBUTION SYSTEMS: D.C and A.C. distribution - radial and ring main distribution - medium voltage distribution network - low voltage distribution network - single line diagram,

Text Books:

1. Wadhwa, C.L., “Electrical Power Systems”, New Age International Publishers Ltd., New Delhi, 6th Edition, 2014.
2. Kothari D. P., Nagrath I. J., “Modern Power System Analysis”, McGraw Hill India Limited, New Delhi, 4th Edition 2014.

Reference Books:

1. Mehta, V.K., Rohit Mehta, “Principles of Power Systems”, S.Chand& Company Private Limited, New Delhi, 14th Edition, 2005.
2. Singh S.N, “Electric Power Generation, Transmission and Distribution”, PHI Learning Private Limited, New Delhi, 2nd Edition, 2009.
3. Uppal, S.L., “Electrical Power”, Khanna Publishers Limited, New Delhi, 13th Edition, 2002.

17EE2008 POWER SYSTEM ANALYSIS

Credits 3:1:0

Prerequisites: 17EE2007 Transmission and Distribution

Course Objectives:

- To understand the operation of electric power systems.
- To study the fault, power flow and stability analysis in a power system.
- To learn the economic operation of power system.

Course Outcomes:

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

- Demonstrate the power system components using single line diagram
- Analyze the impact of a short-circuit on the power system network
- Select the circuit breakers and protective devices
- Perform load flow and stability analysis.
- Optimize the operation of power plants.
- Design of VAR compensator.

Unit I - REPRESENTATION OF POWER SYSTEM: Need for System analysis in planning and operation of power system-System modelling of synchronous machines- transformers- loads - per unit system, single line diagram of electrical networks- Formulation of Bus impedance and admittance matrices.

Unit II - SHORT CIRCUIT STUDIES: Algorithm for short circuit studies -Symmetrical Component transformation - sequence networks. Symmetrical Analysis of Unsymmetrical Line-to-ground (LG), Line-to line (LL), double line to ground (LLG) faults using symmetrical components.

Unit III - LOAD FLOW STUDIES: Formulation of load flow problem - bus classification – Solution by Gauss - Seidal - Newton- Raphson and Fast decoupled methods - Comparison - Computation of slack bus power, transmission loss and line flow.

Unit IV - ECONOMIC LOAD DISPATCH AND UNIT COMMITMENT: Optimal operation of generators – Economical scheduling of thermal plant with and without transmission losses – Loss formula derivation- Unit commitment - Elementary idea of optimal load scheduling of Hydro - Thermal plants

Unit V - STABILITY STUDIES & REACTIVE POWER COMPENSATION: Steady state and Transient stability - Swing equation and its solution by Modified Euler and Runge- Kutta methods- Equal area criterion – Overview of Reactive Power control — Reactive Power compensation in transmission systems — advantages and disadvantages of different types of compensating equipment for transmission systems

Text Books:

1. Hadi Saadat, “Power System Analysis”, Tata McGraw-Hill Education India Private Limited, New Delhi, 3rd Edition 2010.
2. Gupta, B.R., “Power System Analysis and Design”, S.Chand & Company Limited, New Delhi, 2017.

Reference Books:
1. Nagrath I.J., Kothari D.P., 'Modern Power System Analysis', Tata McGraw-Hill, 4th Edition, 2011.
2. Wadhwa C. L., "Electrical Power Systems", New Age International Private Limited, New Delhi, 6th Edition, 2014.
3. Kundur P., "Power System Stability and Control", Tata McGraw Hill Education Pvt. Ltd.,New Delhi, 10th reprint 2010.

17EE2009 POWER SYSTEM PROTECTION AND SWITCH GEAR

Credits 3:0:0
Prerequisite: 14EE2008 Power System Analysis

Course Objectives
- To discuss the causes of abnormal operating conditions (faults, lightning and switching surges) of the apparatus and system.
- To understand the characteristics and functions of relays and protection schemes.
- To know the problems associated with circuit interruption by a circuit breaker.

Course Outcomes
At the end of the course, the student will be able to
- Describe the importance of different types of relay.
- Explain the different schemes used in apparatus protection.
- Interpret the behavior and selection of various types of circuit breakers.
- Analyze the need of lightning arrestors.
- Summarize the importance of earthing and grounding.
- Design a suitable protection system for a specified application.

Unit I - INTRODUCTION AND RELAY CHARACTERISTICS: Need for protection - essential qualities of protective relays - over current relays -directional, distance and differential, under frequency, negative sequence relays -static relays - microprocessor based relays.
Unit II - APPARATUS PROTECTION: Generator and Transformer Protection - Protection of bus bars - transmission lines - CTs & PT's and their application in protective schemes.
Unit III - CIRCUIT BREAKERS: Functions of switchgear - Elementary principles of arc extinction- Arc control devices - Recovery voltage and restriking voltage – Current chopping and capacitance current breaking - Various types of circuit breakers - Selection of circuit breakers -Intelligent circuit breakers
Unit IV - SURGE AND LIGHTENING ARRESTOR: Protection against Over Voltages Different methods of protection against over voltages -lightning arresters. Solid resistance and reactance Earthing - Arc suppression coil - Earthing transformers –Earth wires - Earthing of appliances- Insulation co-ordination.
Unit V - ANALYSIS OF PROTECTION SYSTEMS AND APPLICATIONS: Selection of circuit breakers-Selection of Relays-Analyze and Compare specified protection systems-Choose a suitable protection system – Applications.

Reference Books:
1. Badri Ram, Vishwakarma D N., "Power System Protection and Switchgear", Tata McGraw- Hill Education India Private Limited, 2nd Edition, New Delhi, 2011.
2. B Ravindranath, M Chander, "Power system Protection and Switch gear",2nd Edition, New Age International, 2016.

Reference Books:
1. Bhuvanesh A Oza, Nirmal Kumar C Nair, Rashesh P Mehta and Vijay H Makwana., "Power System Protection and Switchgear", Tata McGraw- Hill Education India Private Limited, New Delhi. 1st Edition, 2010.
2. Soni M.L., Gupta P.V., Bhatnagar U.S., Chakrabarthi A., "A Text Book on Power System Engineering", Dhanpat Rai & Sons Company Private Limited, New Delhi,2008.
3. Sunil, S.Rao, "Switchgear Protection and Power Systems", Khanna Publishers Limited, New Delhi, 12th Edition, 2008.

17EE2010 DC MACHINES AND TRANSFORMERS LABORATORY

Credits 0:0:1
Co-requisite: 17EE2003 DC Machines and Transformers

Course Objectives

- Examine the relationship between the electrical and mechanical parameters of a DC electric machine and Transformer.
- Able to determine/predetermine the performance of the selected machine.
- To study the various types of testing methods

Course Outcomes

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

- Find suitable machine for an application.
- Select Suitable apparatus to perform the Experiments
- Calculate the Efficiency of the machine
- Draw the graph for mechanical and Electrical characteristics of the machine
- Analyze the time taken for braking at various resistance
- Evaluate various losses by direct and indirect testing methods

Description

The laboratory will demonstrate the student

- To explore all the possible configurations of a DC machine and Transformers.
- The performance and control characteristics of these configurations and Transformers.
- The method of testing to derive the equivalent circuit of a given design.

List of Experiments:

1. Open Circuit and Load Characteristics of a Separately-Excited Shunt Generator
2. Open Circuit and Load Characteristics of a Self-Excited Shunt Generator
3. Load characteristics of DC Compound Generator
4. Load test on DC Shunt Motor
5. Load test on DC Series Motor
6. Load test on Single Phase Transformer
7. Speed control of DC Shunt Motor
8. Swinburne's Test
9. Open circuit and Short circuit test on Single Phase Transformer
10. Sumpner's Test on a Single-Phase Transformer
11. Electric Braking of DC Shunt Motor
12. Three Phase Transformer Connections

17EE2011 AC MACHINES LABORATORY

Credits 0:0:2
Co-requisite: 17EE2004 Induction and Synchronous Machines

Course Objectives:

- To prepare students to understand, demonstrate and analyze the concepts of AC Machines.

Course Outcomes:

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

- Recall the working principle and various parts of Induction and Synchronous Machines.
- Conduct brake test on Induction and Synchronous Machines.
- Conduct a suitable test to determine the system parameters of Synchronous Machine.
- Evaluate the performance factors of Induction and Synchronous Machines.
- Predict the performance factors of Induction and Synchronous Machines.
- Perform synchronization of alternator with infinite bus-bar.

Description:

The laboratory will demonstrate the student about the operation and performance analysis of a AC Machines and derive the transfer function for an electromechanical system.

List of Experiments

1. Load Test on Three Phase Squirrel Caged Induction Motor.
2. Load Test on Three Phase Slip Ring Induction Motor.
3. Speed Control of Three Phase Slip Ring Induction Motor.
4. No-load and Blocked Rotor test on Three Phase Induction Motor.
5. Separation of No-load losses of Three Phase Induction Motor.
6. Star-Delta starter of Three Phase Induction Motor.
7. Load Test on Single Phase Induction Motor.
8. No load and blocked rotor test on Single Phase Induction motor.
9. Voltage Regulation of Three Phase Alternator by EMF and MMF method.
10. Load Test on Three Phase Alternator.
11. Synchronization of Alternator with Infinite Bus-bar.
12. V and Inverted V curve of Three Phase Synchronous Motor.
13. Determination of X_d and X_q of a salient pole synchronous machine from slip test.
14. Determination of sub-transient reactance of salient pole synchronous machine.
15. Determination of sequence impedances of salient pole synchronous machine.

17EE2012 POWER ELECTRONICS LABORATORY

Credits 0:0:2
Co-requisite: 17EE2006 Power Electronics

Course Objectives:

- To understand the operating performance of Power Electronic Devices.
- To study the various power electronics circuits, gating methods.

Course Outcomes:

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

- Analyze the static and switching characteristics of Power Devices
- Test and verify the design of Power Converters.
- Develop control circuits for controlling the power converters.
- Use the Data Sheets for the selection of power rating of the device.
- Design suitable power, control and isolation circuits for an application.
- Model a power converter using simulation packages such as MATLAB, PSIM & MULTISIM.

Experiments:

The faculty conducting the laboratory will prepare a list of 12 experiments and get the approval of HoD / UG Program Coordinator and notify it at the beginning of each semester.

List of Experiments

1. Characteristics of MOSFET, IGBT, SCR and TRIAC
2. Single Phase Semi & Full Converter with R & R – L Load
3. Three Phase Half Wave Converter with R & R – L Load
4. MOSFET based DC Chopper with Motor Load
5. Single Phase AC Voltage Controller with R & R – L Load
6. Single Phase Cyclo-converter with R & R – L Load
7. Single Phase Series Inverter with R & R – L Load
8. Switched Mode Power Supply
9. DC Regulated Power Supply
10. Simulation of Power Electronic Circuits using MATLAB / Simulink
11. Simulation of Power Electronic Circuits using PSIM
12. Simulation of Power Electronic Circuits using MULTISIM
13. Various triggering methods for Power Devices
14. Pulse generation using Arduino

17EE2013 COMPUTER AIDED POWER SYSTEMS ANALYSIS LABORATORY

Credits 0:0:2
Co-requisite: 17EE2008 Power System Analysis

Course Objectives

- To enable the students to understand the load flow in a power system.
- To enable the students to do the computation of bus impedance/admittance.
- To enable the students to understand the fault analysis in a power system.

Course Outcomes

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

- Solve the power system problems using MATLAB.
- Simulate armature controlled D.C motor and AVR using mat lab Simulink.
- Determine the sequence line parameters such as L and C.
- Facilitate the modification of the Bus admittance matrix to reflect the network changes.
- Model various power system components that are adequate for the basic system studies of load flow and short-circuit.
- Analyze the fault current under different fault conditions.

List of Experiments

1. Introduction to MATLAB
2. Modeling and Simulation of DC motor using Simulink
3. Automatic Voltage Regulator
4. Computation of Transmission line parameters
5. Formation of Y Bus matrix by Direct Inspection method
6. Formation of Y Bus matrix by Singular Transformation method
7. Formation of Z Bus Matrix by using Z Bus building algorithm
8. Symmetrical Fault analysis using Z Bus
9. Solving load flow equations by Gauss Seidal method
10. Solving load flow equations by Newton Raphson method
11. Economic Load dispatch
12. Transient Stability
13. Fault Analysis of AC Power System Using PSCAD / EMTDC

17EE2014 DESIGN LABORATORY

Credits: 0:0:1
Course Objectives:

- To motivate the students to develop a project with their own ideas

Course Outcomes:

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

- Utilize the data sheets for the selection of Electrical, Electronics and Power Electronics components.
- Apply the concepts of the departmental core subjects in developing a project
- Develop team-building skills and enhance technical knowledge through design projects
- Analyze and design the systems that efficiently generate, transmit, distribute, convert and utilize electric power
- Simulate, design and test the electrical machines, modern electrical drives, energy system.
- Design, implement and test the analog and digital systems using software tools and ICT.

List of Experiments

1. Design and Implementation of FM/AM Radio Receiver
2. Substation-Mathematical Analysis
3. Design and Installation of PV Module
4. Design of step-down transformer, rectifier and filter to drive a motor
5. Design, Testing and operation of DC-DC converter for water pumping application using solar panel.
6. Design Testing and operation of four quadrant Chopper foe electric vehicle application
7. Hardware implementation of a mini project.

17EE2015 ELECTRICAL MEASUREMENTS & CONTROL SYSTEM LABORATORY

Credit: 0:0:1
Co-requisite: 17EI2006 Control Systems

Course Objectives

- To study about the measurement techniques for various electrical quantities
- To know of about qualitative and quantitative measurements.
- To learn about the transfer function using MATLAB.

Course Outcomes

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

- Measure different electrical quantities with appropriate measurement techniques.
- Assess data conversion in signal conditioning.
- Determine the model parameters of Continuous systems.
- Identify the sensor techniques.
- Evaluate the positioning techniques.
- Improve the performance of control system by using different controllers.

Description

This laboratory demonstrates the students about measurement of any parameters using suitable instruments and control system experiments.

List of Experiments

1. PID controllers.
2. Position control systems.
3. Response of Second order system.
4. Signal Conditioning (ADC and DACs).
5. Dynamics of sensors (Current, Voltage, Hall effect sensor and Temp sensor).
6. Power Quality Analyzer.

17EE2016 COMPUTER AIDED GRAPHICS FOR ELECTRICAL ENGINEERS

Credits 0:0:2

Course Objectives:

- To understand the usage of computer graphics for electrical engineering.
- To understand the 3D view of a Machine.
- To understand the layout of a power system

Course Objectives

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

- Distinguish various electrical symbols
- Utilize the skill set to create wiring layout.
- Distinguish various components by labeling
- Sketch drawings to distinguish low power and high power circuits
- Develop technical sketch for power stations
- Develop technical drawing for process flow

List of Experiments

1. Drawing of Electrical Symbols
2. Create circuit diagram of a pocket pager
3. Create circuit diagram of a microphone pre-amplifier
4. Create electrical plan for the given house layout
5. Create electrical plan for the given office layout
6. Create electrical plan for the given patient room
7. Create HVAC drawing - indoor outdoor control
8. Drawing of motor starter circuits
9. Create a power plant diagram

10. Create a piping plan
11. Pole mounted distribution substation
12. Single line diagram of indoor substation

17EE2017 ELECTRON DEVICES AND ELECTRONIC CIRCUITS LABORATORY

Credits 0:0:2
Co-requisite: 17EC2055 Electron Devices and Circuits

Course Objectives

- To understand the principle of operation and characteristics of semi-conductor devices
- To familiarize with the application of transistors
- To study about the functions and applications of oscillators

Course Outcomes

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

- Refresh the construction, theory and performance of various electron devices
- Differentiate the operating range of various semiconductor devices
- Analyze the circuit characteristics with OPAMP ICs
- simulate electronic circuits using standard software packages
- Rebuilt the functional blocks of various oscillatory circuits
- Verify the Features of amplifiers and oscillators

List of Experiments

1. a. Characteristics of PN junction Diode
   b. Halfwave rectifier
   c.Full wave Rectifier
2. Voltage Regulator (series type)
3. Characteristic of BJT
4. Characteristics of JFET
5. RC Coupled Amplifier using BJT
6. Common Source JFET Amplifier
7. Differential Amplifier using BJT
8. Emitter Follower
9. RC Phase Shift Oscillator
10. Colpitts Oscillator
11. Astable Multivibrator
12. Bistable Multivibrator
13. Schmitt Trigger

17EE2018 ELECTRIC DRIVES AND CONTROL

Credits 3:0:0
Pre-requisite: 17EE2003 DC machines and Transformers
17EE2004 Induction and Synchronous machines
17EE2006 Power Electronics

Course Objectives

- Understand the classification and characteristics of Drives.
- Analyze the various types and operations of DC & AC Drives.
- Study the operation of Special Machine Drives.

Course Outcomes

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

- Describe the behavior of Electrical Drives with load conditions
- Select the power rating of the motor based on the duty class.
- Prioritize the converter for DC and AC drives.

- Choose appropriate converter for the Drives.
- Propose the Electric Drive for the particular application.
- Differentiate the closed loop control methods for Electric Drives.

Unit I - DRIVE CHARACTERISTICS: Electric drive – Equations governing motor load dynamics – steady state stability – multi quadrant Dynamics: acceleration, deceleration, starting & stopping – typical load torque characteristics – Selection of motor
Unit II - CONVERTER / CHOPPER FED DC MOTOR DRIVE: Steady state analysis of the single-phase converter fed separately excited DC motor drive – continuous and discontinuous conduction – Time ratio and current limit control – Four quadrant operation of converter / chopper fed drive
Unit III - INDUCTION MOTOR DRIVES: Stator voltage control – energy efficient drive – V/f control – constant air gap flux – field weakening mode – voltage / current fed inverter – closed loop control
Unit IV - SYNCHRONOUS MOTOR DRIVES: V/f control and self-control of synchronous motor: Margin angle control and power factor control – permanent magnet synchronous motor
Unit V - DESIGN OF CONTROLLERS FOR DRIVES: Transfer function for DC motor / load and converter – closed loop control with current and speed feedback – armature voltage control and field weakening mode – design of controllers; current controller and speed controller-converter selection and characteristics

Text Books:

1. Dubey, G.K., "Fundamentals of Electrical Drives", Narosa Publishing House, 2ndEdition, New Delhi, 2013.
2. Bose, B.K., "Modern Power Electronics and ACDrives", Prentice Hall of India, Private Limited, 1stEdition, New Delhi, 2009.

Reference Books:

1. Ion Boldea, Nasar S. A., "Electric Drives", C.R.C Press, New York, 2nd Edition, 2005.
2. Krishnan R, "Electric Motor Drives: Modeling, Analysis and Control", Prentice Hall of India Private Limited, 1stEdition, New Delhi, 2009.
3. Vedam Subramanyam, "Electric Drives: Concepts and Applications", Tata McGraw- Hill Education India Private Limited, New Delhi, 2nd Edition, 2010.

17EE2019 SPECIAL ELECTRICAL MACHINES

Credits: 3:0:0
Pre-requisite: 17EE2003 DC machines and Transformers
17EE2004 Induction and Synchronous Machines

Course Objectives
- To gain knowledge on construction and working of various special electrical machines.
- To study the characteristics of various special electrical machines.
- To learn the control techniques for the operation of special electrical machines.

Course Outcomes
At the end of the course, the students will able to
- Select an energy efficient linear or rotary motor based on the characteristics of the load & application.
- Incorporate the correct control technique to the machine for efficient operation.
- Analyze the behavior of the machine for the applied control technique.
- Improve the performance of the motor by enhancing the motor suitably.
- Explain the theory of travelling magnetic field and applications of linear motors.
- Understand the significance of electrical motors for traction drives.

Unit I - STEPPER MOTOR: Different Types – Construction – Theory of Operation – monofilar and bifilar windings – Modes of excitations Modes of excitations – Single and multi-stack configurations – Torque equations – Characteristics – Microprocessor control of stepping motors – Applications.
Unit II - SWITCHED RELUCTANCE AND SYNCHRONOUS RELUCTANCE MOTORS: Synchronous reluctance motor Constructional features – Types – Axial and radial air gap motors – Operating principle – Reluctance – Phasor diagram – Characteristics – Switched reluctance motor constructional features – Rotary and

Linear SRMs – Principle of operation – Torque production – Characteristics – Power Converters and their controllers – Rotor position sensing methods – Sensorless operation – Applications.

Unit III - PERMANENT MAGNET BRUSHLESS DC MOTOR: Permanent Magnet materials – Magnetic Characteristics – Permeance coefficient -Principle of operation – Types – Magnetic circuit analysis – EMF and torque equations –Commutation - Power controllers – Motor characteristics and control – Applications.

Unit IV - PERMANENT MAGNET SYNCHRONOUS MOTOR: Principle of operation – Ideal PMSM – EMF and Torque equations – Armature reaction MMF – Synchronous Reactance – Sinewave motor with practical windings – Phasor diagram – Torque/speed characteristics – Power controllers – Applications.

Unit V - ELECTRIC MOTORS FOR TRACTION DRIVES: AC series motors – DC motors –Single sided linear induction motor for traction drives – Comparison of AC and DC traction – Applications.

Text Books:

1. Venkataratnam K, "Special Electric Machines", CRC Press, Taylor and Francis, London, 2014.
2. Ramu Krishnan, "Permanent Magnet Synchronous and Brushless DC Motor Drives", CRC Press, London, 2010.

Reference Books:

1. Janardhanan E.G., "Special Electrical Machines", PHI learning private limited, 2014.
2. Simmi P. Burman, "Special Electrical Machines", S. K. Kataria & Sons, Publishers New Delhi, 2nd Edition, 2013.
3. Vinoth Kumar K, Saravanakumar R, Umamaheswari R, "Special Electrical Machines", Nirali Prakashan Publisher, Pune, 1st Edition, 2016.
4. Kenjo, T, "Stepping Motors and Their Microprocessor Control", Clarendon Press, Oxford, 1989.
5. Naser.A, Boldea.I, "Linear Electric Motors: Theory, Design and Practical Application", Prentice Hall Inc., New Jersey, 1987.
6. Kenjo.T, and Naganori. S "Permanent Magnet and Brushless DC Motors", Clarendon Press, Oxford, 1989.
7. Miller, T.J.E. "Brushless Permanent Magnet and Reluctance Motor Drives", Clarendon Press, Oxford, 1989.

17EE2020 AUTOMOTIVE ELECTRONICS

Credits: 3:0:0

Course Objectives

- To gain knowledge about the influence of electronics in automobile
- To study the operation of various automotive systems
- To analyze the performance of the vehicle with digital control system

Course Outcomes

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

- Analyze various parameters that influence the vehicle performance
- Recognize the importance of digital control system in automobiles
- Understand the operation of sensors and actuators
- Develop systems for starting engine and battery charging
- Formulate control strategies with automotive systems for reducing exhaust emission
- Relate the various control strategies for performance improvement

Unit I - BASICS OF ELECTRONIC ENGINE CONTROL: Introduction to SI and CI engines – Motivation for Electronic Engine Control - Exhaust Emissions - Fuel Economy - Concept of an Electronic Engine Control System - Definition of Engine Performance Terms - Exhaust Catalytic Converters - Electronic Fuel-Control System - Analysis of Intake Manifold Pressure - Idle Speed Control - Electronic Ignition.

Unit II - AUTOMOTIVE CONTROL SYSTEM SENSORS AND ACTUATORS: Introduction, Basic sensor arrangement -Variables to be measured - Airflow Rate Sensor, Pressure Measurements, Engine Crankshaft Angular Position Sensor - Throttle Angle Sensor, Temperature Sensors, Typical Coolant Sensor, Sensors for Feedback Control, Knock Sensors, Automotive Engine Control Actuators, Electric Motor Actuators, Throttle Actuator, Solenoids, Stepper Motor-based Actuator Electronics, Vacuum-Operated Actuator

Unit III - STARTING / CRANKING AND ELECTRIC SYSTEMS: Requirement of starting system, Basic component of starting system, Starter motors and Circuits, Starter motor types, Starting and motor characteristics, diagnosing starting system faults, Advanced starting system technology, charging system, Insulated & earth return systems. Positive & negative earth systems, Development of spark in SI engines.

Unit IV - ELECTRONIC FUEL INJECTION, IGNITION SYSTEMS AND DIGITAL ENGINE CONTROL SYSTEM: Introduction, Feedback carburetor systems (FBC), Fuel injection systems, Electric fuel pump, Throttle body injection and multi-port or point fuel injection, Electronic Ignition, Advantages, Types of solid state ignition systems and their principle of operation, Electronic spark timing control. Digital Engine Control Features, Control Modes for Fuel Control, Discrete Time Idle Speed Control, Electronic Ignition Control, Integrated Engine Control System, Engine Crank (Start), Engine Warm-Up, Open-Loop Control, Closed-Loop Control, Hard Acceleration, Deceleration and Idle

Unit V - VEHICLE SAFETY AND MOTION CONTROL SYSTEMS: Active and Passive safety system, Air Bag, Seat Belt, Representative Cruise Control System, Digital Cruise Control, Advanced Cruise Control, Antilock Braking System, Electronic Suspension System, Electronic Steering Control, Four-Wheel Steering, Traction Control System,

Text Books:

1. William B.Ribbens, "Understanding Automotive Electronics", Butterworth, Heinemann Woburn, 7th Edition, 2012.
2. Robert Bosch "Bosch Automotive Electrics and Automotive Electronics", SpringerVieweg, 5th Edition, 2013.

Reference Books:

1. Tom Denton, "Automobile Electrical and Electronic Systems" Elsevier, 3rd Edition, 2003.
2. James D. Halderman, James Linder, "Automotive Fuel and Emissions Control Systems", Prentice Hall PTR, 3rd Edition, 2011
3. Ali G Ulsoy; Huei Peng; Melih CM§akmakci, "Automotive Control Systems", Cambridge University Press, 2012

17EE2021 SWITCHED MODE POWER SUPPLIES

Credits 3:0:0
Pre-requisite: 17EE2006 Power Electronics

Course Objectives:

- To understand the basics of Switched Mode Power Supplies.
- To study the control behind the switching mode power supplies.
- To know the various hardware modules available.

Course Outcomes:

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

- Exhibit the need of Switched Mode Power Supplies and list the various converters.
- Explain the working of each switched mode power converter circuits.
- Select components, power semiconductor devices and controller IC in a converter.
- Analyze the performance of each switched power converter circuits.
- Design a suitable magnetic circuit for the switched mode power converter.
- Construct a suitable switched mode power converter circuit for a low power application.

Unit I - DC – DC CONVERTERS: Linear power supplies - overview of switching power supplies - step down converters - continuous conduction mode - boundary between continuous and discontinuous conduction - discontinuous conduction mode - output voltage ripple - step up converter - continuous conduction mode - boundary between continuous and discontinuous conduction - discontinuous conduction mode

Unit II - SWITCHED DC POWER SUPPLIES: Flyback converter - Forward converter – Push-Pull converter - Half bridge converters - Full bridge converters - Voltage mode control of SMPS - loop gain and stability considerations - shaping the error amp frequency response - error amp transfer function - transconductance error amps - Current mode control of SMPS - current mode control advantages - current mode Vs voltage mode - current mode deficiencies - slope compensation - PWM Control ICs (SG 3525, TL 494, UC3842)

Unit III - RESONANT CONVERTER: Introduction to resonant converters - classification of resonant converters - basic resonant circuit concepts - load resonant converter - resonant switch converter - zero voltage switching clamped voltage topologies - resonant DC link inverters with zero voltage switching - high frequency link integral half cycle converter

Unit IV - MAGNETICS AND CIRCUIT DESIGN: Transformer core material – geometric design – temperature rise – copper loss – Chokes design – choke material – MOSFET and IGBT – gate drive requirement – magnetic-amplifier post regulator – Analysis of Turn On and Turn Off switching losses – Snubber circuits

Unit V - APPLICATION OF SWITCHED MODE POWER SUPPLIES: Electronic Ballast: Electronic Ballast circuits – DC/AC inverter topology – Voltage fed Push Pull topology - Low Input Voltage regulators for Laptop and portable electronics: Boost and Buck regulators (Linear Technology) - Maxim IC regulators – Solar Power Charger – Micro Solar Inverter

Text Books:

1. Abraham I Pressman, Keith Billing, Taylor Morrey, "Switching Power Supply Design", 3rd Edition, Mc-Graw Hill Publishing Company, New York, 2009.
2. H. W. Whittington, B. W. Flynn, D. E. Macpherson, Switched Mode Power Supplies, 2nd Edition, John Wiley & Sons Inc., 1997.

Reference Books:

1. Keith H Billings, "Switch Mode Power Supply Handbook", 2nd sub edition, Mc-Graw Hill Publishing Company, New York, 1989.
2. Sanjaya Maniktala, "Switching power supplies A to Z", Elsevier Incorporation, Oxford, UK, 2006.
3. Daniel M Mitchell, "DC-DC Switching Regulator Analysis", McGraw Hill Publishing Company, 3rd Edition, US, 2011.

17EE2022 ENERGY SYSTEMS

Credits: 3:0:0

Course Objectives

- To impart the basic knowledge on conventional and non–conventional methods of power generation.
- To conserve and audit the electrical energy.
- To study an illumination systems, heating, welding and traction systems.

Course Outcomes

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

- Identify the significance and importance of power generation
- Practice energy conservation and energy audit
- Differentiate the types of power plants, electric lamps, electric braking, heating and welding
- Analyze the cost of electrical energy, illumination requirements, lighting calculations
- Design of resistance heating element
- Summarize the traction systems and its recent trends.

Unit I - REVIEW OF POWER GENERATION METHODS: Conventional Power Generations: Thermal Power plant- site selection- general and different unit's layout in the power plant, Hydro power plant- site selection-classification- layout- Nuclear power plant- nuclear fission- nuclear reactor - types- site selection. Non-conventional Power Generations: Solar power plants- solar photovoltaic (PV) - power generation methods- applications- Solar collector- types- Wind power plant- types.

Unit II - ECONOMICS OF POWER GENERATION METHODS AND ENERGY CONSERVATION METHODS: Load curve- definition of terms and factors- problems related to terms and factors- cost of electrical energy- types of tariffs- problems related to tariffs- Need for electrical energy conservation- methods- energy efficient equipment's- energy auditing- power factor improvements, causes, effects of low power factor, advantages and improvement methods.

Unit III – LIGHTING: Electric lamps –construction and application – control equipment, efficiency and losses – Lighting calculations – determination of MHCP and schemes – polar curves of different types of sources – Rousseau's construction – photometers – lighting schemes – design of lighting schemes – factory & flood lighting.

Unit IV - ELECTRIC HEATING AND WELDING: Electric Heating- modes of heat transfer- essential requirements of good heating elements- materials of heating elements- methods of electric heating- arc heating-induction heating- high frequency dielectric heating. Electric Welding: classification- resistance welding, types, choice of welding time- arc welding, types - Electric welding equipments and accessories.

Unit V - ELECTRIC TRACTION: Requirements of traction system – Systems of traction – Speed time curves – Tractive effort calculations – Power of traction motor – specific energy consumption – Series, parallel control of DC motor, open circuited, shunt and bridge traction – Electric braking- recent trends in electric traction.

Text Books:

1. Wadhwa C L, "Generation Distribution and Utilization of Electrical Energy", New Academic Science; 3rd revised edition 2015.
2. Gupta J.B., "Utilization of Electric Power and Electric Traction", S.K. Kataria & Sons; 2012 edition (2013).

Reference Books:

1. S.Sivanagaraju, M. Balasubba, D. Srilatha Reddy, "Generation and Utilization of Electrical Energy", Pearson Education Series, 1st Edition 2010.
2. Khan B.H., "Non-Conventional Energy Resources", Tata Mc-Graw Hill Publishing Company Ltd, New Delhi, 2010.
3. Open Shaw Taylor E., "Utilization of Electric Energy in SI Units.", Orient Longman Ltd, New Delhi, 11th Reprint, 2007.

17EE2023 POWER SYSTEM STABILITY

Credits 3:0:0
Prerequisite: 17EE2008 Power System Analysis

Course Objectives:

- To impart knowledge about the concept of stability in a Power System.
- To understand the importance of transient and steady state stability under different conditions.
- To learn the different methods of improving the stability.

Course Outcomes:

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

- Model the power system components in stability studies
- Describe the concept of transient, steady state and dynamic stability
- Analyze the stability of the power system under critical condition.
- Plan and establish highly reliable power system network.
- Select suitable circuit Breakers and Protection devices.
- Identify the different methods to improve the stability of a Power system.

Unit I - INTRODUCTION TO STABILITY: Concept of Power system stability - Importance of Stability studies - Steady state and Transient state – The swing equation of machines connected to an infinite bus bar and two machines connected together.
Unit II - STEADY STATE STABILITY: Models used – power flow equations – steady state stability including composite loads – two machine system and Clarke diagram – multi machine system and stability criteria – factors influencing stability limit.
Unit III - TRANSIENT STABILITY: Single and two machine systems – Swing equation – Solution of swing equation by Modified Euler and Runge-kutta method – Equal area criterion and its application – Factor affecting transient stability – Methods of improving stability- Graphical integration – state space representation – phase plane method – stability of multi-machine system
Unit IV - VOLTAGE STABILITY: Classification of voltage stability- modelling requirements- voltage stability analysis - static- dynamic- sensitivity analysis and modal analysis - voltage collapse- prevention of voltage collapse.
Unit V - SMALL SIGNAL STABILITY: Small signal stability of a single machine infinite bus system –effects of excitation system –power system stabilizer –small signal stability of multi machine system.

Text Books:

1. Kundur P., "Power System Stability and Control", Tata McGraw Hill Education Private Limited, New Delhi, 10th reprint 2010
2. Peter W. Sauer & Pai A., "Power system dynamics and stability", stipes publications, 2007.

Reference Books:

1. Nagarath I.J., Kothari D.P. "Modern Power System Analysis", 4th Edition, Tata Mc Graw Hill Publishing Company, New Delhi, 2011.
2. Kothari D. P., I. J. Nagrath, "Modern Power System Analysis", McGraw – Hill Education India Ltd., New Delhi, 4th Edition, 2011.
3. Kimbark E.W., "Power system stability", Wiley Publication, New York, 2017.

17EE2024 POWER SYSTEM OPERATION AND CONTROL

Credits 3:0:0
Pre-requisite: 17EE2008 Power System Analysis

Course Objectives:

- To have an overview of power system operation and control.
- To model power-frequency dynamics and reactive power-voltage interaction
- To learn the economic operation of power system.

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

- Identify and analyze the dynamics of power system
- Suggest the appropriate method of reactive power generation and control
- Analyze the generation-load balance in real time operation and its effect on the frequency
- Solve unit commitment and economic load dispatch problem using computational techniques
- Characterize reliability aspects at all stages of the power system
- Implement the SCADA in a power system network

Unit I - FORECASTING STUDY: An overview of power system operation and control – system load variation – load characteristics – load curves and load-duration curve – load factor – diversity factor – Importance of load forecasting and quadratic and exponential curve fitting techniques of forecasting – plant level and system level controls
Unit II - REAL POWER – FREQUENCY CONTROL: Basics of speed governing mechanism and modeling – speed-load characteristics – load sharing between two synchronous machines in parallel – control area concept – LFC control of a single-area system – static and dynamic analysis of uncontrolled and controlled cases – two-area system–modeling – static analysis of uncontrolled case – tie line with frequency bias control.
Unit III - REACTIVE POWER–VOLTAGE CONTROL: Generation and absorption of reactive power – basics of reactive power control – excitation systems – modeling – static and dynamic analysis – stability compensation – methods of voltage control: tap changing transformer, synchronous condenser, SVC (TCR + TSC) and STATCOM.
Unit IV - UNIT COMMITMENT AND ECONOMIC DISPATCH: Formulation of economic dispatch problem – I/O cost characterization – incremental cost curve – coordination equations without and with loss (No derivation of loss coefficients) – solution by direct method and λ-iteration method – statement of unit commitment problem – priority-list method – forward dynamic programming.
Unit V - COMPUTER CONTROL OF POWER SYSTEMS: Need for computer control of power systems – concept of energy control centre – functions – system monitoring – data acquisition and control – system hardware configuration – SCADA and EMS functions – network topology – state estimation – Contingency Analysis.

Text Books:

1. Olle.I.Elgerd, 'Electric Energy Systems theory – An introduction', Tata McGraw Hill Education Pvt. Ltd., New Delhi, 34th reprint, 2010.
2. Allen. J. Wood and Bruce F. Wollenberg, 'Power Generation, Operation and Control', John Wiley & Sons, 3rd edition, 2013.

Reference Books:

1. Abhijit Chakrabarti, Sunita Halder, 'Power System Analysis Operation and Control', PHI learning Pvt. Ltd., New Delhi, Third Edition, 2010.
2. Nagrath I.J. and Kothari D.P., 'Modern Power System Analysis', Tata McGraw-Hill, 4th Edition, 2011.
3. Kundur P., 'Power System Stability and Control, Tata McGraw Hill Education Pvt. Ltd., New Delhi, 10th reprint, 2010.

17EE2025 HIGH VOLTAGE ENGINEERING

Credits 3:0:0

Course Objectives

- To understand the types of over voltages in power system and protection methods.
- To impart knowledge on Breakdown mechanism in solid, liquid and gaseous dielectrics
- To study the Generation, Measurement and Testing techniques of High voltages.

Course Outcomes

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

- Examines contemporary practices in insulation coordination standards.
- Identify the insulation systems for high-voltage engineering
- Design high-voltage power equipment.
- Explore high-voltage Generation and measuring techniques.
- Handle practical situations encountered in the operation of high-voltage power equipment
- Perform the testing on High Voltage Power Apparatus as per IEC Standards

Unit I - OVER VOLTAGES AND INSULATION COORDINATION: Natural Causes for Over Voltages - Overvoltage due to Switching Surges, System Faults and other abnormal Conditions - Principles of Insulation Coordination on High Voltage and Extra High Voltage Power Systems.

Unit II - CONDUCTION AND BREAKDOWN IN DIELECTRICS: Conduction and Breakdown in Gaseous Dielectrics; Ionization Process, Breakdown in Electro Negative Gases - Conduction and Breakdown in Vacuum - Conduction and Breakdown in Liquid Dielectrics - Conduction and Breakdown in Solid Dielectrics.

Unit III - GENERATION OF HIGH VOLTAGES AND CURRENTS: Generation of high D.C. voltages - Generation of high alternating voltages - Generation of impulse voltages - Generation of impulse currents.

Unit IV - MEASUREMENT OF HIGH VOLTAGES AND CURRENTS: Measurement of high direct current voltages - measurement of high A.C. and impulse voltages - measurement of high d.c., a.c. and impulse currents - cathode ray oscillography for impulse voltage and current measurements - non-destructive testing of materials and electrical apparatus

Unit V - HIGH VOLTAGE TESTING OF ELECTRICAL APPARATUS: Testing of insulators and bushings - testing of isolators and circuit breakers – testing of cables - testing of transformers - testing of surge diverters - testing of power capacitors - design, planning and layout of high voltage laboratories

Text Books:

1. Naidu M.S., Kamaraju V., ‘High Voltage Engineering’, Tata McGraw- Hill, 5th Edition, 2013.
2. Wadhwa C.L., High Voltage Engineering, New Age International (P) Limited, 2nd Edition, New Delhi, 2007

Reference Books:

1. John Kuffel, Peter Kuffel, Ed Kuffel, Waldemar Ziomek, “High Voltage Engineering Fundamentals”, Elseveir, 2016.
2. Farouk A.M. Rizk, Giao N. Trinh, High Voltage Engineering, CRC Press, Taylor and Francis Group 2014
3. Subir Ray, “An Introduction to High Voltage Engineering”, PHI Learning Private Ltd, Delhi. 2nd Edition, 2013.

17EE2026 HVDC AND FACTS

Credits 3:0:0

Course Objectives

- To know the importance of HVDC Transmission and FACTS
- To understand Reactive power control of AC transmission system.
- To gain Knowledge on different kinds of FACTS Controllers.

Course Outcomes

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

- Analyze the Control Characteristics of HVDC Converters.
- Monitor the operation of HVDC Transmission System
- Provide Solutions to Operating Issues in HVDC Transmission
- Design different kinds of FACTS Controllers

- Analyze the features of various FACTS Controllers
- Select appropriate FACTS Device

Unit I - HVDC POWER TRANSMISSION: Introduction – Comparison of AC and DC transmission – Applications of DC Transmission – Description of DC Transmission Systems – Planning for HVDC Transmission, Modern Trends, Operating Problems – VSC HVDC Transmission – UHVDC Transmission.
Unit II - HVDC SYSTEM CONTROL: DC Link Control Principles – Converter Control, System Control, Firing Angle Control, Current and Extinction Angle Control – Starting and Stopping of DC Link – Power Control, Higher Level Control – Control of VSC.
Unit III - FLEXIBLE AC TRANSMISSION: Basics of AC Power Transmission, Control of Power Flow in AC Transmission – Flexible AC Transmission System Controllers – Voltage Source Converter Based Controllers – Application of FACTS Controllers - FACTS Controllers in Distribution Systems
Unit IV - CSC BASED FACTS: Static Var Compensator, Analysis of SVC, Configuration of SVC, Applications of SVC – Basic Concepts of Controlled Series Compensation, Operation of TCSC, Applications of TCSC.
Unit V - VSC BASED FACTS: STATCOM, Advantages, Principle of Operation, Applications – SSSC, Operation of SSSC and the Control of Power Flow, Applications of SSSC – UPFC

Text Books:
1. Padiyar K.R., "HVDC Power Transmission Systems", New Age International Publishers, 3rd Edition, 2015.
2. Padiyar K.R., "Facts Controllers in Power Transmission and Distribution" New Age International Publishers, 2nd Edition, 2016.

Reference Books:
1. Arrillaga J., "High Voltage Direct Current Transmission", IET Power and Energy Series, Vol. 29, London, United Kingdom, 2008.
2. Kamakshaiah S., Kamaraju V., "HVDC Transmission" Tata McGraw Hill Education Private Ltd., 2011.
3. Narain G. Hingorani, Laszlo Gyugyi, "Understanding FACTS: Concepts and Technology of Flexible AC Transmission Systems", John Wiley & Sons, 2000.

17EE2027 RENEWABLE ENERGY – I

Credits 3:0:0

Course Objectives:
- To know the basics of solar technology.
- To understand wind energy technology.
- To identify the technology of grid connected and hybrid system.

Course Outcomes:
At the end of the course, the student will be able to
- Recognize the technology powering solar and wind power plants
- Explain the solar PV technology and model a solar PV cell
- Interpret the importance of solar-thermal energy and energy storage system.
- Identify and Analyze the wind resource area
- Plan and model a small wind energy conversion system
- Evaluate the operation of grid connected and hybrid system.

Unit I - SOLAR PHOTOVOLTAICS AND MODELLING: PV Energy Basics - Electrical Efficiency – Construction of PV Cells – Materials used for PV cells - Models of PV cells – Parameters of PV cells - Output Characteristics of a PV cell -Approximate Determination of the PV Panel Parameters - PV modules and strings – Mismatch losses – Case study
Unit II - SOLAR-THERMAL ENERGY AND STORAGE: Solar radiation and its measurement - Solar energy collectors - Principles of conversion of solar radiation into heat - Flat plat collectors – Energy balance equation and collector efficiency – Concentrating collector – Selective absorber coatings – Solar energy storage systems – Solar Pond – Case study

Unit III - WIND RESOURCE ASSESSMENT & AERODYNAMICS: Power in the wind - Wind characteristics and measurements – Wind data analysis and resource estimation - Wind resource assessment - C_p-λ - Betz limit – Aerodynamics of wind turbine rotor – Airborne wind turbine – Bladeless wind turbine – Case study
Unit IV - WIND ENERGY CONVERSION SYSTEM: Principal wind turbine components – Wind turbine materials – Wind turbine topology - Wind energy conversion – Wind turbine on electrical network – Asynchronous electrical generators – DFIGs – Permanent magnet synchronous generators – Case study
Unit V - STAND ALONE / GRID CONNECTED AND HYBRID SYSTEMS: Inverters for PV – Stand - alone PV system - Stand-alone wind energy conversion systems - Power Electronic Topologies in PV/ Wind Systems - Grid Connected PV/ Wind Energy Conversion Systems – Hybrid Systems – Maximum power tracking in PV/ wind – Case study

Text Books:

1. Rai G. D., "Non-conventional Energy Sources", Fifth Edition, Khanna Publishers, New Delhi, 2013
2. Solanki C S., "Solar Photovoltaics: Fundamentals, Technologies and Applications", PrentiHI Learning Pvt. Ltd., New Delhi, Third Edition, 2015.

Reference Books:

1. Earnest J., "Wind Power Technology", Prentice Hill India Learning Pvt. Ltd., New Delhi, 2nd Edition, 2015.
2. Manwell J. F., J. G. McGowan, A. L. Rogers, "Wind Energy Explained: Theory, Design and Applicaction", John Wiley & Sons, 2nd Edition, 2010.
3. Sumathi S., L. Ashok Kumar, P. Surekha, "Solar PV and Wind Energy Conversion Systems", Springer Nature, 2015.

17EE2028 RENEWABLE ENERGY – II

Credits: 3:0:0

Course Objectives:
- To know the basics of biomass energy.
- To comprehend the working of geothermal, small hydro and oceanic energies.
- To understand the emerging technologies in renewable energy sources

Course Outcomes

At the end of the course, the student will be able to
- Relate the energy conversion mechanism of various alternate energy sources
- Explain the biomass energy conversion technologies
- Interpret the applications of geothermal energy resources
- Identify the different possible sources of energy from the ocean
- Design an energy efficient small hydro power plant
- Describe the emerging technologies for renewable power generation

Unit I - BIOMASS ENERGY: Biomass resources – Biomass conversion technologies – Urban waste to energy conversion – Biomass gasification – Gasifier and its types - Biomass Liquefaction – Biomass to ethanol production – Biogas production from waste biomass – Case study.
Unit II - GEOTHERMAL ENERGY: Origin and distribution of geothermal energy – Types of geothermal resources – Analysis of geothermal resources – Resource assessment – Generating power using geothermal resources – Direct use of geothermal resources - Environmental consideration - Case study.
Unit III - OCEAN ENERGY: Energy from the ocean - Tidal energy – Wave energy – Ocean thermal energy – Marine winds – Marine biomass – Marine currents – Tidal currents – Salinity gradients - Case study.
Unit IV - SMALL HYDRO RESOURCES: Small hydro schemes – Layout of micro-hydro scheme – Water turbines – Turbine classification, characteristics and selection – Generators – Hydrokinetic energy converters - Case study.
Unit V - EMERGING TECHNOLOGIES: Hydrogen and fuel cell technology – Microbial fuel cells - Magneto Hydrodynamic (MHD) power conversion – Thermoelectric power conversion – Thermionic power conversion - Case study.

Text Books:

1. Khan B.H., "Non-Conventional Energy Resources", Tata McGraw-Hill Education Pvt. Ltd, New Delhi, 2nd Edition, 2009.
2. Sawhney G. S., "Non-Conventional Energy Resources", Prentice Hall India Learning Pvt. Ltd., New Delhi, 2012.

Reference Books:

1. Charlier R. H., C. W. Finkl, "Ocean Energy: Tide and Tidal Power", Springer-Verlag Berlin Heidelberg, 2009.
2. Glassley W. E., "Geothermal Energy: Renewable Energy and the Environment", Second Edition, CRC Press, Boca Raton, 2015.
3. Sorenson B., "Hydrogen and Fuel Cells: Emerging Technology and Applications", Second Edition, Elsevier, USA, 2012.

17EE2029 SMART GRID

Credit: 3:0:0

Course Objectives:

- To understand the structure and functional units of a smart grid.
- To learn the communication technologies in smart grid.
- To understand the impacts and the various issues associated with integration of renewable resources to the grid.

Course Outcomes:

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

- Refresh the operation and control of simple power system network
- Classify the communication technologies used in smart grid network.
- Construct the electrical parameter measurement units
- Analyze the role of power electronic devices in the network
- Asses the importance of the information security for smart grid
- Design the prototype model of the smart grid

Unit I - SMART GRID ARCHITECTURAL DESIGNS: Introduction – Comparison of Power grid with Smart grid – power system enhancement – communication and standards - General View of the Smart Grid Market Drivers - Stakeholder Roles and Function - Measures - Representative Architecture - Functions of Smart Grid Components-Wholesale energy market in smart grid-smart vehicles in smart grid.

Unit II - SMART GRID COMMUNICATIONS: Communication and Measurement - Monitoring, Phasor Measurement Unit (PMU), Smart Meters, Wide area monitoring systems (WAMS)- Advanced metering infrastructure- Standard for information exchange.

Unit III - INFORMATION SECUIRTY FOR SMART GRID: Introduction-Encryption and decryption: Symmetric key encryption – public key encryption-Authentication- Digital signature: Secret key signature-public key signature-Message digest-cyber security standards.

Unit IV - DISTRIBUTION MANAGEMENT SYSTEM: SCADA-Customer Information System-Modeling and analysis Tool: Topology analysis-load forecasting-power flow analysis-fault calculation-state estimation-Applications: system monitoring and operation-outage management system-Islanding and smart grid protection and security.

Unit V - RENEWABLE ENERGY AND STORAGE: Renewable Energy Resources-Sustainable Energy Options for the Smart Grid-Penetration and Variability Issues Associated with Sustainable Energy Technology-Demand Response Issues- Storage Technologies-Grid integration issues of renewable energy sources.

Reference Book

1. Janaka Ekanayake, Nick Jenkins, Kithsiri Liyanage, Jianzhong Wu, Akihiko Yokoyama, "Smart Grid: Technology and Applications", John Wiley & sons inc, 2012.

Reference Books:

1. James Momoh, "Smart Grid: Fundamentals of design and analysis",John Wiley & sons Inc, IEEE press 2012.

2. Fereidoon P. Sioshansi, “Smart Grid: Integrating Renewable, Distributed & Efficient Energy”, Academic Press, 2012.
3. Clark W.Gellings, “The smart grid: Enabling energy efficiency and demand response”, Fairmont Press Inc, 2009.

17EE2030 POWER QUALITY

Credits 3:0:0

Course Objectives:

- To educate on production of voltage sags, over voltages and harmonics and methods of control.
- To study the sources and effects of harmonics in power systems
- To impart knowledge on various methods of power quality monitoring.

Course Outcomes:

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

- Comprehend the concept of Power Quality issues for various electrical systems
- Identify different power quality improvement techniques and devices
- Know IEEE PQ standards in distribution side
- Develop and implement the voltage restorer device
- Design of series and shunt Active Filter.
- Monitor the power quality events and analyze the data.

Unit I - INTRODUCTION TO POWER QUALITY: Terms and definitions: Overloading – under voltage – over voltage- Sags and swells – voltage sag – voltage swell – voltage imbalance – voltage fluctuation – power frequency variations -Concepts of transients – short duration variations – long duration variation- - International standards of power quality - Computer Business Equipment Manufacturers Associations (CBEMA) curve.
Unit II - VOLTAGE SAGS AND INTERRUPTIONS: Sources of sags and interruptions – estimating voltage sag performance -Thevenin’s equivalent source – analysis and calculation of various faulted condition -Voltage sags due to induction motor starting - mitigation of voltage sags - Static transfer switches and fast transfer switches.
Unit III – OVERVOLTAGES: Sources of over voltages – Capacitor switching – lightning – ferro resonance - Mitigation of voltage swells – surge arresters – low pass filters – power conditioners - Lightning protection – shielding – line arresters – protection of transformers and cables.
Unit IV - WAVEFORM DISTORTION: Harmonic sources from commercial and industrial loads - locating harmonic sources - Power system response characteristics – Harmonics Vs transients - Effect of harmonics – harmonic distortion – voltage and current distortion – harmonic indices – inter harmonics – resonance - Harmonic distortion evaluation – devices for controlling harmonic distortion – passive and active filters.
Unit V - POWER QUALITY MONITORING: Monitoring and diagnostic techniques for various power quality problems – modelling of power quality (harmonics and voltage sag) problems by mathematical simulation tools – power line disturbance analyzer – quality measurement equipment – harmonic / spectrum analyzer – flicker meters – disturbance analyzer. Applications of expert systems for power quality monitoring.

Text Books:

1. Roger. C. Dugan, Mark. F. McGranagham, Surya Santoso, H.Wayne Beaty, ‘Electrical Power Systems Quality’ McGraw Hill,2016.
2. Bhim Singh, Ambrish Chandra, Kamal Al-Haddad, ‘Power Quality: Problems and Mitigation Techniques’, Wiley, 2014.

Reference Books:

1. Arindam Ghosh, Gerard Ledwich, ‘Power Quality Enhancement Using Custom Power Devices’, Springer Science,2012
2. J. Arrillaga, N.R. Watson, S. Chen, ‘Power System Quality Assessment’, Wiley, 2011.
3. Eswald.F.Fudis, M.A.S.Masoum, “Power Quality in Power System and Electrical Machines,” Elsevier Academic Press, 2013.

17EE2031 TESTING AND INSTALLATION OF POWER SYSTEM APPARATUS

Credits: 3:0:0

Course Objectives

- To perform the different testing of plants and equipments.
- To study the different causes of power quality issues.
- To understand the installation and commissioning of rotating machine and transmission line.

Course Outcomes

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

- Recognize the importance of testing and maintenance of power system apparatus.
- Demonstrate the testing of Power plants and equipments
- Illustrate the testing and installation of electrical machines.
- Analyze the power quality of equipments
- Know standards of commissioning of Machines and transmission line.
- Evaluate electrical safety regulations and rules during maintenance.

Unit I – INTRODUCTION: Safety management during operation and maintenance-Clearance-Electric Shock-Causes of faults-Instrument and tools for trouble shooting.

Unit II - TESTING OF PLANTS AND EQUIPMENTS: Temperature Rise test, insulation and HV test, dielectric absorption, switching impulse test, oscillographic test-Power quality- Power quality specifications- IEEE Recommended Practice for Monitoring Electric Power Quality-Case study.

Unit III - TESTING, INSTALLATION OF ELECTRICAL MACHINES: Testing of Rotating Machine-Installation and commissioning of induction motor and rotating electric machine - Care-commissioning of synchronous generator - protection and automation of synchronous generator - Synchronous motor - D.C. generator and motor with reference to Indian Standard (IS)-Case study.

Unit IV - COMMISSIONING OF TRANSMISSION LINE AND MACHINES: Transmission line-Commissioning of A.C transmission line and HVDC transmission- Substation equipment, Bus bar system, Power transformer, Distribution transformer and special transformer with reference to Indian Standard (IS).

Unit V - ANALYSIS OF ELECTRICAL SAFETY RULES AND REGULATIONS: Analysis of electrical accidents-Safety regulations and safety measures- Prepare trouble shooting chart for various electrical equipment, machines and domestic appliances.

Text Books:

1. Rao, S., “Testing, commissioning, operation and maintenance of electrical equipment”, Khanna Technical Publication, New Delhi, 6th Edition, 2013
2. Tarlok Singh, Installation Commissioning & Maintenance of Electrical Equipment, S. K. Kataria & Sons, 1st Edition,2013

Reference Books:

1. Paul Gill, “Electrical power equipment maintenance and testing”, CRC Press, 2nd Edition ,2013.
2. Wadhwa C.L., “Electrical Power System”, New Age International Publications, 6th Edition 2012.
3. Gupta J.B., “Electrical Installation Estimating & Costing”, S. K. Kataria & Sons, 2009

17EE2032 POWER ELECTRONICS FOR RENEWABLE ENERGY SYSTEMS

Credits: 3:0:0

Course Objectives:

- To understand the application of power electronics in renewable energy systems
- To know the different kinds of power converter topologies
- To control the power converters in a grid-connected distributed power generation system.

Course Outcomes:

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

- Identify the impact of power electronics in renewable energy systems
- Select the appropriate power converter topology
- Demonstrate the application of power electronics in solar PV
- Analyze the performance of power converters in wind technology
- Devise the complete operation of small/medium sized renewable energy system

- Estimate the parameters of power converters for renewable energy systems.

Unit I - IMPACT OF POWER ELECTRONICS: Energy conservation – Renewable Energy Systems – Energy Transmission and Distribution - Bulk Energy Storage – Smart Grid – Electric/Hybrid Electric Vehicles.
Unit II - POWER CONVERTERS FOR RENEWABLE ENERGY: AC-link Universal Power Converters - AC-DC-AC Converters for distributed power generation system – Multilevel converter/ inverter topologies - Multiphase matrix converter topologies
Unit III - POWER ELECTRONICS FOR SOLAR PV: Grid-connected PV system configurations: Centralized, String, Multi-string, AC-module – Control of grid-connected PV systems: MPPT, DC-DC stage converter control, Grid tied converter control – Multilevel Inverter-based PV systems
Unit IV - POWER ELECTRONICS FOR WIND TECHNOLOGY: Power converters for wind turbines – Power semiconductors for wind power converters – Controls and grid requirements for modern wind turbines: Active power control, Reactive power control, Total Harmonic Distortion, Fault ride-through capability – Reliability issues in wind power system
Unit V - UNIVERSAL OPERATION OF SMALL/MEDIUM SIZED RENEWABLE ENERGY SYSTEMS: Distributed power generation systems: Single-stage photovoltaic systems, Small/ medium sized wind turbine system, control structure – Control of power converters for grid interactive distributed power generation system: Droop control, Power control in microgrids, Control design parameters, Harmonic compensation.

Text Books:

1. Abu-Rub H., M. Malinowski, K. Al-Haddad, "Power Electronics for Renewable Energy Systems, Transportation and Industrial Applications, John Wiley & Sons Limited, UK, 2014.
2. Chakraborty S., M. G. Simões, W. E. Kramer, "Power Electronics for Renewable and Distributed Energy Systems: A Sourcebook of Topologies, Control and Integration", Springer – Verlag, London, 2013.

Reference Books:

1. Luo F. L., Y. Hong, "Renewable Energy Systems: Advanced Conversion Technologies and Applications", CRC Press, New York, 2013.
2. Zhong Q., T. Hornik, "Control of Power Inverters in Renewable Energy and Smart Grid Integration", John Wiley & Sons, Ltd, United Kingdom, 2013
3. Fuchs E. F., M. A.S. Masoum, "Power Conversion of Renewable Energy Systems", Springer Science & Business Media, LLC, London, 2011.

17EE2033 ENERGY STORAGE IN POWER SYSTEMS

Credits: 3:0:0

Course Objectives

- To understand the importance of energy storage
- To know different energy storage options
- To gain the knowledge on the selection of energy storage systems

Course Outcomes

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

- List the regulations of the power system
- Recognize the different storage technologies
- Apply the suitable energy storage technique for different energy sources.
- Differentiate the energy storage options based on operating conditions
- Evaluate the integration of energy storage systems to the grid
- Economically analyze the storage options

Unit I - MODERN POWER SYSTEMS: Electric power system-smart grid architecture model- Microgrids - Energy management system-The regulations of the electricity systems and the markets- Generating systems based on renewable power-Grid code requirements
Unit II - ENERGY STORAGE TECHNOLOGIES: Importance of Energy Storage-Thermal Energy Storage-Mechanical Energy Storage-Electromagnetic Energy Storage-Hydrogen Storage – Pumped Hydro Storage.
Unit III - ENERGY STORAGE FOR MEDIUM-TO-LARGE SCALE APPLICATIONS: Utility load leveling, peak shaving and transients, Choice of Energy Storage Systems- Energy Storage for Wind and Solar PV Systems

Unit IV - INTEGRATION AND MANAGEMENT: Power conversion system for electrical storage- Power System Integration- Demand side management.
Unit V - SENSITIVITY ANALYSIS: Parameters characterizing the storage technology, dependence on electricity price, dependence on capital costs and interest rate, dependence on number of cycles.

Text Books:
1. Patrick T. Moseley, Jürgen Garche, "Electrochemical Energy Storage for Renewable Sources and Grid Balancing", Elsevier, USA, 2014
2. Ter-Gazarian, A., "Energy Storage for Power Systems", Peter Peregrinus Limited, London, 2011.

Reference Books:
1. Marc A. Rosen , "Energy Storage ", Nova Science Publishers, 2012 .
2. Jonathan M. Bowen, "Energy Storage: Issues and Applications", Nova Science Publishers, 2011.
3. Robert A. Huggins, "Energy Storage", Springer, Germany, 2015.

17EE2034 MICROGRIDS

Credits: 3:0:0

Course Objectives
- To study the concept of microgrids and its configuration
- To gain the knowledge on microgrids controllers.
- To understand the benefits of microgrids.

Course Outcomes
At the end of the course the student will be able to
- Choose the configuration for microgrids application.
- Explain the operational methods of microgrids
- Design a prototype model of Micro Grid and implement its feature
- Summarize the various control techniques and communication protocols used in microgrids
- Perform assessment on the different benefits of microgrids
- Distinguish on the technical difference between smart grids and microgrids

Unit I - BASICS OF A MICROGRID: Concept and definition of microgrid, microgrid drivers and benefits, review of sources of microgrids, typical structure and configuration of a microgrid, AC and DC microgrids, Power Electronics interfaces in DC and AC microgrids.
Unit II - CONTROL AND OPERATION OF MICROGRID: Modes of operation and control of microgrid: grid connected and islanded mode, Active and reactive power control-Power Electronic Interfaces (AC to DC and DC to AC)-Power Architecture.
Unit III - IMPACT OF GRID INTEGRATION: Requirements for grid interconnection, limits on operational parameters: voltage, frequency, THD, response to grid abnormal operating conditions, islanding issues. Impact of grid integration with NCE sources on existing power system: reliability, stability and power quality issues.
Unit IV - POWER QUALITY ISSUES IN MICROGRIDS: Power quality issues in microgrids- Modelling and Stability analysis of Microgrid, regulatory standards, Microgrid economics, Introduction to smart microgrids, Microgrids case study.
Unit V - MICROGRID PROTECTION AND COMMUNICATION: Microgrid Communication used for frequency and voltage in Home area network and Neighborhood area network. -Protection- Power Saving. Used in System reliability, Power theft detection. Micro Energy Management System -Used in Residential and Distribution system.

Text Books:
1. Nikos Hatziargyriou, "Microgrids: Architectures and Control", Wiley-IEEE Press, USA, Press, 2013.
2. Shin'ya Obara, "Optimum Design of Renewable Energy Systems: Microgrid and Nature Grid Methods", Engineering Science Reference Series, USA, 2014

Reference Books:
1. Carlos Moreira., "Microgrids", LAP Lambert Academic Publishing, 2012.
2. Ritwik Majumder, "Microgrid: Stability Analysis and Control", VDM Publishing, Germany, 2010.
3. Robert Galvin, Kurt Yeager, "Perfect Power", McGraw Hill Incorporation, USA, 2009

17EE2035 POWER SYSTEM OPTMIZATION

Credits 3:0:0

Course Objectives

- To know the importance of power system optimization
- To acquire a comprehensive idea on various aspects of power system optimization problems and their formulations.
- To understand various optimization techniques.

Course Outcomes

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

- Recall the basic concept of power system
- Categorize various power system optimization problem
- Apply evolutionary optimization techniques in power system applications.
- Formulate different power system optimization problems
- Compare the different optimization techniques
- Analyze the optimal operation of the power system network

Unit I - FUNDAMENTALS OF OPTIMIZATION: Definition-Classification of optimization problems-Unconstrained and Constrained Optimization-Optimality Conditions-Classical Optimization techniques (Linear and non-linear programming, Quadratic programming, Mixed integer programming)-Intelligent Search methods (Optimization neural network, Evolutionary algorithms, Tabu search, Particle swarm optimization, Application of fuzzy set theory).

Unit II - EVOLUTIONARY COMPUTATION TECHNIQUES: Evolution in nature-Fundamentals of Evolutionary Algorithms-Working Principles of Genetic Algorithm- Evolutionary Strategy and Evolutionary Programming-Genetic Operators-Selection, Crossover and Mutation-Issues in GA implementation- GA based Economic Dispatch solution- GA for unit commitment-GA based Optimal power flow.

Unit III - PARTICLE SWARM OPTIMIZATION: Fundamental principle-Velocity Updating-Advanced Operators-Parameter selection- Hybrid approaches (Hybrid of GA and PSO, Hybrid of EP and PSO) -Binary, discrete and combinatorial PSO-Implementation Issues-Convergence issues- PSO based OPF problem and unit commitment-PSO for reactive power and voltage control-PSO for power system reliability and security.

Unit IV - ADVANCED OPTIMIZATION METHODS: Simulated annealing algorithm-Tabu search algorithm-SA and TS for unit commitment-Ant colony optimization- Bacteria Foraging Optimization-Differential evolution.

Unit V - MULTI OBJECTIVE OPTIMIZATION: Concept of Pareto optimality-Conventional approaches for MOOP-Multi-objective GA-Fitness assignment-Sharing function-Economic Emission dispatch using MOGA-Multi-objective PSO (Dynamic neighborhood PSO, Vector evaluated PSO) –Multi-objective OPF problem.

Text Books:

1. Kothari D.P., Dhillon J.S., “Power System Optimization”, Prentice Hall India learning private limited, 2nd Edition,2010.
2. Kalyanmoy Deb, “Multi objective optimization using Evolutionary Algorithms”, John Wiley and Sons, 2008.

Reference Books:

1. Soliman Abdel Hady,Abdel Aal Hassan Mantawy, “Modern optimization techniques with applications in Electric Power Systems” Springer,2012.
2. Carlos A.Coello Coello, Gary B.Lamont, David A.Van Veldhuizen, “Evolutionary Algorithms for solving Multi Objective Problems”, 2nd Edition, Springer, 2007.
3. Jizhong Zhu, “Optimization of Power System Operation”, IEEE Press Series in Power Engineering, Wiley-IEEE Press, 2nd Edition, 2015.

17EE2036 SUBSTATION DESIGN

Credits: 3:0:0

Course Objectives

- To acquire knowledge of basic substation components
- To understand on the constructional features and design of substations
- To gain basic concepts of substation automation and control

Course Outcomes

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

- Develop Substation Layouts
- Select Switching Configuration
- Design Air Insulated and Gas Insulated Substation
- Interface Communication Techniques
- Monitor and Control the Substation Operation
- Adopt Substation Technology Advances in future.

Unit I - AIR INSULATED SUBSTATION DESIGN: Substation Types - Traditional and Innovative Substation Design, Construction and Commissioning Process – Air-Insulated Substations: Bus/Switching Configurations – High Voltage Switching Equipments.

Unit II - GAS INSULATED SUBSTATION DESIGN: Construction and Service Life – Circuit Breaker, Current Transformers, Voltage Transformers, Disconnect Switches, Ground Switches - Interconnecting Bus, Air Connection, Power Cable Connections, Direct Transformer Connections - Surge Arrester, Control System, Gas Monitor System, Gas Compartments and Zones - Electrical and Physical Arrangement, Grounding, Testing - Installation Operation and Interlocks, Maintenance.

Unit III - SUBSTATION GROUNDING AND SHIELDING DESIGN: Reasons for Substation Grounding System - Accidental Ground Circuit - Design Criteria - Lightning Stroke Protection - Lightning Parameters - Empirical Design Methods - The Electro Geometric Model (EGM).

Unit IV - SUBSTATION COMMUNICATIONS DESIGN: Supervisory Control and Data Acquisition: SCADA Functional Requirements, SCADA Communication Requirements, Relay Communication Requirements - Components of a SCADA System, Structure of a SCADA Communication Protocol, SCADA Communication Protocols: Past, Present and Future - Security for Substation Communications - Electromagnetic Environment.

Unit V - SUBSTATION AUTOMATION SYSTEMS: Physical Challenges – Measurements - State Monitoring and Control Functions - Communication Networks inside the Substation - Testing Automation Systems - Role of Substations in Smart Grids: Transformation of the Grid - Substation Technology Advances - Platform for Smart Feeder Applications - IEC 61850 in Smart Substations, Smart Grid.

Text Books:

1. John D. McDonald, “Electric Power Substations Engineering”, CRC Press, USA, 3rd Edition, 2012.
2. Gupta P.V., Satnam P.S., “Substation Design and Equipment”, Dhanpat Rai Publications Private Limited, New Delhi, 2013.

Reference Books:

1. Dominik Pieniazek P.E., “HV Substation Design: Applications and Considerations”, IEEE CED, USA, 2012.
2. Leon Kempner, “Substation Structure Design Guide”, ASCE Publications, USA, 2008.
3. Praneesh Prasad, “Substation Design”, California State University, Sacramento, 2006.

17EE2037 TESTING AND COMMISSIONING OF ELECTRICAL EQUIPMENT

Credits: 3:0:0

Course Objectives

- To understand the testing procedure of various electrical equipment.
- To get exposure to the commissioning of various electrical equipment.
- To acquire the knowledge on testing standards.

Course Outcomes

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

- Demonstrate testing of electrical machines.
- Commission various electrical equipment.
- Gain knowledge on testing standards.
- Suggest suitable method for earth resistance measurement.
- Analyze various testing procedures for switch gear equipments.
- Understand the importance of testing before and after the commissioning of electrical equipments.

Unit I - SITE MANAGEMENT AND STANDARD RULES: Overview of Site Management - site activities - Various testing standards- Study of testing standard -ISO 9000, BVQI, BIS and EMC etc. on electrical equipment, checks on control and protection circuits, Field quality management systems interpretation of data sheets of equipment.
Unit II - VARIOUS TESTS OF PLANTS AND EQUIPMENTS: Stages of testing their scope and purpose, Tests-Development test, Type test, Routine test, Commissioning test, Maintenance test, Insulation tests and High Voltage test, Application and procedure of continuity test.
Unit III - TESTING OF ELECTRICAL MACHINES: Testing of Transformers, DC machines, Induction machines, Synchronous machines and other Electric apparatus- Type tests and routine tests, commissioning, maintenance and testing of alternators. DC Resistance Measurements.
Unit IV - TESTING ELECTRICAL EQUIPMENTS: Testing of Circuit Breakers, Metal Clad Switchgear, Testing of Contactors, Testing of Insulators and Bushings, Testing of Cables, Testing of Surge arrestors, Testing of Isolators, Testing of current transformers.
Unit V - APPLICATION OF TESTING METHODS: Testing of residential wiring, Testing and measurement of earth resistance, Testing and commissioning of industrial machinery, Maintenance of DG sets-Maintenance schedule, Engine storage, Maintenance Checks-Daily, Weekly, Seasonal, Maintenance of CVT/PT, Maintenance of Battery bank and Battery charger for UPS.

Text Books:

1. Rao S, “Testing, Commissioning, Operation and Maintenance of Electrical Equipment”, Khanna Publishers, New Delhi, 2014.
2. Singh R.P., “Electrical Workshop: Safety, Commissioning, Maintenance & Testing of Electrical Equipment”, I.K. International Publishing House Private Limited, New Delhi, 2012.

Reference Books:

1. Hemant Joshi, “Residential, Commercial and Industrial Electrical Systems: Protection, testing and commissioning”, Tata McGraw-Hill Education, New Delhi,2008
2. M S Naidu and V Kamaraju, “High Voltage Engineering”, McGraw Hill Companies, 4th Edition, 2012.
3. Paul Gill, “Electrical Power Equipment Maintenance and Testing”, CRC Press, USA, 2nd Edition, 2008.

17EE2038 ELECTRICAL ESTIMATION AND COSTING

Credits: 3:0:0

Course Objectives

- To understand electrical engineering drawing, IE rules, NEC, different types of electrical installation and their design considerations
- To explain the methods and procedure of estimating the material required; develop the skill of preparing schedule of material; detailed estimates; costing of different types of Installation
- To know the preparation of the tender documents, procedure for tendering, evaluation and billing of executed work of different types of electrical Installation Project.

Course Outcomes

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

- Define different types of Electrical Installation and interpret the Electrical Engineering Drawing
- State IE rules, NEC related to Electrical Installation and testing.
- Describe the basic terms, general rules, circuit design procedure, wiring design and design considerations of Electrical Installations.
- Make out the tender document and its related procedures.
- Inspect and test an electrical installation in residential and commercial buildings.
- Design and select suitable size of conductor and type of wiring and do the Estimation and costing.

Unit I - GENERAL PRINCIPLES OF ESTIMATION: Introduction to estimating and costing, Electrical Schedule, Catalogues, Market survey and source selection, Recording of estimates, Determination of required quantity of material, Labour conditions, Determination of cost of material and labor, Contingencies, Overhead charges, Profit, Purchase orders, payment of bills, Tender form, General idea about IE rule, Indian Electricity Act and major applicable I.E.rules.

Unit II - RESIDENTIAL BUILDING ELECTRIFICATION: Principles of circuit design in lighting and power circuits, procedures for designing the circuits and deciding the number of circuits, Wiring diagrams, load calculations and selection of size of conductor, Selection of rating of main switch, distribution board, Earthing of residential installation, Service connections.
Unit III - ELECTRIFICATION OF COMMERCIAL INSTALLATION: Concept of commercial installation, Design considerations of electrical installation for commercial building, Load calculation and selection of size of service connection and nature of supply, Deciding the size of the cables, bus bar and bus bar chambers, mounting arrangements and positioning of switch boards, distribution boards, main switch etc,, Preparation of detailed estimate and costing of commercial installation.
Unit IV - PROTECTION, INSPECTION AND TESTING OF INSTALLATION: Protective switch gear-ELCB and MCB, Selection of MCB for house hold applications, Inspection of internal wiring installations, inspection of new installations, testing of installations, testing of wiring installations, Reasons for excess recording of energy consumption by energy meter.
Unit V – APPLICATIONS: Wiring and estimation of Smart home and industry, wiring of sensors -PIR, LDR, voice recognition systems, wiring and connection of UPS, connection of DG set, wiring system for CCTV installation, wiring of solar panel, Change over circuit wiring for multiple supply system.

Text Books:

1. Uppal, S.L., Carg, G.C., "Electrical Wiring Estimation and Costing, Oscar Publications", New Delhi, 2011.
2. Raina, K.B., Bhattacharya, S.K., "Electrical Design, Estimating and Costing", New Age International Private Limited, New Delhi, 2005.

Reference Books:

1. Gupta, J.B., "Electrical Installation Estimating & Costing", S. K. Kataria & Sons, New Delhi 2009.
2. Arora, B.D., "Handbook of Electrical Wiring Estimating & Costing", R.B. Publication, New Delhi, 2011.
3. Adam Ding, "Electrical Estimating Professional Reference", Cengage Learning, Kentucky 2008.

17EE2039 ILLUMINATION ENGINEERING

Credits: 3:0:0

Course Objectives
- To know the basic concepts of illumination.
- To learn about different lighting accessories.
- To understand the concept of lighting system maintenance, basic lighting, energy audit and economic analysis of lighting.

Course Outcomes
At the end of the course, the student will be able to
- Perform indoor & outdoor lighting design calculations.
- Determine appropriate lighting control techniques and equipment to a sample project.
- Outline the basic lighting energy audit to a sample project.
- Exhibit an electrical system including cost estimate and energy efficient lighting systems in residential, commercial and industrial establishments.
- List the current guidelines in the design, construction, and management of safe and energy-efficient road lighting.
- Illustrate the concept of lighting system maintenance, basic lighting energy audit and economic analysis of lighting.

Unit I - LANGUAGE OF LIGHT & LIGHTING: Eye & vision – Light & Lighting – Light & Vision –, Light & Color – Basic Concepts and Units – Photometry – Measurement and Quality of Lighting.
Unit II - LIGHTING ACCESSORIES: Light sources: Daylight, Incandescent – Electric Discharge – Fluorescent – Arc lamps – Lasers – Neon signs – LED-LCD displays – Luminaries – Wiring.
Unit III - CALCULATION AND MEASUREMENT: Polar curves – Effect of voltage variation on efficiency and life of lamps – Lighting calculations– Illumination from point, line and surface sources – Photometry and Spectrometry-photometry – photocells.
Unit IV - INTERIOR LIGHTING: Lighting design procedure for Industrial – Residential – Office – Departmental stores – Indoor stadium – Theatres – Hospitals-Studio Lighting.

Unit V - EXTERIOR LIGHTING: Environment and glare – Lighting Design procedure for Flood – Street – Aviation and Transport lighting – Lighting for Displays and Signaling.

Text Books:

1. Jack L. Lindsey, "Applied Illumination Engineering", Prentice Hall of India, New Delhi, 3rd Sub Edition, 2008.
2. Leon Gaster, John Stewart Dow, "Modern Illuminants and Illuminating Engineering", Nabu Press, Washington DC, 1st Edition, 2010.

Reference Books:

1. Cady, "Illuminating Engineering", General Books, USA, 2010.
2. Kamlesh Roy, "Illuminating Engineering", Laxmi Publications, 2nd Edition, 2006
3. William Edward Barrows, "Electrical Illuminating Engineering", Bibliolife Publishers, USA, 2010.

17EE2040 BUILDING AUTOMATION

Credits: 3:0:0

Course Objectives

- Understand about the building automation and its management system.
- Study about the security and safety systems in smart building.
- Suggest suitable possibilities to integrate system and its managements for intelligent building.

Course Outcomes

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

- Define the characteristics and the features of building automation system
- Identify the suitable HVAC system and safety system based on the usage of building
- Apply the building automation system and communication facilities in modern intelligent buildings; and apply networking technologies in building automation.
- Compare the different integrated automation systems
- Evaluate the different security systems and its effectiveness based on the sensitivity.
- Construct and design structured building system by enabling integrated system connections.

Unit I - BUILDING AUTOMATION SYSTEM: Introduction – Types of building and requirements, Features, Characteristics and Drawbacks of Building Automation system – Building Management System, HVAC System parameters-monitoring and control.

Unit II - ENERGY MANAGEMENT SYSTEM: Types of wiring, Cable selection, Energy Meters Types-Smart meters – Meter Networking – Monitoring Energy Parameters, Analysis of Power Quality, causes of poor power quality - Power quality improvement, Energy efficient buildings.

Unit III - SAFETY SYSTEM: Introduction to safety – Fire Development Stages-Fire behavior indicators-types of fire and fire extinguishers, automatic safety system, location selection for fire sensors and practical issues.

Unit IV - SECURITY SYSTEM: Various security system-Biometric systems, Voice recognizing system – Introduction to video management - CCTV Camera Basics – Digital Video Recording, Video Management System – case study.

Unit V - INTEGRATED SYSTEM AND APPLICATIONS: Building integrated systems -Application for commercial building, residential building and public buildings- Design, IOT.

Text Books:

1. Shengwei Wang, "Intelligent Buildings and Building Automation", Spons Architecture Price Book, New York, 1st Edition, 2009.
2. Jong-jin Kim, "Intelligent Buildings", Butterworth-Heinemann, Illustrated Edition, London, 2006.

Reference Books

1. Derek Clements - Croome, "Intelligent Buildings: Design Management and Operation", Thomas Telford Ltd., UK, Illustrated Edition, 2004.
2. Reinhold A. Carlson, Robert A. Di Giandomenico, "Understanding Building Automation Systems (Direct Digital Control, Energy Management, Life Safety, Security, Access Control, Lighting, Building Management Programs)", R.S. Means Company Incorporation, 1991.

3. Hermann Merz, Thomas Hansemann, Christof Hübner, “Building Automation: Communication systems with EIB/KNX, LON and BACnet”, Springer, Germany, 2009

17EE2041 FUNDAMENTALS OF ELECTRICAL SAFETY

Credits: 3:0:0

Course Objectives

- To exhibit the knowledge of safety rules and regulations, and demonstrate the awareness of hazards in the workplace.
- To explain the use of personal protective equipment.
- To Understand the various reasons for electrical accidents

Course Outcomes

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

- Demonstrate proper safety procedures.
- Show Proper use of hand and power tools.
- Identify various trades used in the construction industry.
- Suggest Ideas related to occupational safety.
- Identification of risks at dangerous Zones.
- Suggesting methods of proper usage of personal protective devices.

Unit I - INTRODUCTION TO ELECTRICAL SAFETY: Basic Definitions and Nomenclature - Fundamentals of Electrical Safety - Mathematical Principles of Electrical Safety - The Earth - Effects of Electric Currents Passing Through the Human Body and Safety Requirements.

Unit II - STUDY OF ELECTRICAL SAFETY COMPONENTS: Introduction to conductors and insulators - Wire Characteristics – Ampacity - Insulation Type, Wire Size, Cables & Cords – Electrical Standards- Safety against over voltages - Safety against Static Electricity.

Unit III - INDOOR AND OUTDOOR SAFETY PRECAUTIONS: Indoor safety-Check Equipment - Wet/Damp Areas, Metal Objects - Electrical Emergencies. Outdoor safety-Overhead Power Lines, Underground Power Lines, Outdoor Equipment, Antennas/Ladders, Recreational Safety, Job Site Hazards, Electrical Emergencies.

Unit IV - ELECTRICAL HAZARDS: Main Factors in Electrical Accidents-Electrical Shock- Definition- Arc Flash-Arc Flash Burn Injuries -Arc Blast Pressure - Inhalation Injuries- Determining Safe Approach Distance Determining Arc Hazard Category.

Unit V - STANDARD FOR ELECTRICAL SAFETY IN WORK PLACE Occupational safety and health administration standards, Indian Electricity Acts related to Electrical Safety, maintenance requirement for specific equipment and location- regulatory bodies- national electrical safety code.

Text Books:

1. Massimo A. G. Mitolo**,** “Electrical Safety of Low-Voltage Systems”, McGraw-Hill, USA, 2nd Edition, 2009.
2. John Cadick, Mary Capelli-Schellpfeffer, Dennis K. Neitzel, ‘Electrical Safety Hand book, McGraw-Hill, New york, USA, 4th Edition, 2012.

Reference Books:

1. Kenneth G. Mastrullo, Ray A. Jones,”The Electrical Safety Program Book”, Jones and Bartlett Publishers, London, 2nd Edition, 2011.
2. Fordham Cooper, W., “Electrical Safety Engineering” Butterworth and Company, London, 1986.
3. Palmer Hickman, “Electrical Safety-Related Work Practices”, Jones & Bartlett Publishers, London, 2009.

17EE2042 BASICS OF ELECTRIC AND HYBRID VEHICLE

Credits: 3:0:0

Course Objectives:

- To understand the concepts of electric and hybrid vehicle
- To analysis various battery module by performing Power, Energy, and temperature testing
- To gain knowledge about the necessity of alternative and novel energy sources

Course Outcomes:

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

- Comprehend the concept and need of hybridization
- Analyze the propulsion requirement for various application.
- Understand the operation and characteristics of various energy sources for vehicle
- Relate the characteristics of the propulsion system with the load requirement
- Develop a hybrid vehicle with existing renewable system
- Analyze the performance of ancillary systems

Unit I – INTRODUCTION: Electrical Vehicle History- Battery electric vehicles- Hybrid vehicle- Fueled electric vehicles- Solar and wind powered vehicles-Different configuration of hybrid vehicles -Electric vehicles which use flywheels and super capacitors.

Unit II – BATTERIES: Introduction- Battery Parameter-Self-discharge rates-Battery temperature, heating and cooling needs -Battery life- Introduction to Lead Acid Batteries, Nickel-based Batteries, Lithium Batteries. Use of Batteries in Hybrid Vehicles.

Unit III - ALTERNATIVE ENERGY SOURCES AND STORAGE DEVICES: Introduction -Solar Photovoltaic -Wind Power- Flywheels- Super Capacitors-Supply Rails Fuel Cells: Basic Principles-Hydrogen storage methods.

Unit IV - ELECTRIC VEHICLE PROPULSION AND CONTROL: Operation and control techniques of DC motor-Brushless Electric Motors-Switched reluctance motors. General Issues in Design (with respect to torque, speed, regenerative braking)

Unit V - DESIGN OF ANCILLARY SYSTEMS: Introduction- Heating and Cooling Systems -Design of the Controls -Power Steering -Choice of Tires-Wing Mirrors, Aerials and Luggage Racks -Electric Vehicle Recharging and Refueling.

Text Books:

1. Tom Denton, "Electric and Hybrid Vehicles", Routiedge, 1st Edition, 2016.
2. Iqbal Husain, "Electric and Hybrid Vehicles Design Fundamentals", CRC Press, New York, USA. 2nd Edition, 2013.

Reference Books:

1. Ali Emadi, "Handbook of Automotive Power Electronics and Motor Drives", CRC Taylor and Francis, USA. 2010
2. Amir Khajepour, M. Saber Fallah, Avesta Goodarzi, "Electric and Hybrid Vehicles: Technologies, Modeling and Control - A Mechatronic Approach", Wiley, 2014
3. Erjavec, Jack, "Hybrid, Electric and Fuel-Cell Vehicles", Cengage Learning, Inc, 2013

17EE2043 INDUSTRIAL ELECTRONICS

Credits: 3:0:0

Course Objectives

- To learn electronics in applied manner with perspective of industry.
- To understand the design philosophy for mechanical processes control based on analog and digital electronics and electrical machines.
- To know troubleshooting

Course Outcomes

At the end of the course, the students can able to

- Describe the modeling of Programmable Controller for the particular industrial application.
- Select the Proper Power Electronic Devices for the firing and control circuits.
- Develop the proper converter to satisfy the Industry requirements.
- Analyze various parameters in the Closed Loop System to improve the performance of the system
- Propose the system without any fault condition
- Formulate the New technology for the existing system.

Unit I - INDUSTRIAL SOLID STATE DEVICES Thyristors – TRIAC - Programmable UJT - Transistor based Industrial Applications - Industrial Photoelectric Devices- Lasers- Fiber Optics - Bar Code Equipment.

Unit II - INDUSTRIAL POWER SUPPLIES, CONVERTERS AND OPERATIONAL AMPLIFIERS & LOGIC CIRCUITS Industrial Logic Circuits - Solid State Relays – Comparison - Industrial Times - Programmable Controllers: Operation - Numbering system for PLCs. Industrial Rectifier Circuits-Applications for Industrial Power Supplies-Inverters –DC/DC Control - Operational Amplifiers: Overview-Differential and Instrumentation Amplifiers-Applications.
Unit III - INDUSTRIAL CONTROLLERS Overview of feedback System-Understanding Gain, Reset and Rate – Example of an Industrial System –Tuning the Controllers – Advanced Closed Loop System- Data Communications for Industrial Electronics based on IoT -Servo- Applications- ALLEN-BRADLEY PLC5 and SLC500 PID Instruction.
Unit IV - INDUSTRIAL ELECTRIC DRIVES Overview of Input and Output Devices– Installing and Trouble shooting in DC and AC motors– Industrial Wiring Standard - Troubleshooting of Wiring System –Industrial Heating – Case Studies of Industrial Applications.
Unit V - SMART TRANSDUCERS Concept of smart/intelligent transducer – comparison with conventional transducers – self diagnosis and calibration features – measurement of flow, Ph with smart transducers

Text Books:

1. Thomas E. Kissel, "Industrial Electronics", Prentice Hall of India, New Delhi, 3rd Edition, 2003.
2. Bogdan M. Wilamowski and David Irwin. J, "The Industrial Electronics Hand Book – Fundamentals of Industrial Electronics", CRC Press, London, 2nd Edition, 2011.

Reference Books:

1. Dale R. Patrick and Stephen W. Fardo, "Industrial Electronics: Devices and Systems", Fairmont Press, Georgia, 2000.
2. Paul, A. B., "Industrial Electronics and Control", Prentice Hall of India Limited, 2nd Edition, 2009.
3. Skvarenina, Timothy L., "The Power Electronics handbook", CRC press, New York, 2001.

17EE2044 ELECTRONICS IN AGRICULTURAL AUTOMATION

Credits: 3:0:0

Course Objectives

- To get exposed to the automation opportunities available in agriculture.
- To get more knowledge on fundamentals of instrumentation in agriculture.
- To understand the use of computers and communication systems in agriculture automation.

Course Outcomes

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

- Know the agricultural scenario of our country and possible automation systems.
- Identify suitable sensor and transducer for the appropriate sensing requirements.
- Discover the environmental problems and provide solutions to agricultural sector.
- Analyze the necessities of the agricultural field and suggest apt automation process.
- Recommend the suitable communication system for the wireless sensor networks.
- Design an automation system for all agricultural activities like sowing, cultivation, fertilizing, harvesting, monitoring, etc.,

Unit I - AGRICULTURAL AUTOMATION: Basics of Agriculture - World agricultural scenario – Indian agriculture sector – Agriculture equipments - Need and importance of Agricultural automation – Information, Interpretation and Instruction system – Soil and canopy sensing - Agricultural Production system – Nutrition management system – Pesticide application system – Irrigation management system – Worksite management – Post harvest automation.
Unit II - AGRI INSTRUMENTATION: Characteristics of Transducer – Classification – Temperature, pH, conductivity Humidity, Grain & soil moisture transducer – Gas transducers – Intelligent transducers – Salinity tester - Specific ion analyzer - Leaf area and Chlorophyll content measurement – Agro Meteorological instruments – Anemometers, Atmometers, Pyranometers, Pyrheliometers, Sun photometers, Sunshine recorder.
Unit III - PRECISION FARMING: Need of Precision Farming – Subsystem and components – GPS/GIS, Agri sensors, DAQ, Communication systems - Sensing by Electro Magnetic Induction(EMI) – Sensing of Soil properties – Site specific soil cultivation – Site specific Sowing - Site Specific Fertilizing - Site Specific Weed control - Site Specific Recording of Yields.

Unit IV - WIRELESS SENSOR NETWORK FOR AGRICULTURE: Wireless sensor network – Architecture - Components, Anatomy of sensor node – Radio communication – Link management - Time synchronization – Routing protocols – Localization techniques – Designing and deploying WSN for agriculture applications.
Unit V – APPLICATIONS: Microprocessor based system – Grain Moisture Measurement System – Grain Storage System Monitoring – Soil Nutrient Estimation System – Automatic Drip Irrigation System - Computer based Automatic Weather Station - Green House Instrumentation – Crop Preservation - Agricultural Robots.

Text Books:

1. Krishna Kant, "Microprocessor-based Agri-Instrumentation", PHI Learning Pvt. ltd., 2013.
2. Qin Zhang, Francis J. Pierce, "Agricultural Automation: Fundamentals and Practices", CRC Press, 2016.

Reference Books:

1. Anna Forster, "Introduction to Wireless Sensor Networks", John Wiley & Sons, 2016.
2. Michale, A.M., "Principles of Agricultural Engineering – Vol I & II", Jain Brothers, New Delhi, 2016.
3. Hermann J. Heege, "Precision in Crop Farming: Site Specific Concepts and Sensing Methods: Applications and Results", Springer Science & Business Media, 2013.

17EE2045 GREEN ELECTRONICS

Credits: 3:0:0

Course Objectives

- To gain knowledge in the area of Green electronics
- To know the challenges in executing green electronics based projects
- To explore the scope of nanotechnology in green electronics

Course Outcomes

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

- Understand the green electronics and eco-design concepts
- Identify relevant issues on environmental impact of electronics assembly
- Utilize the green materials in new electronic products
- Analyze the nanotechnology opportunities in green electronics
- Assemble lead-free electronic product
- Design reliable range of sustainable green electronic products

Unit I - INTRODUCTION TO GREEN ELECTRONICS AND ENVIRONMENTAL REGULATIONS: Environmental concerns of the modern society – Overview of electronics industry and their relevant regulations. Restriction of Hazardous substances (RoHs) – Waste Electrical and Electronic equipment (WEEE) – Energy using Product(EUP) and Registration Evaluation, Authorization and Restriction of Chemical substances(REACH).
Unit II - GREEN ELECTRONICS MATERIALS AND PRODUCTS: Lead -free solder pastes, conductive adhesives, halogen-free substrates and components – X-Ray Fluorescence (XRF) for identifying hazardous substances in electronic products – Tin whiskers in lead-free electronic assemblies – Nanotechnology opportunities in green electronics.
Unit III - GREEN ELECTRONICS ASSEMBLY AND RECYCLING: Green electronic assembly – Soldering process – Lead-free solder tip and bumps – Fatigue design of lead-free electronics— Card assembly and surface mount technology – Management on e-waste recycle system construction - Product disassemble technology.
Unit IV - FLIP-CHIP ASSEMBLY AND BONDING FOR LEAD-FREE ELECTRONICS: Flip-Chip assembly process — Design and processing of flip-chip bonding structures – Integrating flip chip into a standard SMT lead-free reflow soldering techniques and analytical methods - Opto-electronic integration.
Unit V - CASE STUDIES: Environmental impacts of waste recycling – Manufacturing issues in Lead free product- Reuse and recycle of End-of-Life (EOL) electronic products (Computer Peripherals) - Thermal analysis of flip-chip packaging – RLC for flip-Chip packages –Life cycle assessment of photocopier.

Text Books:

1. Sammy G Shina, "Green Electronics Design and Manufacturing", McGraw-Hill Incorporation, New York, 2008.
2. John X. Wang, "Green Electronics Manufacturing: Creating Environmental Sensible Products", CRC Press Indian Prentice Hall, 2012.

Reference Books:

1. Goldberg, Lee H., "Green Electronics/Green Bottom line: Environmentally responsible engineering", Newnes Publications, 2000.
2. Paul Scherz, Simon Monk, "Practical Electronics for Inventors", McGraw-Hill/TAB Electronics, New York, 3rd Edition, 2013.
3. David Findley, "Do-It-Yourself Home Energy Audits: 101 Simple Solutions to Lower Energy Costs, Increase Your Home's Efficiency, and Save the Environment", TAB Electronics, 2010.

17EE2046 FEM ANALYSIS LABORATORY

Credits: 0:0:2

Course Objectives:

- Demonstrate an awareness of the potential areas of applications of FEM tools.
- Demonstrate an ability to formulate, implement and document solutions to solve simple engineering problems using the Finite Element Method.

Course Outcomes

At the end of the course, the student can able to

- Visualize the Electromagnetic theory using the software MAGNET & ANSYS Maxwell
- Observe the Variations in the flux path due to the changes in the input parameter
- Produce the Simulation model of the Electrical Machines using Magnet Software
- Compare the results of various electrical machines
- Select the appropriate Electrical Machine based on its performance, for the industry application.
- Validate the simulation results with the analytical calculation

List of Experiments

1. Introduction to Magnet Software (2D) and ANSYS Maxwell Software.
2. Understanding the Basic Tools in the Software
3. Implementation of Magnetic Circuits
4. Designing C-Core Electromagnet.
5. Calculation of DC motor Design Parameters using Dimensional Equations
6. Flux linkage Analysis of DC motor
7. Calculation of Induction Motor Design Parameters using Dimensional Equations
8. Flux linkage Analysis of Induction Motor
9. Calculation of Stepper Motor Design Parameters using Dimensional Equation
10. Flux linkage Analysis of Stepper Motor
11. Comparison of DC and AC Motor.
12. Student Project using software's.

17EE2047 SMART GRID LABORATORY

Credits 0:0:1

Course Objectives

- To Study about Smart Grid technologies, different smart meters and advanced metering infrastructure.
- To familiarize the data acquisition and storage.
- To familiarize the high-performance computing for Smart Grid applications.

Course Outcomes

At the end of the course, the students can able to

- Refresh the concepts of electric Grid and its present developments
- Differentiate the information exchange of traditional grid and smart grid.
- Implement different Smart Grid communication technologies.
- Develop smart grid prototype model.
- Model the smart meter with limited features.
- Protect and secure the electrical parameters

List of Experiments

1. Introduction to PYTHON programming/Grid Lab/ HOMER

2. Introduction to various operating systems & communications protocols
3. Measuring and integration of electrical parameters
4. Two-way communication with the help of basic communication protocols
5. Dynamic pricing
6. System Data Protection with cyber security
7. Phasor measurements unit –customized prototype model
8. Digital relaying and management applications
9. Smart Meters for
   (a) Revenue Metering
   (b) Demand side Management
10. Renewable energy resources integration

17EE2048 POWER ELECTRONICS APPLICATION TO RENEWABLE ENERGY LABORATORY

Credits 0:0:1

Course Objectives:

- To study the role of power electronics in photovoltaic energy conversion and wind energy conversion systems.

Course Outcomes:

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

- Identify the renewable energy sources for the generation of power.
- Prepare the specifications of power electronic devices used in solar PV /wind energy systems
- Design suitable power converters for solar and wind based systems.
- Test the functioning of power electronic components used in renewable energy system
- Compare the performance of the power electronic devices used in renewable energy system
- Troubleshoot inverters / converters used in Solar PV system and Wind turbines.

Description:

This laboratory demonstrates the students the usage of Power Electronics in Solar and Wind Energy based systems.

List of Experiments:

1. Solar and Wind Resources Assessment.
2. Design and simulation of power converters for Solar PV.
3. Connect solar PV panels in series and parallel to test the performance for different intensities of light
4. Troubleshoot inverters used in solar PV systems (Study)
5. Design and simulation of power converters for wind energy system
6. Test performance of wind turbine for different wind speeds

17EE2049 ELECTRIC DRIVES AND CONTROL LABORATORY

Credits: 0:0:1

Course Objectives:

- To understand the operation and control strategies of electric drives.
- To study the control algorithms used in electric drives.
- To analyze the characteristics of electric drives.

Course Outcomes:

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

- Choose the right drive circuit based on the joint torque-speed characteristics of the load.
- Possess an understanding of feedback control theory.
- Develop control algorithms for electric drives.
- Analyse the control techniques used in DC chopper.
- Interpret the speed control characteristics of induction motor and synchronous motor.
- Assess the performance of solar and battery powered drives.

Description:

The lab will consist of giving the students hands-on experience with electric drives (AC and DC), power converter, and control algorithms for electric drives.

List of Experiments:

1. To study and perform the characteristics of 1-Φ Fully Controlled converter of separately excited Motor.
2. To perform the Closed loop speed control of DC motor using PID controller
3. To obtain Parabolic speed response of second order dc motor system on LabView.
4. To study control of DC motor for Current limit control
5. To study control of DC motor for Closed loop torque control
6. To study control of DC motor for closed loop speed control.
7. To study chopper control of DC Motor for motoring and generating control.
8. To study and perform the characteristics of Inverter based speed control of Induction motor.
9. To study and analyse the characteristics of Inverter based speed control of Synchronous motor
10. To study solar and battery powered drives.

17EE2050 ELECTRICAL MACHINES

Credits: 3:1:0

Course Objectives

- To impart knowledge on Constructional details, principle of operation, performance of Machines.
- Apply the concepts to special machines.
- To introduce the concept of drives and its applications

Course Outcomes

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

- Infer the principle and constructions of DC and AC machines
- Calculate the losses and efficiency of DC and AC machines
- Identify the type of electrical machine for a particular application
- Appraise the usefulness of special machines for control applications
- Design electrical drives for microprocessor based application.
- Design a prototype for real time applications

Unit I - D.C MACHINES: Construction of D.C. Machines - Principle and theory of operation of D.C. generator - EMF equation - Characteristics of D.C. generators - Principle of operation of D.C. motor - Types of D.C. motors and their characteristics - Applications.

Unit II - TRANSFORMERS: Principle - Theory of ideal transformer - EMF equation - Construction details of shell and core type transformers - Open circuit and Short circuit tests - Equivalent circuit - voltage regulation, Losses, Efficiency, All Day efficiency

Unit III - A.C MACHINES: Induction motor - Construction and principle of operation - Classification of induction motor, Torque equation - Condition for maximum torque - Speed control of induction motors

Unit IV - FRACTIONAL HP MACHINES: Double revolving field theory – Capacitor start capacitor run motors – Shaded pole motor – Repulsion type motor – Universal motor – Brushless D.C motor - Servomotor

Unit V - DRIVE AND ITS APPLICATION: Introduction - DC drives and AC drive – microprocessor based control of drives –selection of drives and control schemes for steel rolling mills, paper mills, lifts and cranes.

Reference Book:

1. Nagrath, I.J., and Kothari, D.P., “Electrical Machines”, Tata McGraw – Hill Education, New Delhi, 2004.
2. Murugesh Kumar, K., “DC Machines and Transformers”, Vikas Publishing House Private Limited., New Delhi, 2nd Edition, 2004.

Reference Books:

1. Fitzgerald A.E, Kingsley C., Umans, S. and Umans S.D., “Electric Machinery”, McGraw- Hill, Singapore, 2016.
2. 2. Cotton, H., “Advanced Electrical Technology”, Sir Isaac Pitman and Sons Ltd., London, 2011.
3. Bimbhra.P. S, Electrical Machinery, Khanna Publishers, IL Kosow, “Electrical Machines & Transformers”, Prentice Hall of India. 2nd edition 2011.
4. IL Kosow, “Electrical Machines & Transformers”, Prentice Hall of India. 2nd Edition 2011.

17EE3001 POWER SEMICONDUCTOR DEVICES

Credits: 3:0:0

Course Objectives

- To understand various static and dynamic performances of static switches.
- To familiarize the student on switching and steady state characteristics power electronic devices.
- To analyze the control circuits and switching losses in power devices.

Course Outcomes

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

- Select the switching device suitable for the give power electronic controller.
- Estimate the SOA for the particular device.
- Design switching circuits using power semiconductor devices.
- Interpret terminal characteristics and model the component
- Specify design criteria (power, efficiency, ripple voltage and current, harmonic distortions, power factor).
- Assess the thermal characteristics and design heat sink for the requirement.

Unit I - STATIC SWITCHES AND POWER DIODES Status of Development of power semiconductor Devices - Types of static switches - Controlled and uncontrolled - Ideal and real switches - Static and dynamic performance - Use of heat sinks – Electrical analogy of thermal components – Mounting types. Power Diodes: Types - Electrical rating - Switching and steady state characteristics - switching aid circuits - Series and parallel operation - Schottky diodes – Fast recovery diodes.

Unit II - THYRISTOR FAMILY Physics of device operation - Electrical rating - Switching and steady state characteristics – Gate circuit requirements - Protection - Series and parallel operation - Driver circuit - Types of Thyristors: Asymmetrical Thyristor - Reverse Conducting Thyristor - Light Fired Thyristor - switching losses.

Unit III - SPECIAL TYPES OF THYRISTORS: TRIACs, GTOs and MCTs: Electrical rating - Switching and steady state characteristics - protection - Gate circuit requirements-Turn ON and Turn OFF methods – Series and Parallel operation of GTO Thyristors.

Unit IV - POWER BJT & POWER MOSFETS: Power Transistors: Types - Ratings - Static and switching characteristics - Driver circuit - Switching aid circuit - Power Darlington. Power MOSFETS: Types - Comparison with BJTs - Structure - Principle of operation - Switching losses - Driver circuit - Switching aid circuit.

Unit V - IGBTS & EMERGING DEVICES: IGBT: Structure – working principle - switching characteristics - Gate drive requirements. Emerging Devices: FCT, IGCT and SITs - Power Integrated circuit - New semiconductor materials for devices - Intelligent power modules – GaN based devices.

Reference Books:

1. Rashid. M.H., "Power Electronics – Circuits, Devices and Applications", Pearson Education Inc., 3rd Edition, New Delhi, 2014.
2. Ned Mohan, Undeland and Robbins, "Power Electronics – Converters, Applications and Design,", Wiley India Pvt. Ltd., New Delhi, 2010.
3. Joseph Vithayathil, "Power Electronics – Principles and Applications", Tata McGraw-Hill Edition, New Delhi, 2010.
4. Jayant Baliga B., "Fundamentals of Power Semiconductor Devices", Springer-Verlag Publication, New Delhi, 1st Edition, 2008.
5. Dr. P.S. Bhimbra, "Power Electronics", Khanna Publishers, New Delhi, 2015.

17EE3002 POWER CONVERTER ANALYSIS – I

Credits: 3:0:0

Course Objectives

- To give in depth knowledge of the various power electronics circuits
- To analyze the behavior of the Power Electronic circuits along with the design.
- To understand the control methods of various power converters.

Course Outcomes

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

- Analyze the circuits and select them for the suitable applications.
- Troubleshooting the power electronic circuits
- Design various firing circuits for the converters
- Ability to acquire and apply knowledge of mathematics and converter/machine dynamics in Electrical engineering.
- Ability to model, analyze and understand power electronic systems and equipment using computational software.
- Ability to formulate, design, simulate power supplies for generic load and for machine loads.

Unit I - SINGLE PHASE AC-DC CONVERTER: Half controlled and fully controlled converters with R-L, R-L-E loads and freewheeling diodes – continuous and discontinuous modes of operation - inverter operation – performance parameters- Dual converter – Effect of source impedance – Single Phase Series Converter operation
Unit II - THREE PHASE AC – DC CONVERTER: Semi and fully controlled converter with R, R-L loads and freewheeling diodes – inverter operation– dual converter– performance parameters – effect of source impedance and overlap – 12 pulse converters.
Unit III - DC – DC CONVERTERS: Principles of step-down and step-up converters – Analysis of buck, boost, buck boost and Cuk Regulators – Four quadrant chopper.
Unit IV - AC VOLTAGE CONTROLLERS: Principle of phase control: single phase and three phase controllers – analysis with R and R-L loads – PWM Control – Matrix Converter
Unit V - CYCLOCONVERTERS: Principle of operation – Single phase and three phase cyclo-converters – Load Commutated cyclo-converters

Reference Books:

1. Rashid. M.H., “Power Electronics – Circuits, Devices and Applications”, Pearson Education Inc., 3rd Edition, New Delhi, 2014.
2. Ned Mohan, Undeland and Robbins, “Power Electronics – Converters, Applications and Design”, Wiley India Pvt. Ltd., New Delhi, 2010.
3. Joseph Vithayathil, “Power Electronics – Principles and Applications”, Tata McGraw-Hill Edition, New Delhi, 2010.
4. Muhammad H. Rashid, “Power electronics Hand Book”, 3rd Edition, Butterworth-Heinemann, USA, 2016.
5. Vedam Subrahmanyam, “Power Electronics”, New Age International (P) Limited, New Delhi, Revised 2nd Edition, 2011.
6. Dr. P.S. Bhimbra, “Power Electronics”, Khanna Publishers, New Delhi, 2015.

14EE3003 POWER CONVERTER ANALYSIS – II

Credits: 3:0:0

Course Objectives:
- To give in depth knowledge of the inverters and its configurations
- To Analyze the behavior of the Power Electronic circuits along with their design
- To understand the control methods of various power converters

Course Outcomes:
At the end of the course, the student will be able to
- Describe the behavior of Inverters by finding the performance parameters.
- Differentiate the various technique to control the voltage of the inverter
- Analyze the Inverter in single phase and Three phase
- Explain the difference between the current source and voltage source Inverter
- Choose the proper multilevel Inverter for the particular application
- Develop the inverter using resonant elements

Unit I - SINGLE PHASE INVERTERS: Principle of operation of half and full bridge inverters – Performance parameters – Voltage control of single phase inverters using various PWM techniques – various harmonic elimination techniques-forced commutated Thyristor inverters – Design of UPS.

Unit II - THREE PHASE VOLTAGE SOURCE INVERTERS: 180 degree and 120-degree conduction mode inverters with star and delta connected loads – voltage control of three phase inverters: sinusoidal PWM - space vector modulation techniques.

Unit III - CURRENT SOURCE INVERTERS: Single phase CSI with ideal switches – Capacitor commutated inverters with R Load – Auto sequential commutated inverter (ASCI) – Comparison of current source inverter and voltage source inverters

Unit IV - MULTILEVEL AND BOOST INVERTERS: Multilevel concept – diode clamped – flying capacitor – cascade type multilevel inverters - Comparison of multilevel inverters - application of multilevel inverters - Single phase & three phase Impedance source inverters

Unit V - RESONANT INVERTERS: Series and parallel resonant inverters - voltage control of resonant inverters – Class E resonant inverter – Resonant DC link inverters.

Reference Books:

1. Rashid. M.H., "Power Electronics – Circuits, Devices and Applications", Pearson Education Inc., 3rd Edition, New Delhi, 2014.
2. Ned Mohan, Undeland and Robbins, "Power Electronics – Converters, Applications and Design", Wiley India Pvt. Ltd., New Delhi, 2010.
3. Joseph Vithayathil, "Power Electronics – Principles and Applications", Tata McGraw-Hill Edition, New Delhi, 2010.
4. Muhammad H. Rashid, "Power electronics Hand Book", 3rd Edition, Butterworth-Heinemann, USA, 2016.
5. Vedam Subrahmanyam, "Power Electronics", New Age International (P) Limited, New Delhi, Revised 2nd Edition, 2011.
6. Dr. P.S. Bhimbra, "Power Electronics", Khanna Publishers, New Delhi, 2015.

17EE3004 SOLID STATE DC DRIVES

Credits: 3:0:0

Course Objectives:

- To understand steady state operation and transient dynamics of a motor load system
- To study and analyze the operation of the converter / chopper fed DC drive, both qualitatively and quantitatively.
- To analyze and design the current and speed controllers for a closed loop solid state DC motor drive.

Course Outcomes:

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

- Acquire and apply knowledge of mathematics and converter/machine dynamics in Electrical engineering.
- Formulate, design, and simulate power supplies for generic load and for machine loads.
- Analyze, comprehend, design and simulate direct current motor based adjustable speed drives.
- Design the controllers for direct current motor drives as per the specifications
- Understand different quadrant operation of dc motor drives with converter and chopper
- Design and simulate controller for dc motor drives.

Unit I - DC MOTORS FUNDAMENTALS AND MECHANICAL SYSTEMS: DC motor- Types, induced EMF, speed-torque relations; Speed control – Armature and field speed control; Ward Leonard control – Constant torque and constant horse power operation -Introduction to high speed drives and modern drives. Characteristics of mechanical system – dynamic equations, components of torque, types of load; Requirements of drives characteristics - stability of drives – multi-quadrant operation; Drive elements, types of motor duty and selection of motor rating.

Unit II - CONVERTER CONTROL: Principle of phase control – Fundamental relations; Analysis of series and separately excited DC motor with single-phase and three-phase converters - Waveforms, performance parameters, performance characteristics. Continuous and discontinuous armature current operations; Current ripple and its effect on performance; Operation with freewheeling diode; Implementation of braking schemes; Drive employing dual converter.

Unit III - CHOPPER CONTROL: Introduction to time ratio control and frequency modulation; Class A, B, C, D and E chopper controlled DC motor - Performance analysis, multi-quadrant control - Chopper based implementation of braking schemes - Multi-phase chopper; Related problems.

Unit IV - CLOSED LOOP CONTROL: Modeling of drive elements - Equivalent circuit, transfer function of self, separately excited DC motors; Linear Transfer function model of power converters - Sensing and feeds back elements - Closed loop speed control – current and speed loops, P, PI and PID controllers - Response comparison - Simulation of converter and chopper fed DC drive.
Unit V - DIGITAL CONTROL OF DC DRIVE: Phase Locked Loop and micro-computer control of DC drives - Program flow chart for constant horse power and load disturbed operations; Speed detection and current sensing circuits.

Reference Books:

1. G. K. Dubey, "Fundamentals of Electric Drives", Narosa Publishing House, India, 2nd Edition, 2016.
2. Krishnan. R, "Electric Motor Drives –Modeling, Analysis and Control", Prentice Hall of India Pvt. Ltd., New Delhi, 2015.
3. Gopal. K. Dubey, "Power Semiconductor controlled Drives", Prentice Hall Inc., New Jersey, 1989.
4. Vedam Subramanyam, "Electric Drives – Concepts and Applications", McGraw-Hill Education, New Delhi, 2010.
5. P.C Sen "Thyristor DC Drives", John wiley and sons, New York, 1981.

17EE3005 SOLID STATE AC DRIVES

Credit: 3:0:0

Course Objectives:
- To understand various operating regions of the induction motor drives.
- To study and analyze the operation of VSI & CSI fed induction motor control.
- To get an idea about the concepts of speed control and Field oriented controlled Induction Motor Drives

Course Outcomes:
At the end of the course, the student will be able to
- Select a drive for a particular application based on power rating
- Operate and maintain solid state drives for speed control of machines
- Describe different methods of braking used in any electric drive
- Analyze the working of various advance electrical machines drives
- Design drives for solar powered pump and battery powered electrical vehicles
- Formulate and simulate power supplies for generic load and for machine loads

Unit I - INTRODUCTION TO INDUCTION MOTORS: Steady state performance equations – Rotating magnetic field–torque production, Equivalent Circuit - Variable voltage, constant frequency operation – Variable frequency operation, constant Volt/Hz operation - Drive operating regions, variable stator current operation, different braking methods.
Unit II - VSI AND CSI FED INDUCTION MOTOR CONTROL: AC voltage controller circuit – Six step inverter voltage control - Closed loop variable frequency
PWM inverter with dynamic braking - CSI fed IM variable frequency drives comparison.
Unit III - ROTOR CONTROLLED INDUCTION MOTOR DRIVES: Static rotor resistance control - Injection of voltage in the rotor circuit – Static scherbius drives - power factor considerations – modified Kramer drives.
Unit IV - FIELD ORIENTED CONTROL: Field oriented control of induction machines – Theory – DC drive analogy –Direct and Indirect methods –Flux vector estimation - Direct torque control of Induction Machines – Torque expression with stator and rotor fluxes, DTC control strategy.
Unit V - SYNCHRONOUS MOTOR DRIVES: Wound field cylindrical rotor motor – Equivalent circuits– performance equations of operation from a voltage source–Power factor control and V curves–starting and braking, self control – Load commutated Synchronous motor drives - Brush and Brushless excitation.

Reference Books:

1. Bimal. K. Bose, "Modern Power Electronics and AC Drives", Pearson Education Asia 2015.
2. Vedam Subramanyam, "Electric Drives –Concepts and Applications", McGraw Hill Education, 2010.
3. Gopal. K. Dubey, "Power Semiconductor controlled Drives", Prentice Hall Inc., New Jersey, 1989.

4. Krishnan. R, “Electric Motor Drives –Modeling, Analysis and Control”, Prentice Hall of India Pvt. Ltd., New Delhi, 2015.
5. G. K. Dubey, “Fundamentals of Electric Drives”, Narosa Publishing House, India, 2nd Edition, 2016.

17EE3006 GENERALIZED THEORY OF ELECTRICAL MACHINES

Credits: 3:0:0

Course Objectives

- To impart knowledge on the generalized representation and model of electrical machines.
- To study the steady state and analysis of electrical machines using the model.
- To understand the knowledge on various reference frames.

Course Outcomes

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

- Describe the Generalized Representation of machines and their analysis.
- Analyze the steady state analysis and transient analysis of various machines.
- Designate the performance of Induction and Synchronous machines and their representation.
- Predict the behavior of the machine by applying braking operation.
- Simulate the modeling of AC Machine and DC Machine.
- Incorporate the model technique to the machine for efficient operation.

Unit I - GENERALIZED THEORY: Conventions - The basic two pole machine - Transformer with a movable secondary - Transformer and Speed Voltages in the Armature machine - Analysis of electrical machines.

Unit II - BASICS OF ELECTRICAL MACHINES AND TRANSFORMATIONS: Electrical radians and Synchronous speed - Flux per pole and Induced voltage - Spatial MMF distribution of a winding - Invariance of Power - Three phase transformations – Clarke’s Transformation - Park’s Transformation – d-q transformation applied to line elements - Transformation between abc and Stationary d-q - Transformation between abc and Rotating d-q - Case studies – Simulation of various transformations using MATLAB/SIMULINK.

Unit III - DC MACHINES: Generalized Representation – Generator and Motor operation - Steady state and transient analysis - Operation with displaced brushes - Sudden short circuit - Sudden application of inertia load - Electric braking of DC motors - Case Studies - Simulation on MATLAB/SIMULINK - Methods of braking – Startup and Loading of a shunt dc Generator and Resistance starting of a dc Shunt Motor.

Unit IV - INDUCTION MACHINES: Introduction - Circuit Model of a Three-phase Induction Machine - Machine Model in Arbitrary d-q Reference frame – d-q stationary and Synchronous Reference frames - Steady state model - Transient Model - Linearized Model - Case Studies – Simulation of Induction Machine in the Stationary Reference frame using MATLAB/SIMULINK

Unit V - SYNCHRONOUS MACHINES: Introduction - Mathematical Model - Transformation to the Rotor’s d-q Reference frame - Flux Linkages in terms of Winding Currents - Referring rotor Quantities to the stator - Voltage Equations in the rotor’s qd Reference frame - Electromagnetic Torque - Steady State Operation - Transient Operation - Case Studies - Simulation on MATLAB/SIMULINK – Six Phase Synchronous Machines - Three phase Synchronous Machine.

Reference Books:

1. Bimbhra P.S., “Generalized Theory of Electrical Machines”, Khanna Publishers Limited, New Delhi, 5th Edition, 2011.
2. Fitzgerald. A. E, Charles Kingsley and Stephen D. Umans, “Electric Machinery”, McGraw Hill Education, New Delhi, 2016.
3. Chee-Mun Ong., “Dynamic Simulation of Electric Machinery using Matlab/Simulink”, Prentice Hall PTR, Upper Saddle River, New Jersey, 1998.
4. Bandyopadhyay M. N., “Electrical Machines: Theory and Practice” PHI Learning, New Delhi, 2007.
5. Gupta J B.” Theory & Performance of Electrical Machines”, S. K. Kataria & Sons, New Delhi, 2011.
6. Paul C.Krause, Oleg Wasynczuk, Scott D.Sudhoff., “Analysis of Electric Machinery and Drive Systems”, Wiley India Private Ltd, New Delhi, 2nd Edition, 2010.

17EE3007 SPECIAL MACHINES AND CONTROLLERS

Credits: 3:0:0

Course Objectives

- To impart knowledge on the construction, principle of operation and the control techniques of stepper motor and Switched Reluctance Motors.
- To study the characteristics of permanent magnet brushless DC motor.
- To understand the control methods, applications of PMSM and linear motors.

Course Outcomes

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

- Select an energy efficient linear or rotary motor based on the characteristics of the load & application.
- Incorporate the correct control technique to the machine for efficient operation.
- Analyze the behavior of the machine for the applied control technique.
- Improve the performance of the motor by enhancing the motor suitably.
- Explain the theory of travelling magnetic field and applications of linear motors.
- Understand the significance of electrical motors for traction drives.

Unit I - STEPPER MOTOR: Different Types – Construction – Theory of Operation – monofilar and bifilar windings – Modes of excitations Modes of excitations – Single and multi-stack configurations – Torque equations – Characteristics – Microprocessor control of stepping motors – Applications.

Unit II - SYNCHRONOUS RELUCTANCE MOTOR: Constructional features – Types – Axial and radial air gap motors – Operating principle – Reluctance – Phasor diagram – Characteristics – Vernier motor – Applications.

Unit III - SWITCHED RELUCTANCE MOTORS: Constructional features – Principle of operation – Torque prediction – Power controllers, Non-linear analysis, Microprocessor based control – speed – torque Characteristics – Computer control – Applications.

Unit IV - PERMANENT MAGNET BRUSHLESS DC MOTOR: Permanent Magnet materials – Magnetic Characteristics – Permeance coefficient -Principle of operation – Types – Magnetic circuit analysis – EMF and torque equations –Commutation - Power controllers – Motor characteristics and control – Applications.

Unit V - PERMANENT MAGNET SYNCHRONOUS MOTOR AND LINEAR MOTORS: Principle of operation – Ideal PMSM – EMF and Torque equations – Armature reaction MMF – Synchronous Reactance – Sinewave motor with practical windings – Phasor diagram – Torque/speed characteristics – Power controllers – Linear Induction Motor (LIM) classification – Linear Induction Motor (LIM) Construction – Principle of Operation – Concept of Current sheet – Goodness factor – DC Linear Motor (DCLM) types –Circuit equation – Applications.

Reference Books:

1. Venkataratnam. K., “Special Electric Machines”, CRC Press, Boca Raton, U.S.A., 2008.
2. Krishnan .R, “Switched Reluctance Motor Drives”, CRC Press, Boca Raton, U.S.A., 2001.
3. Kenjo, T, “Stepping Motors and Their Microprocessor Control”, Clarendon Press, Oxford, 1989.
4. Naser.A, Boldea.I, “Linear Electric Motors: Theory, Design and Practical Application”, Prentice Hall Inc., New Jersey, 1987.
5. Kenjo.T, Naganori. S “Permanent Magnet and Brushless DC Motors”, Clarendon Press, Oxford, 1989.
6. Miller, T.J.E. “Brushless Permanent Magnet and Reluctance Motor Drives”, Clarendon Press, Oxford, 1989.

17EE3008 DSP BASED CONTROL OF POWER CONVERTERS AND DRIVES

Credits: 3:0:0

Course Objectives:

- To gain knowledge on the basics of motion control Digital Signal Processor.
- To learn about the transformation technique involved for drive application.
- To study about the open loop/closed loop control of drive using a DSP

Course Outcomes:

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

- List the architectural functionalities of the DSP.

- Illustrate the working of Event Manger and its various functions.
- Configure the GPIO, ADC, Timer, compare unit, Capture unit and QEP circuit.
- Perform the mathematical computation with DSP such as Parke's transformation, Clarke's transformation, creation of lookup table etc.
- Implement the Open loop/closed loop control with DSP based Control for a power converter circuit.
- Implement the DSP based Control for the selected drive.

Unit I - TMS320C2812 DIGITAL SIGNAL PROCESSOR: TMS320C2812 architecture overview – Central Processing Unit – CPU Interrupts – Pipelining – Emulation Features - Memory – Code security module – Clocking
Unit II - EVENT MANAGERS OF TMS320C2812 DSP: General Purpose I/O functionality – Interrupts – Event Managers – General Purpose Timers – Compare Units – Capture Units – Quadrature Encoded Pulse Circuitry – Analog to Digital Converters
Unit III - PWM GENERATION & GENERALIZED TRANSFORMATION: PWM signal generation (Asymmetrical & Symmetrical) – Sinusoidal PWM – Space Vector PWM – Clarke's transformation – Parke's transformation – Field Oriented Control of Induction motor
Unit IV - CONTROL OF POWER CONVERTERS: Buck Converter – Boost Converter – Buck-Boost Converter – Multilevel Inverter – Matrix Converter – Flyback Converter
Unit V - CONTROL OF ELECTRIC DRIVES: Stepper Motor Control – Control of Permanent Magnet Synchronous Motor – Switched Reluctance Motor control – BLDC Motor Control.

Reference Books:

1. Texas Instrument "TMS320x281x DSP System Control and Interrupts Reference Guide", SPRU078G, Revised Literature, 2012.
2. Texas Instrument, "TMS320C28X CPU and Instruction Set Reference Guide", SPRU430E, Revised Literature, 2009.
3. Texas Instrument, "TMS320x281x DSP Event Manager Reference Guide", SPRU065E, Revised Literature, 2007.
4. Hamid A. Toliyat, Steven G.Campbell, "DSP based Electromechanical Motion Control", CRC Press, 2004.
5. Bimal K. Bose, "Power Electronics and Variable Frequency Drives – Technology and Applications", IEEE Press, 1997.

17EE3009 POWER ELECTRONICS LABORATORY

Credits: 0:0:1
Co-requisite: 17EE3002 Power Converter Analysis – I
17EE3003 Power Converter Analysis - II
Course Objectives:

- To understand the operating performance of Power Electronic Devices.
- To study the various power electronics circuits, gating methods.
- To learn the principles of operation, simulation and design procedures of AC/DC, DC/AC, AC/AC, DC/AC Converters.

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

- Test and verify the design of Power Converters.
- Evaluate the static and switching characteristics of Power Devices
- Develop control circuits for controlling the power converters.
- Exercise the Data Sheets for the selection of power rating of the device.
- Plan a mathematical model a power converter with suitable devices.
- Design suitable power, control and isolation circuits for an application.

Experiments:
The faculty conducting the laboratory will prepare a list of 10 experiments and get the approval of HoD / UG Program Coordinator and notify it at the beginning of each semester.

1. Performance Comparison of Semi-converter and Full Converter with R and R-L Load
2. Testing and Operation of Three Phase Half-Wave Converter on Resistive and Inductive Load
3. MOSFET Based D.C. Chopper with R and R-L Load
4. Design and Testing of Four Quadrant Chopper with R and R-L Load
5. Testing & Operation of Various Turn – on Techniques: R-C Phase Shift Control, UJT Phase Shift Control, Op-Amp based triggering
6. Testing & Operation of Single Phase Series Inverter with PV Panel
7. Testing & Operation of Single Phase Parallel Inverter on Resistive (R) Load
8. Testing & Operation of Single Phase Mc-Murray Inverter Circuit
9. Testing & Operation of Single Phase Cyclo-Converter on R and R-L Load
10. Testing of Switched Mode Power Supply (SMPS)
11. Design, Testing of Single Phase AC Voltage Controller with R & R – L Load
12. Design of triggering circuits using microcontrollers

17EE3010 ADVANCED ELECTRIC DRIVES AND CONTROL LABORATORY

Credits: 0:0:1

Co-requisite: 17EE3004 Solid State DC Drives
17EE3005 Solid State AC Drives

Course Objectives:
- To understand the operating performance of DC Drives.
- To study the operating performance of AC Drives.
- To learn the working performance of advanced Drives.

Course Outcomes:

At the end of the course, the student will be able to
- Analyze the performance characteristics DC / AC Drives.
- Develop new control algorithms for controlling Drives using power converters for the required applications.
- Derive expressions for forces and torques in electromechanical devices. Understand how power electronic converters and inverters operate.
- Possess an understanding of feedback control theory.
- Develop control algorithms for electric drives which achieve the regulation of torque, speed, or position in the above machines.
- Formulate a Simulink® model which dynamically simulates a electric machine and drive systems and their controllers.

List of Experiments:

The faculty conducting the laboratory will prepare a list of 10 experiments and get the approval of HoD / UG Program Coordinator and notify it at the beginning of each semester.

1. IGBT Based Inverter fed Induction Motor Drive
2. Chopper fed DC Motor Drive
3. Multilevel Inverter fed Induction Motor Drive
4. DSP (TMS320f2812) Based Switched Reluctance Motor Drive
5. Space Vector PWM Control of Induction Motor.
6. Three Phase Rectifier fed DC Motor Drive
7. Three Phase AC Voltage Controller fed Induction Motor Drive
8. Matrix Converter fed Induction Motor Drive
9. DSP (TMS320f2407) Based Permanent Magnet Synchronous Motor Drive
10. Control of DC Motor Using dSPACE ACE 1103 Control Kit
11. DSP (TMS320f2812) BLDC Motor Drive
12. FPGA Based Motor Control
13. Measurement and Recording of Quality of Power Source.

17EE3011 ENERGY ENGINEERING

Credits: 3:0:0

Course Objectives

- To create environment-friendly and energy-efficient buildings
- To deal with actively harnessing renewable natural resources like solar energy and utilizing materials
- that cause the least possible damage to the global commons – water, soil, forests and air.
- To deal with global and Indian energy scenario.

Course Outcomes

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

- Narrate the national and Global energy scenario
- Illustrate the various renewable energy systems and its performance
- Effectively manage the energy requirements
- Work out for the new available sources and its utilization in energy
- Solve the environmental issues regarding the energy sources
- Outline on the evolution of Smart Grids and risks to the Smart Grid

Unit I - INTRODUCTION TO ENERGY: Definition and Units of energy, power, Forms of energy, Conservation of energy, Energy flow diagram to the earth. Conventional and nonconventional energy sources- Origin of fossil fuels, time scale of fossil fuels, Renewable Energy Resources, Role of energy in economic development and social transformation. Commercial and non-commercial forms of energy, energy consumption pattern and its variation as a function of time.

Unit II - NATIONAL AND GLOBAL ENERGY SCENARIO: Energy resources available in India, urban and rural energy consumption, nuclear energy - promise and future, energy as a factor limiting growth, need for use of new and renewable energy sources. Energy consumption in various sectors, projected energy consumption for the future, exponential increase in energy consumption, energy resources, coal, oil, natural gas, nuclear power and hydroelectricity, impact of exponential rise in energy consumption on global economy, future energy options.

Unit III - VARIOUS RENEWABLE ENERGY SYSTEMS: Introduction and overview of solar, wind, bio-mass, geothermal, oceanic energy systems. Hydrogen and Fuel cells – types-scope, stand-alone power generations- Issues related to grid-connections- Global and National Policies, Funding Agencies.

Unit IV - ENVIRONMENTAL IMPACT: Kyoto protocol- Environmental degradation due to energy production and utilization, Primary and secondary pollution, air, thermal and water pollution, depletion of ozone layer, global warming, biological damage due to environmental degradation. Pollution due to thermal power station and their control. Pollution due to nuclear power generation, radioactive waste and its disposal. Effect of hydroelectric power stations on ecology and environment.

Unit V - SMART GRIDS: Electric grid operation - evolution of Smart Grids, electric system design and operation, technical and tariff changes - integration between utilities and Regional Transmission Organizations. Smart Grid components- metering, demand response, virtual power plants, dynamic pricing, grid enhancement funding, demand analysis, promotion of “green” resources, governmental regulation, network standards, network integration, loan guarantees, consumer privacy -Risks to the Smart Grid - protective measures – Wireless Sensor Networks and its applications – Introduction to Deregulation.

Reference Books

1. Vaclav Smil, Energy: A Beginner’s Guide, One world Publications, Oxford, 2006.
2. Stuart Borlase, “Smart Grids: Infrastructure, Technology, and Solutions” Taylor and Francis, Boca Raton,2010
3. Narendra Jadhav, Rajiv Ranjan, Sujan Hajra, “Re-Emerging India - A Global Perceptive”, The ICFAI University Press, Hyderabad, 2005.
4. Eric Jeffs, “Green energy: sustainable electricity supply with low environmental impact” CRC Press,USA, 2010.
5. Kishore V.V.N., “Renewable Energy Engineering And Technology Principles and Practice”, Earthscan,Publications Ltd, UK, 2009.

17EE3012 ENERGY MANAGEMENT AND AUDIT

Credits: 3:0:0

Course Objectives

- To understand various energy management techniques
- To understand energy auditing techniques
- To understand the importance of energy conservation

Course Outcomes

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

- Become efficient energy managers
- Differentiate energy auditing methods and the implementation procedures
- Analyze the energy requirement for domestic and industrial application
- Apply energy conservation act on transportation and agriculture sectors
- Design the economic financial model for an industry
- Create own energy management policies

Unit I - ENERGY MANAGEMENT: Energy management: concepts, energy demand and supply, economic analysis, duties and responsibilities of energy managers. Energy conservation: concepts, energy conservation in – household, transportation, agricultural and industrial sectors, lighting- Energy Conservation act

Unit II - ENERGY AUDIT: Definition – needs–types-approaches; energy costs, bench marking, energy performance, matching energy supply to requirement, fuel and energy substitution, energy audit instruments, duties and responsibilities of energy auditors- Energy policy

Unit III - ENERGY ACTION PLANNING: Key elements, force field analysis, energy policy- purpose, perspective, contents, formulation, ratification; location of energy management, top management support, energy manager-accountability, motivation- information system strategies- marketing and communicating- training and planning - Successful Energy Management in Industries-Case study.

Unit IV - MONITORING AND TARGETING: Defining – elements, data and information analysis; techniques, energy consumption, production, cumulative sum of differences, energy service companies, energy management information Systems-Star Labeling for Electrical appliances. Role of BEE in star labeling.

Unit V - ECONOMIC ANALYSIS AND FINANCIAL MANAGEMENT: Objectives, Investment needs, appraisal and criteria, sources of funds. Simple payback period, Return on investment (ROI), Net Present value (NPV), Internal Rate of Return (IRR), and Annualized cost, Time value of money, Cash flows, Discounting, Inflation Risk and sensitivity analysis, financing options. Pros and cons of the common methods of analysis.

Reference Books

1. Steve Doty, Wayne C. Turner, "Energy Management Handbook" Fairmont Press, Lilburn, 2009.
2. Barney L. Capehart, Wayne C. Turner, William J. Kennedy, "Guide to Energy Management", Fairmont Press, Lilburn, 2008.
3. Clive Beggs, "Energy: Management, Supply and Conservation" Butterworth-Heinemann Publications, Oxford, 2009
4. Albert Thumann, William J. Younger, Terry Niehus, "Handbook of Energy Audits" Fairmont Press, Lilburn, 2010.
5. Moncef Krarti, "Energy Audit of Building Systems: An Engineering Approach" Taylor & Francis, Boca Raton, 2010.

17EE3013 HYDROGEN AND FUEL CELLS

Credits: 3:0:0

Course Objectives:

- To understand hydrogen energy technology
- To understand fuel cell technology
- To enlighten the student community on various technological advancements, benefits and
- prospects of utilizing hydrogen/fuel cell for meeting the future energy requirements.

Course Outcomes:

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

- Know detail on the hydrogen production methodologies, possible applications and various storage options.
- Understand the working of a typical fuel cell and its types
- Elaborate on thermodynamics and kinetics of fuel cells
- Analyze the cost effectiveness and eco-friendliness of Hydrogen and Fuel Cells.
- Apply the knowledge about fuel cells in the field of automobiles and space applications.
- Suggest methods of power generation using fuel cells for domestic and large scale purposes.

Unit I - HYDROGEN – BASICS AND PRODUCTION TECHNIQUES: Hydrogen – physical and chemical properties, salient characteristics – Production of hydrogen – steam reforming – water electrolysis – gasification and woody biomass conversion – biological hydrogen production – photo dissociation – direct thermal or catalytic splitting of water.

Unit II - HYDROGEN STORAGE AND APPLICATIONS: Hydrogen storage options – compressed gas – liquid hydrogen – Hydride – chemical Storage – comparisons – Hydrogen transmission systems – Applications of Hydrogen.

Unit III - FUEL CELLS: History – principle – working – thermodynamics and kinetics of fuel cell process – performance evaluation of fuel cell – comparison on battery vs fuel cell

Unit IV - FUEL CELL – TYPES: Types of fuel cells – AFC, PAFC, SOFC, MCFC, DMFC, PEMFC – relative merits and demerits

Unit V - APPLICATION OF FUEL CELL AND ECONOMICS: Fuel cell usage for domestic power systems – large scale power generation – Automobile, Space. Economic and environmental analysis on usage of Hydrogen and Fuel cell – Future trends in fuel cells.

Reference Books

1. Rebecca L., Busby, “Hydrogen and Fuel Cells: A Comprehensive Guide”, Penn Well Corporation, USA,2005
2. Bent Sorensen, “Hydrogen and Fuel Cells: Emerging Technologies and Applications”, Elsevier Science Technology, United Kingdom, 2005
3. Jeremy Rifkin, “The Hydrogen Economy”, Penguin Group, New York, 2002
4. Viswanathan B., Aulice Scibioh M, “Fuel Cells – Principles and Applications”, Universities Press, India, 2006.
5. Thomas B.Johansson, Henry Kelly, Amulya K.N.Reddy, Robert.H.Williams, “Renewable Energy Sources for Fuels and Electricity”, Island Press, Washington DC, 2009.

17EE3014 PHOTOVOLTAIC SYSTEMS

Credits 3:0:0

Course Objectives:

- To provide necessary knowledge about the modeling, design and analysis of various PV systems
- To show that PV is an economically viable, environmentally sustainable alternative to the world's energy supplies.
- To understand the power conditioning of PV system’s power output.

Course Outcomes

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

- Explain basics of solar photovoltaic systems.
- Identify the feasibility of PV systems as an alternative to the fossil fuels
- Design efficient stand alone and grid connected PV power systems
- Analyze the structure, materials and operation of solar cells, PV modules, and arrays.
- Differentiate the characteristics of the solar cell under local climatic working conditions.
- Apply the concept to design PV systems for various applications.

Unit I - PHOTOVOLTAIC BASICS: Structure and working of Solar Cells-Types, Electrical properties and Behavior of Solar Cells -Cell properties and design- PV Cell Interconnection and Module Fabrication -PV Modules and arrays -Basics of Load Estimation.

Unit II - MANUFACTURING OF PV CELLS & DESIGN OF PV SYSTEMS: Commercial solar cells - Production process of single crystalline silicon cells, multi crystalline silicon cells, amorphous silicon, cadmium telluride, copper indium gallium diselenide cells. Design of solar PV systems and cost estimation. Case study of design of solar PV lantern, standalone PV system - Home lighting and other appliances, solar water pumping systems.
Unit III - CLASSIFICATION OF PV SYSTEMS AND COMPONENTS: Classification - Central Power Station System, Distributed PV System, Standalone PV system, Grid Interactive PV System, small system for consumer applications, Hybrid solar PV system, Concentrator solar photovoltaic. System components - PV arrays, inverters, batteries, charge controls, net power meters. PV array installation, operation, costs, reliability.
Unit IV - INVERTERS FOR PV SYSTEMS: Inverter control topologies for stand-alone and grid-connected operation-Analysis of inverter at fundamental frequency and at switching frequency-Feasible operating region of inverter at different power factors for grid connected systems and stand-alone PV systems. Consumer applications-residential systems-PV water pumping-PV powered lighting-rural electrification.
Unit V - PV SYSTEM APPLICATIONS: Building-integrated photovoltaic units, grid -interacting central power stations, stand- alone devices for distributed power supply in remote and rural areas, solar cars, aircraft, space solar power satellites. Socio-economic and environmental merits of photovoltaic systems.

Reference Books

1. C.S. Solanki: Solar Photovotaics–Fundamentals, Technologies and Applications, PHI LearningPvt. Ltd., 2011.
2. John R. Balfour, Michael L. Shaw, Sharlave Jarosek "Introduction to Photovoltaics", Jones & Bartlett Publishers, Burlington, 2011.
3. Chetan Singh Solanki., Solar Photovoltaic: "Fundamentals, Technologies and Application", PHI Learning Pvt., Ltd., 2009.
4. Partain .L.D, Fraas L.M., " Solar Cells and Their Applications", 2nd ed., Wiley, 2010.
5. Sukhatme .S.P, Nayak .J.K, " Solar Energy", Tata McGraw Hill Education Private Limited, New Delhi, 2010.

17EE3015 POWER ELECTRONIC CIRCUITS

Credits: 3:0:0

Course Objectives:
- To impart the knowledge of various conversion techniques of electrical energy using power electronic components.
- To establish the link between efficient usage of power and conservation of energy resources of the world.
- To provide the design details of various power electronic converters.

Course Outcomes:
At the end of the course, the students will be able to
- Identify the power semiconductor switches and its Characteristics
- Understand the significance of the characteristics of various power semiconductor switches
- Design of power electronic conversion systems
- Analyze various modulation (control) techniques
- Describe the various harmonic Reduction Methods
- Evaluate the performance of various Converters

Unit I - POWER SEMICONDUCTOR SWITCHES: Classification of power converters-Ideal switch and rectifier-Semiconductor power switching devices used in power electronic circuits: Diode, bipolar junction transistor (BJT), silicon controlled rectifier (thyristor), Gate turn-off thyristor (GTO), MOSFET, insulated gate bipolar transistor (IGBT), integrated gate commutated thyristor (IGCT)- I-V characteristics, operation principles, maximum voltage and current ratings. Gating circuits for controlled semiconductor switches- Series and parallel commutation circuits for turning-off of thyristors.
Unit II - AC TO DC CONVERTERS: Single phase and three phase bridge rectifiers, half controlled and fully controlled converters with RL, RLE loads, Freewheeling diode, Dual Converter. Evaluation of performance

parameter, Input harmonics and output ripple, smoothing inductance, power factor, effect of source impedance, overlap, Design of converter circuits – Snubber circuit design – Control circuit strategies.

Unit III - DC TO DC CONVERTERS: DC Choppers: Step down dc chopper with R, RL and RLE loads – Control strategies – Continuous and discontinuous current operations – Two quadrant and four quadrant DC chopper – Multiphase DC chopper – Switching mode regulators: Buck, Boost, Buck-Boost and CUK regulators – Chopper circuit design – Control circuit strategies.

Unit IV - INVERTERS & RESONANT CONVERTERS: Single phase and Three phase bridge inverters – Evaluation of performance parameters – Voltage control and Waveform improvement Techniques – Current source inverters – Inverter circuit design. Resonant Switch: Introduction – Classification – Resonant Switch – Quasi-Resonant Converters – Multi resonant Converters.

Unit V - AC PHASE CONVERTER: Principle of phase control, single-phase bidirectional controllers with R, L and R-L loads, 3-phase bidirectional Controllers, different Configurations, Analysis with pure R and L loads. Principle of operation – single phase and three phase cyclo-converters – Control circuit strategies.

Reference Books

1. Rashid M.H., “Power Electronics Circuits, Devices and Applications”, Prentice Hall India, New Delhi, 2003.
2. Sen P.C., “Modern Power Electronics”, Tata McGraw Hill, New Delhi, 2004.
3. Ned Mohan, Tore M. Undeland, William P Robbins, “Power Electronics: Converters, Applications, and Design”, John Wiley and Sons Inc., New York, 2003.
4. Joseph Vithayathil, “Power Electronics”, New Age International (P) Limited, New Delhi, 2010.
5. Singh M.D., Khanchandani K B, “Power Electronics”, Tata McGraw Hill, 2nd Edition, New Delhi, 2006.

17EE3016 WIND ENERGY

Credits: 3:0:0

Course Objectives:

- To gain detailed understanding of the issues associated with the development of wind energy for electrical energy supply
- To study the aerodynamic design of wind turbines
- To understand the issues of location and grid connection of wind energy power plants

Course Outcomes:

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

- Outline the various wind turbine topologies and conversion technologies
- Estimate the cost involved and other economic aspects of wind energy system
- Assess the wind resource in a given geographical location
- Select the appropriate blade design parameters
- Categorize the different kinds of generators used in wind energy system
- Explain grid interconnection strategy and hybridization of wind energy system

Unit I - WIND ENERGY SYSTEM AND ECONOMICS: Introduction – Power contained in the wind – Principal wind turbine components – Wind turbine materials – Machine elements – Wind turbine topologies – Wind turbine power curve - Economic assessment of wind energy systems – Capital costs – Operation and maintenance cost – Value of wind energy – Economic analysis methods

Unit II - WIND CHARACTERISTICS, RESOURCES AND IMPACTS: General characteristics of wind resource – Characteristics of atmospheric boundary layer - Wind data analysis and resource estimation – Wind turbine energy production estimates – Regional wind resource assessment – Wind prediction and forecasting – Wind measurement and instrumentation – Wind turbine siting – Installation and operation issues – Wind farms – Off shore wind energy - Environmental impacts of wind energy systems.

Unit III - AERODYNAMICS OF WIND TURBINES: Introduction – One-dimensional momentum theory and the Betz Limit – Ideal horizontal axis wind turbine with wake rotation – Airfoils and general concepts of aerodynamics – Blade design for modern wind turbines – Momentum theory and blade element theory – Blade shape for ideal rotor without wake rotation – General rotor blade shape performance prediction – Blade shape for optimum rotor with wake rotation – Generalized rotor design procedure – Aerodynamics of vertical axis wind turbines.

Unit IV - ELECTRICAL ASPECTS OF WIND TURBINES: Electrical machines as applied to wind turbines: DFIG, PMSG – Fixed speed and variable speed operation– Stand-alone configurations – Transmission and distribution network interfaces – Power converters for wind technology – Active power control – Reactive power control – Wind farm power quality - Ancillary electrical equipment.

Unit V - WIND TURBINE CONTROL, GRID INTEGRATION AND HYBRID POWER SYSTEMS Overview of wind turbine control system – Grid connected turbine operation – Supervisory control – Dynamic control theory and implementation – Wind turbines and wind farms in electrical grid - Distributed generation – Hybrid power system – Energy storage.

Reference Books

1. Manwell, J.F., McGowan, J.G. and Rogers A.L., "Wind Energy Explained – Theory, design and application", John Wiley & Sons, UK, 2009.
2. Heier, S., "Grid Integration of Wind Energy Conversion Systems", John Wiley & Sons, Chichester, 2nd Edition, 2006.
3. Burton, T., Jenkins N., Sharpe, D. and Bossanyi, E., "Wind Energy Handbook", John Wiley & Sons, Chichester, 2nd Edition, 2011.
4. Ackermann, T., "Wind power in power systems ", John Wiley& Sons, Chichester 2006.
5. Olimpo Anaya-Lara, Nick Jenkins, Janaka Ekanayake, Phill Cartwright, Michael Hughes, "Wind Energy Generation: Modelling and Control, John Wiley& Sons, Chichester 2009

17EE3017 PV SYSTEM DESIGN AND INSTALLATION

Credits: 3:0:0

Course Objectives:

- To impart knowledge on the different configurations of photovoltaic Energy systems.
- To provide knowledge in the PV System design procedures.
- To enhance skills in the sizing, maintenance and troubleshooting of different components used in the PV System.

Course Outcomes:

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

- Define the basic terminologies related to solar PV and Electricity
- Estimate solar resource availability and electrical power requirement
- Prepare the specification for solar PV components by using proper sizing procedure
- Design and install a new solar PV system for the required demand
- Identify and troubleshoot the faults in the solar PV system
- Assess the safety hazards and implement the safety procedures

Unit I - SOLAR PV AND ELECTRICITY FUNDAMENTALS: Development of Photovoltaics-Current and Emerging Opportunities- Advantages and Disadvantages of PV – Environmental, Health and Safety Issues, PV System Components and Types, PV Electric Principles-Terminology- Matching Appliances to the System – Electrical Circuits, Series and Parallel Circuits in Power Sources & Electrical Loads, Series and Parallel Wiring Exercises

Unit II - SOLAR RESOURCE AND ELECTRICAL LOAD ASSESSMENT: Solar Radiation Fundamentals-Photovoltaics and Weather-Gathering Site Data – Solar Site Analysis-Calculating the solar Energy-Site Survey-Energy Efficiency – Electrical Load Requirements-Refrigeration-Lighting-Load Calculation- Case Study

Unit III - SOLAR PV COMPONENTS DESIGN AND SIZING: PV Principles, Characteristics of Modules-Module Performance-Factors affecting Module Performance- Mounting PV Modules-Battery Types and Operation-Specifications-Battery Safety and Wiring Configuration - Battery Sizing Exercise- Controller Types - Controller Features - Specifying a Controller - Controller Sizing Exercise- Case Study

Unit IV - SOLAR PV INVERTERS: Inverter Operating Principles and Types - Inverter Features –Battery less Grid-Tied Inverters- Grid-tied with Battery Back-up Inverters- Stand-alone inverters- AC Coupled Systems- Stand-alone Inverter Sizing Exercise Four Configurations of Solar Power -Stand-alone - Grid-Tie-Grid-Interactive- Grid-Fallback - Case Study

Unit V - SOLAR PV INSTALLATION AND MAINTENANCE: Planning Regulations and Approvals- Grid Interconnection Requirement- Residential Design- Commercial Design and Utility Design - System Installations- Troubleshooting and Maintenance-Hazards- Safety

Reference Books

1. "Photovoltaics: Design and Installation Manual", Solar Energy International, Canada, 2004.
2. Steven Magee, "Solar photovoltaic Design for residential, commercial and Utility Systems", Createspace Independent Publishing Platform; 1st Edition ,2010
3. Michael Boxwell, "Solar Electricity Handbook: A simple practical guide to solar Energy-Designing and Installing Photovoltaic Solar Electric Systems", Greenstream Publishing, UK, 2012.
4. Geoff Stapleton, Susan Neill, "Grid-connected Solar Electric Systems: The Earthscan Expert Handbook for Planning, Design and Installation", Earthscan, Oxon, 2012.
5. Deutsche Gesellschaft für Sonnenenergie "Planning and Installing Photovoltaic Systems", Earthscan, USA, 2008.

17EE3018 SOLAR TRACKING SYSTEMS CONTROL

Credits: 3:0:0

Course Objectives:

- To understand the concept of control for solar tracking systems
- To implement the control system for solar energy applications
- To use the advanced controllers for solar power plant

Course Outcomes:

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

- Spell the basics of a controller operation.
- Demonstrate the working of basic controller such as Proportional, Integral and Derivative control.
- Use the MATLAB software for simulating the mathematical model of a system.
- Realize the control of a solar tracking system with embedded control.
- Choose suitable control technique and control algorithm for solar tracking system.
- Develop a closed loop control system for solar tracking system.

Unit I - CONTROLLER PRINCIPLES: Basic concepts of process control, discontinuous and continuous mode operation. Introduction to proportional, integral and derivative control. Controller design, characteristics and feedback compensation. Response of controllers.

Unit II - MODEL REPRESENTATION: Introduction to MATLAB, matrix operation, different graphical output, integration and solution to differential equation. Types of error - Convergence and stability. Models of electro-mechanical system – Thermo-fluid systems, solar photo voltaic cell and DC motor. Transient and steady state response of system. Simulation of model using MATLAB.

Unit III - EMBEDDED SYSTEM AND APPLICATION: Introduction to Embedded system - Design cycle and 8051 microcontroller requirement, challenges, trends and issues. Use of emulator and in-circuit emulator. Applications of Embedded system in control system and automation, handheld computer, IVR system and GPS receivers.

Unit IV - CONTROL OF SOLAR TRACKERS: Fixed Tilt Single Axis Tracker - Horizontal Single Axis Tracker - Seasonal Tilt – Tip-Tilt Dual Axis tracker – Azimuth-Altitude Dual Axis tracker – Angle optimizer – Angle controller - Tilt controller – Tilt Motor controller

Unit V - CONTROL ALGORITHM FOR SOLAR TRACKERS: Linear Quadrative Regulator (LQR) control, Repetitive control, Internal Mode control (IMC), Iterative learning control (ILC), Model based predictive control strategies, frequency domain control and robust optimal control. Introduction to fuzzy logic control and LABVIEW

Reference Books

1. Eduardo F. Camacho, Manuel Berenguel, Francisco R. Rubio, Diego Martinez, "Control of Solar Energy Systems", Springer, 2012.
2. Johnson C.D., "Process Control and Instrumentation Technology", 8th Edition, Pearson Education Limited, 2006.

3. Palm W.J., “Introduction to MATLAB for Engineers”, 3rd Edition, Tata McGraw-Hill Book company, New Delhi, 2010.
4. Pulle, Duco. W.J,Darnell, Pete, “ Applied Control of Electric Drives” Springer International Publishing, Switzerland, 1st Edition, 2015.
5. Parimita Mohanty, Tariq Muneer, Mohan Kolhe, “Solar Photovoltaic System Application: A Guide for Off-Grid Electrification” Springer international publishing, Switzerland, 1st Edition, 2015.

17EE3019 SOLAR ENERGY LABORATORY

Credits: 0:0:1
Co-requisite: 17EE3014 Photovoltaic Systems

Course Objectives

- To learn the characteristics of PV array and calculate the charge carrier life time of PV cell.
- To understand the algorithms for efficient and optimal power tracking of PV modules.
- To have practical experience on SAPV and Grid tied PV systems

Course Outcomes

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

- Identify the characteristics of the PV modules and the charge carrier lifetime.
- Locate the faulty modules of the PV array.
- Apply the Maximum power point tracking procedure in solar PV systems.
- Analyze the performance of PV modules at different environmental conditions and inclination angle.
- Setup the standalone PV system and calculate its efficiency.
- Evaluate the performance of grid tied PV system with linear and non-linear load condition.

LIST OF EXPERIMENTS

1. Characteristics of PV Panel
2. Characteristics of PV panel under series and parallel combination
3. Solar energy Measurement
4. Estimating the effect of sun tracking on Energy Generation of solar PV Modules
5. Study of shadow effect on the PV panel
6. Carrier Lifetime Measurements for a Solar Cell
7. Perturb and observe MPPT Algorithm
8. Efficiency measurement of Standalone Solar PV System
9. Observation of current waveforms for linear and nonlinear loads and calculations in a Grid tied solar PV system
10. Solar Cell Simulation Using PC1D Simulator

17EE3020 WIND ENERGY LABORATORY

Credits: 0:0:1
Co-requisite: 17EE3016 Wind Energy

Course Objectives:

- To study the various wind power forecasting techniques.
- To learn the control algorithm for maximum power operation.
- To know the impact of blade geometry in wind energy system.

Course Outcomes:

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

- Assess and predict the wind resources at a given site.
- Simulate the model of a wind power system
- Implement suitable controller to track maximum wind power.
- Experimentally determine the power coefficient of wind turbine energy system
- Analyze the power quality of wind turbine energy system with AC and DC loads
- Evaluate the pressure distribution across an airfoil at different angles of attack

LIST OF EXPERIMENTS:

1. ANN based wind energy forecasting
2. Fuzzy logic based wind energy forecasting

3. Modeling of wind turbine power curve
4. Simulation of variable pitch wind turbine
5. Simulation of PMSG based wind turbine system using PSIM
6. Maximum power tracking in wind energy system
7. Evaluation of power coefficient and tip speed ratio of a wind turbine
8. Power analysis of wind energy system with AC and DC loads
9. Flow visualization over symmetric and cambered airfoils
10. Pressure distribution on a cambered airfoil at different angles of attack.

17 EE3021 POWER ENGINEERING SIMULATION LABORATORY

Credits: 0:0:1

Course Objectives:

- To understand the usage of MATLAB / SIMULINK for simulating Power Electronic Circuits.
- To understand the usage of PSIM / PSPICE for simulating Power Electronic Circuits.
- To understand the usage of PSCAD / EMTDC for simulating Power Electronic Circuits.

Course Outcomes:

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

- Analyze the performance characteristics of Power Devices and Power converters.
- Select and compare appropriate simulation tool for the required applications.
- Develop mathematical model for the system.
- Use the various functional blocks in the simulation packages for the problems specified.
- Design and simulate any power electronic circuits.
- Propose and investigate the performance of the model developed.

LIST OF EXPERIMENTS:

1. Simulation of AC Voltage Controller Using MATLAB
2. Simulation of Single Phase Rectifier Using MATLAB
3. Simulation of AC Voltage Controller Using MATLAB / SIMULINK
4. Simulation of Induction Motor Drive Using MATLAB/SIMULINK
5. Simulation of Multilevel Inverter Using MATLAB/SIMULINK
6. Simulation of Buck-Boost Converter Using PSIM
7. Simulation of ZVS and ZCS Resonant Converters using PSIM
8. Simulation of Three-Phase Pwm Inverter using PSIM
9. Simulate and Compare the output of a Single-Phase Half Wave Rectifier using Thermal Module Devices of PSIM
10. Simulation of Speed Control of DC Motor using SIM-Coupler
11. Fault Analysis of AC Power System using PSCAD / EMTDC
12. Simulation of Class E Resonant Inverter using PSPICE

17EE3022 POWER QUALITY ISSUES AND MITIGATION

Credits 3:0:0

Course Objectives:

- To study the power quality problems in grid connected system and isolated systems.
- To learn the effects of harmonics on various power system components.
- To describe various equipment used for power monitoring.

Course Outcomes:

At the end of the Course, the student would be able to:

- Recognize the cause and source of power system disturbances.
- Calculate harmonic voltages and currents by analyzing types of electrical systems loads and their power quality considerations.
- Suggest suitable mitigation scheme for some of the power quality issues.
- Examine the methods of reducing excessive harmonics using advanced modelling technique.
- Analyze the power quality issues using the Power quality indices.
- Design of series and shunt Active Filter.

Unit I - OVERVIEW & CHARACTERIZATION OF ELECTRIC POWER QUALITY: Power Quality Issues - Power Quality and Electro Magnetic Compatibility (EMC) Standards- CBEMA & ITI Curves- Short Interruptions- Long Interruptions- End user issues.
Unit II - VOLTAGE QUALITY: Voltage Sags—Characterization- Mitigation Methods- Transients and Over Voltage Protection- Utility Capacitor Switching Transients- Utility lightning protection
Unit III - POWER FREQUENCY DISTURBANCES: Waveform Distortion- Harmonic sources from commercial loads and industrial loads- Locating Harmonic sources - harmonics Distortion Evaluation - Principles of controlling Harmonics - Active and passive filters-Types.
Unit IV - POWER QUALITY MONITORING: Monitoring and diagnostic techniques for various power quality problems – power line disturbance analyzer – quality measurement equipment – harmonic / spectrum analyzer – flicker meters – disturbance analyzer -Planning, Conducting and Analyzing power quality survey.
Unit V - CONTROL THEORY FOR POWER QUALITY CONDITIONER: Instantaneous Reactive power theory – Instantaneous symmetrical control theory – SRF theory –DFT theory.

Reference Books:

1. Bhim Singh, Ambrish Chandra, Kamal Al-Haddad, "Power Quality: Problems and Mitigation Techniques", Wiley, 2014.
2. Arindam Ghosh, Gerard Ledwich, "Power Quality Enhancement Using Custom Power Devices", Springer Science, 2012
3. Roger. C. Dugan, Mark. F. McGranagham, Surya Santoso, H.Wayne Beaty, "Electrical Power Systems Quality" McGraw Hill, 2003.
4. J. Arrillaga, N.R. Watson, S. Chen, "Power System Quality Assessment", Wiley, 2011.
5. Eswald.F.Fudis and M.A.S.Masoum, "Power Quality in Power System and Electrical Machines," Elsevier Academic Press, 2013.

17EE3023 SIMULATION OF POWER ELECTRONIC SYSTEMS

Credits: 3:0:0

Course Objectives

- To understand the basics of static and dynamic models of power electronic switches
- To learn the usage of the software tools like MATLAB, PSIM and PSPICE
- To understand the operation of different types of power electronic converters using the above mentioned tools

Course Outcomes

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

- Handle various simulation mechanisms
- Develop mathematical model for the system
- Use the various functional blocks available in the simulation packages for the problems specified
- Design and simulate any power electronic circuits
- Investigate the performance of the model developed
- Compare the performance of the developed model with other simulation tools

Unit I – INTRODUCTION: Need for simulation - Virtual Experimentation – Simulation Mechanics: Circuit Oriented Simulators – Equation Solvers, Exploring Simulation Tools, Overview of MATLAB and SIMULINK , PSIM, and PSpice, Mathematical modeling of power electronic systems: Static and dynamic models of power electronic switches - Static and dynamic equations and state space representation of power electronic systems.
Unit II - MATLAB PROGRAMMING: MATLAB – Introduction –File types, Variables, Scalar, Vectors, Matrices – Operators: Arithmetic – Relational – Logical, operator precedence, Operators and Special Characters, Control Structures, Input / Output Commands – File Handling – 2D Plots – 3 D Plots. Functions and Function files – Differential Equation Solver - MATLAB Programming to analyze Diode rectifiers - controlled rectifiers - AC voltage controllers- PWM generation.
Unit III - MATLAB SIMULINK: SIMULINK: Introduction – Basic Block – Sources and Sinks model analysis using SIMULINK – Simpower systems- Overview of Electrical Sources Library, Elements Library, phasor Elements Library, Power Electronics Library, Machines Library, and Measurements Library- Simulating Induction

Motor Drive, DC Motor - Three Phase Inverter – Boost – Buck Boost - Cyclo Converters- Performing Harmonic Analysis using the FFT Tool.

Unit IV – PSIM: General information – Power circuit components – Control circuit & other components –Analysis specification – Circuit schematic design – Waveform processing – Error and warning Messages- Simulation of PWM inverters- Simulation of BLDC and SRM

Unit V – PSPICE: File formats - Description of circuit elements - Circuit description - Output variables –Dot commands - SPICE models of Diode, Thyristors, TRIAC, BJT, Power MOSFET, IGBT. Simulation of voltage source and current source inverters - Resonant pulse inverters – Zero current switching and zero voltage switching inverters.

Reference Books:

1. Shailendra Jain, "Modelling & Simulation using MATLAB &Simulink", Wiley-India,2013.
2. Agam Kumar Tyagi, "Matlab and Simulink for Engineers", Oxford University Press, 2012.
3. SimPowersystems User Guide, 2011.
4. PSIM User's Guide", Powersim Inc., 2011.
5. Rashid.M.H., "SPICE for Power Electronics and Electric Power", CRC Press, NewDelhi, 3rd Edition, 2013.

17EE3024 SOFT COMPUTING TECHNIQUES

Credits: 3:0:0

Course Objectives

- To develop an in-depth understanding of various soft computing techniques.
- To analyze the mechanisms of different Artificial Intelligent techniques and modern heuristics algorithms.
- To develop skills to apply the soft computing techniques for various practical optimization problems.

Course Outcomes

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

- State the mechanisms of fuzzy logic and ANN used for engineering applications.
- Understand the techniques used in Ant colony optimization algorithms and genetic algorithm.
- Demonstrate the cuckoo search and firefly algorithms
- Analysis of Firefly Algorithm for Global Optimization
- Summarize the optimization technique used in differential evolution.
- Apply the soft computing techniques for practical applications

Unit I - INTRODUCTION TO ARTIFICIAL NEURAL NETWORK (ANN) & FUZZY LOGIC: Review of fundamentals - Biological neuron and Artificial neuron - Activation function - Single Layer Perceptron - Limitations - Multi Layer Perceptron - Back propagation algorithm (BPA) - Fuzzy set theory - Fuzzy sets - Operation on Fuzzy sets - Methods - Fuzzy membership functions.

Unit II - NEURAL NETWORKS FOR MODELLING AND CONTROL: Generation of training data - Optimal architecture - Model validation - Control of non linear system using ANN - Direct and Indirect neuro control schemes - Adaptive neuro controller - Familiarization of Neural Network Control Tool Box.

Unit III - FUZZY LOGIC FOR MODELLING AND CONTROL: Modeling of non linear systems using fuzzy models (Mamdani and Sugeno) - TSK model – Fuzzy Logic controller - Fuzzification - Knowledge base - Decision making logic – Defuzzification -Adaptive fuzzy systems - Familiarization of Fuzzy Logic Tool Box.

Unit IV - ADVANCED HEURISTIC ALGORITHMS: Basic concept of Genetic algorithm - Algorithmic steps - Solution of typical control problems using genetic algorithm – Introduction to search techniques such as Tabu search - Ant colony optimization(ACO) - Particle swarm optimization - Cuckoo search - Firefly algorithm - Differential Evolution.

Unit V - HYBRID CONTROL SCHEMES: Fuzzification and rule base using ANN - Neuro fuzzy systems - Familiarization of Matlab fuzzy-logic toolbox and ANFIS Tool Box - Optimization using Genetic Algorithm and Particle Swarm Optimization - Survey on Differential Evolution based applications - ACO applications to power system and power electronics optimization problem - Case studies.

Reference Books:

1. Timothy J. Ross, "Fuzzy Logic with Engineering Applications", Wiley, 3rd Edition, 2010.

2. Laurene V. Fausett, “Fundamentals of Neural Networks, Architecture, Algorithms, and Applications”, Pearson Education, 2008.
3. David E. Goldberg, “Genetic Algorithms in Search, Optimization, and Machine Learning”, Pearson Education, 2009.
4. Marco Dorigo and Thomas Stutzle, “Ant Colony Optimization - A Bradford Book”, The MIT Press, London, 2004.
5. Xin-She Yang, “Cuckoo Search and Firefly Algorithm: Theory and Applications”, Springer, Switzerland, 2014.
6. Anyong Qing, “Differential Evolution: Fundamentals and Applications in Electrical Engineering, John Wiley and Sons, IEEE Press, Singapore, 2009.

17EE3025 ELECTRIC AND HYBRID VEHICLES

Credit 3:0:0

Course Objectives

- To understand the concept of various types of Electric Vehicle Technology.
- To know about various Electrical propulsion system.
- To learn designing and mathematical modelling of EHV and drives.

Course Outcomes

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

- Realize the need of Hybrid Vehicles and Electric vehicles.
- State different types of Electric & Hybrid Vehicles.
- Use the energy on-board optimally.
- Understand the merits and demerits of various mathematical models of Electric and hybrid Vehicle.
- Design the EHV using the mathematical Model.
- Simulate and observe the behavior of the EHV.

Unit I - FUNDAMENTALS OF ELECTRIC AND HYBRID VEHICLES: Environmental Impact and History of Modern Transportation – Configuration of EV– Performance of Electric Vehicles - Configuration and Types of HEV and its merits and demerits - Fuel Cell Vehicles – Battery – principle and Chemical reaction of Lead acid and Lithium Batteries, Ultra capacitors – Fly Wheels.

Unit II - ELECTRIC PROPULSION SYSTEMS: DC Motor Drives Principle and Performance - Induction Motor Drives - Principles – Steady state Performance - Permanent Magnetic Brush-Less DC Motor Drives - Basic Principles of BLDC Motor Drive – SRM - Principles – Steady state Performance –Fundamentals of Regenerative Braking

Unit III - DESIGN CONSIDERATIONS OF ELECTRIC AND HYBRID VEHICLES: Vehicle Architecture - Tractive Effort - Aerodynamic Considerations - Consideration of Rolling Resistance - Transmission Efficiency-Consideration of Vehicle Mass - Electric Vehicle Chassis and Body Design

Unit IV - MODELLING OF ELECTRIC AND HYBRID VEHICLES: Linear, Dynamic Model and reference Model - Modelling Vehicle Acceleration - Modelling Electric Vehicle Range – IC Engine for Hybrid Vehicle Modelling - Battery Modelling – Modelling DC Motor drive and Controller - Induction Motor drive and controller.

Unit V - APPLICATIONS: Case studies- Honda Insight, FCX clarity – Audi A3 E Tron, BMW i8, Chevrolet Spark EV, Mercedes S550, Nissan Leaf, Performance simulation of the GM EV1, importing and creating driving cycles, range simulation of the GM EV1 electric car, fuel cell vehicle range Simulation.

Reference Books

1. James Larminie and John Loury, “Electric Vehicle Technology – Explained”, John Wiley & Sons Ltd, 2003.
2. Mehrdad Ehsani, Yimin Gao, Sebatien Gay, Ali Emadi, “Modern Electric, Hybrid Electric and Fuel cell vehicles: Fundamentals, Theory and Design”, CRC press, 2004.
3. Ronald K Jurgen, “Electric and Hybrid – Electric Vehicles”, SAE, 2002.
4. Ron Hodkinson, John Fenton, “Light Weight Electric/Hybrid Vehicle Design”, Butterworth – Heinemann, 2001.
5. Seref Soylu, “Electric Vehicles – Modelling and Simulations”, InTech, Croatia, 2011.

6. Haitham Abu-Rub, Atif Iqbal, Jaroslaw Guzinski, “High Performance Control of AC Drives with Matlab / Simulink Models”, John Wiley, U.K., 2012.

17EE3026 EV ENERGY SOURCES AND ENERGY RECOVERY

Credit 3:0:0

Course Objectives

- To understand the methods of energy storage in electric vehicles.
- Understand the operation of various storage devices, their characteristics and maintenance.
- Learn the various parameters affecting the service life of battery and other storage devices.

Course Outcomes

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

- Understand the usage of various storage devices used in electric vehicles.
- Interpret their characteristics and performance
- Select a suitable storage device based on load requirement
- Develop schemes for recovering energy in electric vehicle
- Comprehend the functions of energy management system
- Develop schemes for energy management in an EV

Unit I – INTRODUCTION: Essential of energy storage in Electric vehicles - Power and Energy of Electric Propulsion - Standard Driving Cycles - Types of Energy Sources - Energy storage systems requirements, conversion and power systems from the perspective of HEV propulsion systems - Comparison of Different Energy Storage Technologies for HEVs

Unit II - BATTERY TECHNOLOGIES: Basic Terms of Battery Performance and Characterization - Principle - Battery Parameters Battery Charging Methods and EV Charging Schemes - Lead Acid Batteries - Nickel-Based Batteries, Lithium Batteries, Metal–Air Batteries Battery Modeling - Constant Current Discharge Approach - Equivalent Circuit Models of Battery - Run-Time Battery Characterization and Management - Battery Aggregation - Estimation of Battery Power Availability

Unit III - FUEL CELL: Operating Principles of Fuel Cells - Electrode Potential and Current–Voltage Curve - Fuel and Oxidant Consumption - Fuel Cell System Characteristics - Fuel Cell Technologies: Proton Exchange Membrane Fuel Cells, Alkaline Fuel Cells, Phosphoric Acid Fuel Cells, Molten Carbonate Fuel Cells, Solid Oxide Fuel Cells, Direct Methanol Fuel Cells - Fuel Supply - Hydrogen Storage - Nonhydrogen Fuel Cells

Unit IV - ENERGY RECOVERY SCHEMES: Ultra-capacitors - Features - Principle - Performance - Ultra high speed flywheels - Features - Principle - Performance - Regenerative Braking - Energy Consumption in Braking - Braking Power and Energy on Front and Rear Wheels - Brake System of EVs and HEVs: Series Brake Optimal Feel and Optimal Energy Recovery, Parallel Brake, ABS

Unit V - ENERGY MANAGEMENT: Design and Sizing of ESS - Battery Cell Balancing - Balancing Control Algorithms and Evaluation - Battery Management - Parameter Monitoring - Calculation of SOC - Fault and Safety Protection - Charge Management - Integrated ESS - Management of Vehicle to Grid (V2G) - Thermal Management

Reference Books:

1. Chris Mi, M. Abul Masrur, David Wenzhong Gao, “Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives”, John Wiley, 2011
2. Christopher D. Rahn, Chao-Yang Wang, “Battery Systems Engineering”, Wiley Publication 2013.
3. Davide Andrea “Battery Management Systems for Large Lithium Battery Packs”, Artech House Publishers 2010
4. Rodrigo Garcia-Valle and João A. Peças Lopes “Electric Vehicle Integration into Modern Power Networks (Power Electronics and Power Systems)”, Springer Publication, 2012 Edition.
5. James Larminie and John Loury, “Electric Vehicle Technology – Explained”, John Wiley & Sons Ltd, 2003.

17EE3027 HYBRID ELECTRIC VEHICLE POWER MANAGEMENT

Credits: 3:0:0

Course Objectives

- To understand the need for power management of HEV.
- To understand analytical controller.
- To understand the Controller modelling for EHV drives.

Course Outcomes

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

- Understand the need of mathematical modelling the Electric and Hybrid Vehicle.
- Classify various existing methods of HEV power management
- Design mathematical and intelligent HEV energy management techniques
- Develop new energy management techniques for optimizing power management
- Design and simulate the behavior of the EHV under the influence of energy management
- Analyze the performance of the existing power management techniques

Unit I – INTRODUCTION: Vehicle Configurations - Vehicle Fuel Consumption and Performance - Vehicle Energy Losses - Vehicle Emissions - Vehicle Performance and Drivability Analysis - Vehicle Operation Modes - Power Demand in Drive Cycles - Definition and Standards of Drive Cycles - Power Demand - Definitions and Objectives of Vehicle Power Management - Power Management in Conventional Vehicles and HEV - Energy Management of Hybrid Electric Vehicles - Classification of Energy Management Strategies - The Optimal Control Problem in Hybrid Electric Vehicles

Unit II - ANALYTICAL APPROACH: Simplified Analytical Solution - Vehicle Model - Control Strategy - Determining the Thresholds Using Constant Speed Driving - Validation of Control Parameter Table Using PSAT - Implementation of the Control Strategy in Standard Driving Cycles - Unified Analytical Solution - The Total Fuel Consumption and Total Battery Energy - Optimization Strategy - Model Setup for the Powertrain Components

Unit III - WAVELET TECHNOLOGY: Fundamentals of Wavelets and Filter Banks - Continuous Wavelet Analysis - Discrete Wavelet Transform- Filter Banks - Feasibility Analysis of Wavelets Applied to Vehicle Power Management - Adverse Effects of Certain Transient Power Demand on Power Sources- Applications and Advantages of Wavelets on Analyzing Transient Processes in Electrical Power Systems Power Source Combinations Available for Wavelet Applications in Vehicles -Wavelet-Based Power Split Strategy

Unit IV - DYNAMIC PROGRAMMING AND QUADRATIC PROGRAMMING: Principle - Hybrid Electric Vehicle Powertrain Analysis and DP Realization for Series - Parallel - Series Parallel - Efficiency Optimization of PHEV Using Quadratic Programming - Power Flow Analysis- Power Management Using QP

Unit V - INTELLIGENT SYSTEM APPROACH: Fundamentals of Fuzzy Logic - Neural Networks - Application of Fuzzy Logic and Neural Network in Vehicle Power Management - A Fuzzy Logic Controller Based on DP Results - for a Parallel HEV - Sliding Mode and Fuzzy Logic Based Powertrain Controller for a Series HEV - Fuzzy Logic and Sliding Mode Based Regenerative Braking Control in HEV

Reference Books:

1. Xi Zhang, Chris Mi, "Vehicle Power Management: Modeling, Control and Optimization", Springer – Verlag, London, 2011.
2. Onori, S, Serrao L, Rizzoni G, "Hybrid Electric Vehicles Energy Management Strategies", Springer, 2016.
3. Chris Mi, M. Abul Masrur, David Wenzhong Gao, "Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives", John Wiley, 2011.
4. Rodrigo Garcia-Valle and João A. Peças Lopes "Electric Vehicle Integration into Modern Power Networks (Power Electronics and Power Systems)", Springer Publication, 2012.
5. Davide Andrea "Battery Management Systems for Large Lithium Battery Packs", Artech House Publishers, 2010.

17EE3028 SWITCHED MODE POWER CONVERTERS

Credits: 3:0:0

Course Objectives

- To understand the concept of various switched mode power converters.
- To know about power factor correction in switched mode power supplies.
- To learn designing of power converters.

Course Outcomes

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

- Understand isolated and non-isolated DC-DC converters and their operation in continuous conduction mode and discontinuous conduction mode.
- Calculate minimum inductance, capacitance in single switch DC-DC converters.
- Apply current control and voltage control methods to regulate the output power.
- Design DC-DC converters and evaluate the stability of the system.
- Select suitable values for inductor for power factor correction in switched mode power converters.
- Derive transfer functions for various converter topologies.

Unit I - DC-DC CONVERTERS: Basic topologies of buck, boost converters, buck-boost converter and cuk converter, isolated DC/DC converter topologies—forward, and fly-back converters, half and full bridge topologies, modeling of switching converters.
Unit II - CURRENT MODE AND CURRENT FED TOPOLOGIES: Voltage mode and current mode control of converters, peak and average current mode control, its advantages and limitations, voltage and current fed converters.
Unit III - CONVERTER TRANSFER FUNCTIONS: Application of state-space averaging to switching converters, derivation of converter transfer functions for buck, boost, and fly-back topologies.
Unit IV - POWER CONVERTER DESIGN: Design of filter inductor & capacitor, and power transformer, Ratings for switching devices, current transformer for current sensing, design of drive circuits for switching devices, considerations for PCB layout.
Unit V - AC–DC POWER-FACTOR CORRECTION SUPPLIES: Single-Phase Single-Stage Non-Isolated Boost PFC, Output Capacitor Size, DCM Boost Inductor Selection, CCM Boost Inductor Selection, High-Power PFC and Load Sharing, Surge Protection, Load Short-Circuit Protection, Three-Phase PFC.

Reference Books:

1. Keng C Wu, “Switch Mode Power Converters, Design and Analysis”, Elsevier Academic Press, USA, 2006.
2. Ned Mohan, Undeland and Robbins, “Power Electronics – Converters, Applications and Design,”, Wiley India Pvt. Ltd., New Delhi, 2010.
3. Abraham I. Pressman, “Switching Power Supply Design”, Mc Graw Hill International, Second Edition, 1999.
4. P.C. Sen, “Modern Power Electronics”, Schand Publishing, New Delhi, 2004.
5. Andrzej M. Trzynadlowski, “Introduction to Modern Power Electronics”, 3rd Edition, Wiley India, 2015.
6. Muhammad H. Rashid, “Power electronics Hand Book”, 3rd Edition, Butterworth-Heinemann, USA, 2016.

17EE3029 POWER ELECTRONICS IN WIND AND SOLAR POWER CONVERSION

Credits: 3:0:0

Course Objectives

- To study the role of power electronics in various photovoltaic energy conversion and wind energy conversion.
- To analyze the performance of various converters and inverters.
- To learn the integration of renewable energy conversion system with the grid.

Course Outcomes

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

- Design PV systems to meet the requirement of battery operated vehicle and other related applications

- Understand various factors which affect the wind energy conversion system.
- Develop isolated power generators used in wind energy conversion system.
- Interpret the power conditioning methods
- Describe the Electrical storage methods
- Discuss about the Grid integrated system.

Unit I – INTRODUCTION: Trends in energy consumption - World energy scenario - Energy sources and their availability - Conventional and renewable sources - Solar energy availability and wind survey in India - New energy technologies.

Unit II - PHOTOVOLTAIC ENERGY CONVERSION: Photovoltaic Energy Conversion: Solar radiation and measurement - Solar cells and their characteristics - Influence of insulation and temperature - PV arrays - Electrical storage with batteries - Switching devices for solar energy conversion - Maximum power point tracking - DC Power conditioning converters - Maximum power point tracking algorithms - AC power conditioners - Line commutated inverters - Harmonic problems.

Unit III - WIND ENERGY CONVERSION: Basic Principle of wind energy conversion - Components of wind energy – Classification and conversion systems - Performance of induction generators for WECS - Self excited induction generator (SEIG) for isolated power generators - Power conditioning schemes - Doubly Fed Induction Generator (DFIG) system.

Unit IV - GRID INTEGRATION: Grid connectors concepts - wind farm and its accessories - Grid related problems - Generator control - Performance improvements – Different schemes - AC voltage controllers - Harmonics and PF improvement - Wind/solar PV integrated systems - Optimization of system components - Storage – Reliability evaluation.

Unit V - ADVANCED POWER CONVERTERS FOR RENEWABLE ENERGY: Voltage Lift Converter: P/O Luo Converters - N/O Luo Conveters - Cuk Converters - SEPIC Converters – Super lift converters for Solar and Wind power - Advanced Multilevel Inverters: Laddered MLI and Trinary Hybrid MLI for Solar Panel - AC/DC/AC Converters for Wind Turbine Systems

Reference Books:

1. Rai, G.D., "Non-conventional Energy Sources", Khanna Publishers Limited, New Delhi, 1st Edition, 2004.
2. Rai, G.D., "Solar Energy Utilization", Khanna Publishers Limited, New Delhi, 2000.
3. Mukund R Patel, "Wind and Solar Power Systems", Taylor & Francis Group, United Kingdom, 2nd Edition, 2005.
4. Fang Lin Luo and Hong Ye, "Renewable Energy System: Advanced Conversion Technologies and Applications", CRC Press, Taylor and Francis Group, Boca Raton 2013.
5. Hermann-josef Wagner, JyotirmayMathur, "Introduction to Wind Energy Systems: Basics, Technology and Operation", Springer International, United Kingdom, 2009.
6. Adrian Ioinovici, "Power Electronics and Energy Conversion Systems", John Wiley and Sons Limited., United Kingdom, 2013.

17EE3030 MODELING OF POWER CONVERTERS

Credits: 3:0:0

Course Objectives:

- To impart the knowledge of latest advances in the field of power electronics.
- To understand the basics of modeling of power converters.
- To introduce the phenomena of non-linearity in power converters.

Course Outcomes:

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

- Analyze the effect of power electronic converter in a system using their models and transfer functions
- Select appropriate filters for converters used in various applications
- Model the pulse-width modulator from an equivalent circuit
- Examine the effect of an input filter on converter transfer functions
- Illustrate the impact of non-linear phenomena in power electronic circuits
- Evaluate the stability and bifurcation in power electronic induction motor drive systems

Unit I - AC EQUIVALENT CIRCUIT MODELING: Basic AC modeling approach – State-space averaging – Circuit averaging and averaged switch modeling – Canonical circuit model – Modeling the pulse-width modulator – Problems.
Unit II - CONVERTER TRANSFER FUNCTIONS: Analysis of converter transfer functions – Graphical construction of impedances and transfer functions – Graphical construction of converter transfer functions – Measurement of AC transfer functions and impedances – Problems.
Unit III - INPUT FILTER DESIGN: Introduction – Effect of an input filter on converter transfer functions – Buck converter example – Design of a damped input filter – Problems
Unit IV - NON-LINEAR PHENOMENA IN DC-DC CONVERTERS: Basics of bifurcation and chaos theory – Border collision bifurcations in the current mode controlled boost converter - Bifurcations and chaos in the latched voltage controlled buck converter - Routes to chaos in the voltage controlled buck converter without latch – Saddle-node and Neimark bifurcations in PWM DC-DC converters-Nonlinear analysis of the operation in discontinuous conduction mode - Nonlinear phenomena in the Cuk converter
Unit V - NON-LINEAR PHENOMENA IN OTHER POWER ELECTRONICS CIRCUITS AND SYSTEMS: Modeling nonlinear inductor circuits - Inverters under tolerance band control - Nonlinear noise interactions in converters/inverters - Nonlinear phenomena in the current control of induction motors - Analysis of stability and bifurcation in power electronic induction motor drive systems

Reference Books

1. Erickson R.W., Maksimovic D., "Fundamentals of Power Electronics", Kluwer Academic Publishers, USA, 2nd Edition, 2004.
2. Banerjee S., Varghese G. C., "Non-linear phenomena in Power Electronics: Attractors, Bifurcations, Chaos and Non-linear control", IEEE press, New York, 2001.
3. Chi Kong Tse, "Complex Behaviour of Switching Power Converters", CRC Press, New York, 2004.
4. Ned Mohan, T. M. Undeland, W. P. Robbins, "Power Electronics: Converters, Applications and Design", John Wiley & Sons, USA, 3rd Edition, 2010.
5. Hua Bai, Chris Mi, "Transients of Modern Power Electronics", John Wiley & Sons, UK, 2011.

17EE3031 NEURO-FUZZY CONTROLLERS FOR ELECTRIC DRIVES

Credits: 3:0:0

Course Objectives

- To impart the knowledge on the fundamental concept of neurons and their artificial models.
- To understand the structure of fuzzy logic controller and its application to electric drives.
- To provide comprehensive knowledge of fuzzy logic and neuro controllers.

Course Outcomes

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

- Explain the concept of Neural Networks and Fuzzy Systems.
- Apply the concepts of fuzzy logic for Non-linear analysis and system identification.
- Develop an estimator based on fuzzy logic/neural network.
- Develop a predictive technique with neural network/fuzzy logic using learning algorithms.
- Design a Fuzzy Logic Controller for an Electric Drive.
- Design a Neuro Controller for an Electric Drive

Unit I - INTRODUCTION TO NEURAL NETWORK: Introduction - Biological neurons and their artificial models - Learning, adaptation and neural network's learning rules - Types of neural networks- Single layer, multiple layer- Feed forward, feedback networks; Back propagation - Learning and training –Hopfield network – Adaline Network – System Identification
Unit II - COMPETITIVE & SELF ORGANIZING NETWORKS: Competitive networks – Fixed weight competitive network – Kohonen Self-organizing maps – architecture, algorithm – Learning vector quantization – architecture, algorithm. Adaptive resonance theory – ART1; architecture, algorithm
Unit III - INTRODUCTION TO FUZZY LOGIC: Fuzzy sets- Fuzzy operation -Fuzzy arithmetic - Fuzzy relations- Fuzzy relational equations -Fuzzy measure -Fuzzy functions -Approximate reasoning -Fuzzy propositions - Fuzzy quantifiers - if-then rules.

Unit IV - FUZZY CONTROLLER: Structure of fuzzy logic controller -Fuzzification models- Data base -Rule base –inference engine defuzzification module - Non-linear fuzzy control-PID like FL sliding mode FLC -Sugeno FLC -adaptive fuzzy control - Lyapunov stability Analysis -direct and indirect. Fuzzy identification, estimation-fitting functions to data, least squares method, gradient methods, clustering methods, and extraction of rules from data

Unit V - APPLICATIONS TO ELECTRIC DRIVES: Neuro controllers for AC Drives - Fuzzy Controllers for AC Drives – Hybrid Neuro- Fuzzy Controllers for BLDC motors – Adaptive Neuro – Fuzzy Controllers for Switched Reluctance Motor Drives.

Reference Books:

1. Timothy Ross, "Fuzzy Logic with Engineering Applications", Wiley India Pvt Ltd, New Delhi, 2011.
2. Jacek M Zurada, "Introduction to Artificial Neural Systems", Jaico Publishing House, New Delhi, 2001.
3. Jang Jyh-shing Roger, Sun Chuen-tsai, Mizutani Eiji," Neuro-Fuzzy and Soft Computing: A Computational Approach to Learning and Machine Intelligence" PHI Learning Pvt limited,2009.
4. Laurene Fausett, "Fundamentals of Neural Networks: Architectures, Algorithms and Applications", Pearson Education India, New Delhi, 2009.
5. Driankov, Hellendroon, "Introduction to Fuzzy Control", Narosa Publishers Limited, New Delhi, 1996.

17EE3032 ADVANCED CONTROL OF ELECTRIC DRIVES

Credits: 3:0:0

Course Objectives

- To impart the basic knowledge about various AC and DC drives.
- To understand the working of Reluctance and BLDC drives.
- To know about various DSP based and AI based Drives.

Course Outcomes

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

- Design, test and analyze Torque and Vector controlled drives.
- Apply the DSP and AI based drives for applications.
- Demonstrate detailed understanding of the dynamic behavior of IM and PMSM.
- Use computer modeling for drive system analysis and control design.
- Display in-depth knowledge of vector and direct torque control strategies used in modern drive systems.
- Demonstrate the predictive control applied to motor drives.

Unit I - VECTOR CONTROL OF INDUCTION-MOTOR DRIVES: Induction Machine Equations in Phase Quantities: Assisted by Space Vectors –Dynamic analysis of induction machines in terms of DG windings-Emulation of DC and Brushless DC Drive Performance -Vector Control of Induction- Transformer Equivalent Circuit - Vector Control with *d*-Axis Aligned with the Rotor Flux - Torque, Speed, and Position Control - Transformation and Inverse-Transformation of Stator Currents - The Estimated Motor Model for Vector Control - *d*-Axis Rotor Flux Linkage Dynamics - Motor Model - Vector Control - Speed and Position Control Loops - Calculating the Stator Voltages - Designing the PI Controllers -Detuning Effects in Induction Motor Vector Control

Unit II - DYNAMIC ANALYSIS OF DFIG AND DIRECT TORQUE CONTROL (DTC) AND ENCODERLESS OPERATION OF INDUCTION MOTOR DRIVES: Understanding DFIG Operation - Dynamic Analysis of DFIG - Vector Control of DFIG -Principle of Encoderless DTC Operation Calculation - Calculation of the Stator Flux - Calculation of the Rotor Flux - Calculation of the Electromagnetic Torque - Calculation of the Rotor Speed - Calculation of the Stator Voltage Space Vector - Direct Torque Control

Unit III - VECTOR CONTROL OF PERMANENT-MAGNET SYNCHRONOUS MOTOR DRIVES AND SWITCHED-RELUCTANCE MOTOR (SRM) DRIVES: Non salient pole machine:- *d-q* Analysis of Permanent Magnet - Flux Linkages - Stator *dq* Winding Voltages - Electromagnetic Torque - Electrodynamics - Relationship between the *dq* Circuits and the Per-Phase Phasor-Domain Equivalent Circuit in Balanced Sinusoidal Steady State - *dq*-Based Dynamic Controller - Salient-Pole Synchronous Machines - Electromagnetic Torque - *dq*-Axis Equivalent Circuits -Space Vector Diagram in Steady State -Switched-Reluctance Motor -Electromagnetic Torque-Induced Back- Power Processing Units for SRM Drives -Determining the Rotor Position for Encoderless Operation -Control in Motoring Mode.

Unit IV - PREDICTIVE CONTROL OF POWER CONVERTERS AND DRIVES: Basics of Predictive Control – Principles- Predictive Control of a Three Phase Inverter- Predictive Speed Control of Induction Machine- Field Oriented Control of an Induction Machine Fed by a Matrix Converter Using Predictive Current Control, Predictive Torque Control of an Induction Machine Fed by a Voltage Source Inverter, Predictive Torque Control of an Induction Machine Fed by a Matrix Converter-Design of model predictive control-Evaluation of model parameters errors

Unit V - ELECTRICAL DRIVES FOR DIRECT DRIVE RENEWABLE ENERGY SYSTEMS: DSP Controlled Drives –Cogging Torque Minimization Techniques in Drives –AI-based Techniques: Fuzzy Logic and Neural-Network based Drives -Drives for Renewable Energy Systems: Micro -Hydro Systems -PMDD Generator: Principle and Design –Application in Zephyros Wind Turbine –Archimedes Wave Swing (AWS) Direct Drive

Reference Books:

1. Ned Mohan, "Advanced Electric Drives: Analysis, Control and Modeling using Simulink", John Wiley and Sons Limited, New Jersey, 2014.
2. Hamid A Toliyat and Steven G. Campbell, "DSP Based Electromechanical Motion Control", CRC Press, UK, 2004.
3. Maurizio Cirrincione, Marcello Pucci and Gianpaolo Vitale, "Power Converters and AC Electrical Drives", CRC Press, Boca Raton, 2012.
4. Rik De Doncker, Duco W. J. Pulle and Andre Veltman, "Advanced Electrical Drives: Analysis, Modeling and Control", Springer, London, 2011
5. Jose Rodriguez, Patricio Cortes, "Predictive Control of Power Converters and Electrical Drives", John Wiley & Sons, United Kingdom, 2012.
6. Patricio Cortés, et.al, "Predictive Control in Power Electronics and Drives", IEEE Transactions on Industrial Electronics, Vol.55, No.12, December 2008.

17EE3033 HVDC TRANSMISSION

Credits: 3:0:0

Course Objectives

- To impart the knowledge of various HVDC systems.
- To understand the basics power converters used in HVDC system
- To study the basics of harmonics and their reduction mechanism.

Course Outcomes

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

- Analyze the effect of power electronic converter in the HVDC system.
- Select appropriate filters for converters used for its operation & control.
- Outline the benefits of using dc transmission and its operation & control.
- Model HVDC systems using Simulation tools.
- Illustrate the impact of non-linear phenomena in power electronic circuits.
- Evaluate the challenges and its solutions available in high voltage engineering.

Unit I - DC POWER TRANSMISSION TECHNOLOGY: Historical development – Types of HVDC Systems – Equipments for HVDC – Comparison: Economics of Power Transmission, Technical Performance, and Reliability – Limitations of HVDC.

Unit II - ANALYSIS OF HVDC CONVERTERS: Line commutated converter: Graetz bridge without overlap – Voltage source converter: basic two level converters – Converter analysis: two and three valve mode – three and four valve mode – Capacitor commutated converter.

Unit III - CONVERTER AND HVDC SYSTEM CONTROL: Principles of DC link control – Converter control characteristics – Control hierarchy – Firing angle control – Power control – Higher level controllers.

Unit IV - CONVERTERS FAULTS & PROTECTION: Converter faults: Commutation failure, Arc through, Misfire, Current extinction and Short circuit in a bridge – Protection against over currents – Over voltages in a converter station – Protection against over voltages – Functions of smoothing reactor.

Unit V - HARMONICS AND FILTERS: Problems due to harmonics – Characteristic harmonics – Non-characteristic harmonics – Filters: Design criteria of ac filters – Types of ac filters – DC filters - Active filter – Carrier frequency and RI noise.

Reference Books:

1. Padiyar. K. R, "HVDC Power Transmission Systems", 3rd Edition, New Age International Publishers Pvt. Ltd., New Delhi, 2015.
2. Kamakshaiah. S, Kamaraju. V, "HVDC Transmission", Tata McGraw Hill Education Pvt. Ltd., New Delhi, 2011.
3. Erich Uhlmann, "Power Transmission by Direct Current", Springer International Edition, 2004.
4. Neville R. Watson, Y. H. Liu, J. ArrillagaArrilaga J., "Flexible Power Transmission: The HVDC Options", John Wiley & Sons, 2007.
5. Chan-ki Kim, Vijay K. Sood, Gil-soo Jang, Seong-joo Lim, Seok-jin Lee, "HVDC Transmission: Power Conversion Applications in Power Systems", John Wiley (IEEE Press), 2009.

17EE3034 DISTRIBUTED GENERATION AND MICROGRID

Credits: 3:0:0

Course Objectives

- To impart the concept of distributed generation and microgrid
- To provide knowledge on power architecture, configuration and control strategies for distributed generation
- To give details of the impacts of distributed resources to the grid and the various issues associated with integrating such resources to the grid

Course Outcomes

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

- Define the concept of distributed generation and microgrid
- Classify various distributed generation sources and energy storage
- Sketch the power electronic topologies for distributed generation
- Employ appropriate power electronic topologies for distributed generation
- Design controllers for power electronic converters of distributed generation
- Compare different microgrid architectures and controls

Unit I - DG OVERVIEW AND TECHNOLOGY TRENDS: History of Power System-Representation of Power Systems - SLD, PU System - DG - Microgrid - Smart Grid -Power Grid Vs Microgrid - DG Definition - Interface with the Grid -IEEE 1547 Standards - Impact of DG on Distribution System - Impact of DG on Transmission System and Central Generation- DG Advantages & Disadvantages.

Unit II - DG UNITS: Microturbines - Reciprocating Engines - Wind Generators - Photovoltaic Generators - Fuel Cells-Combined Heat and Power Generation - Solar Thermal - Small Hydro - hydro kinetic - Geothermal - Oceanic power generation-Energy Storage

Unit III - POWER ELECTRONIC INTERFACE FOR DG: General Topology - Power Electronics Topologies for Microturbines -Power Electronics Topologies for Reciprocating Engines - Power Electronics Topologies for the Wind Energy Systems - Power Electronics Topologies for the PV Systems - Power Electronics Topologies for Fuel Cell Systems -Power Electronics Topologies for the Battery Energy Storage Systems – Charging of Electric Vehicles

Unit IV - DG PROTECTION AND POWER QUALITY ISSUES: Voltage Regulation- DG Grounding Issue - Transient Response and Fault Behaviors - Reclosing - DC Current Injection - Flicker Concerns - Current Distortion from Power Electronics of DG - Anti-Islanding Protection of DG - Radial Feeder Models and Cases for Voltage Regulation Analysis - Unbalanced Grid- DG Design Considerations to Meet Power Quality Requirements

Unit V – MICROGRIDS: Microgrid Definition - Microgrid Architecture - Power Electronic Interfaces (AC to DC & DC to AC) - Power Architecture - distributed and centralized - DC and AC distribution - Controls: distributed, autonomous, and centralized systems - Grid interconnection - Issues, planning. Microgrid communication infrastructure - Power quality issues in microgrids - Regulatory standards, Microgrid economics-Case study

Reference Books

1. N. Jenkins, J.B. Ekanayake and G. Strbac, Distributed Generation, IET, UK,2010

2. Felix A. Farret, M. Godoy Simoes, Integration of Alternative Sources of Energy, Wiley-IEEE Press, John Wiley & Sons Ltd., Canada, 2006
3. Math H. Bollen, Fainan Hassan, Integration of Distributed Generation in the Power System, Wiley-IEEE Press, John Wiley & Sons Ltd., Canada, 2011
4. Nikos Hatziargyriou, Microgrids Architectures and Control, Wiley-IEEE Press John Wiley and Sons Ltd, UK,2014
5. S. Chakraborty, M. G. Simoes, William E.Kramer, Power Electronics for Renewable and Distributed Energy Systems, Springer-Verlag, London 2013
6. Suleiman M. Sharkh, Mohammad A. Abu-Sara, Georgios I. Orfanoudakis, Babar Hussain, Power Electronic Converters for Microgrids, Wiley-IEEE Press John Wiley & Sons Ltd., Singapore, 2014.

17EE3035 FLEXIBLE AC TRANMISSION SYSTEMS

Credits: 3:0:0

Course Objectives:

- To introduce the students to the concept of FACTS, and familiarize them with the basic design and principle of operation of HVDC systems.
- To understand the implementation of UPFC in real time applications.
- To the design the FACTS controllers for various non-linear structure controls.

Course Outcomes

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

- Refresh on basics of power transmission networks and need for FACTS controllers
- Attain knowledge about Controlled Series Compensation
- Report the significance about different voltage source converter based FACTS Controllers
- Analyze on FACTS controller interaction and control coordination
- Select the suitable FACTS devices to enhance the security, capacity and flexibility of Power transmission systems.
- Design the FACTS controller for renewable energy integration

Unit I – INTRODUCTION: Review of basics of power transmission networks-control of power flow in AC transmission line- Analysis of uncompensated AC Transmission line- Passive reactive power compensation: Effect of series and shunt compensation at the mid-point of the line on power transfer- Need for FACTS controllers- types of FACTS controllers.

Unit II - STATIC VAR COMPENSATOR (SVC): Configuration of SVC- voltage regulation by SVC- Modelling of SVC for load flow analysis- Modelling of SVC for stability studies-Design of SVC to regulate the mid-point voltage of a SMIB system- Applications: transient stability enhancement and power oscillation damping of SMIB system with SVC connected at the mid-point of the line.

Unit III - THYRISTOR AND GTO THYRISTOR CONTROLLED SERIES CAPACITORS (TCSC and GCSC): Concepts of Controlled Series Compensation – Operation of TCSC and GCSC- Analysis of TCSC-GCSC – Modeling of TCSC and GCSC for load flow studies- modeling TCSC and GCSC for stability studied- Applications of TCSC and GCSC.

Unit IV - VOLTAGE SOURCE CONVERTER BASED FACTS CONTROLLERS: Static synchronous compensator(STATCOM)- Static synchronous series compensator(SSSC)- Operation of STATCOM and SSSC-Power flow control with STATCOM and SSSC- Modelling of STATCOM and SSSC for power flow and transient stability studies –operation of Unified and Interline power flow controllers (UPFC and IPFC)- Modelling of UPFC and IPFC for load flow and transient stability studies- Applications.

Unit V - CONTROLLERS AND THEIR CO-ORDINATION: FACTS Controller interactions – SVC–SVC interaction - co-ordination of multiple controllers using linear control techniques – Quantitative treatment of control coordination.

Reference Books:

1. Mohan Mathur, R., Rajiv. K. Varma, "Thyristor – Based FACTS Controllers for Electrical Transmission Systems", IEEE press and John Wiley & Sons, Inc, 2002.
2. K.R.Padiyar," FACTS Controllers in Power Transmission and Distribution ", New Age International (P) Ltd., Publishers, New Delhi, Reprint, 2008.

3. A.T.John, “Flexible AC Transmission System”, Institution of Electrical and Electronic Engineers (IEEE), 1999.
4. NarainG.Hingorani, Laszio. Gyugyl, “Understanding FACTS Concepts and Technology of Flexible AC Transmission System”, Standard Publishers, Delhi, 2001.
5. V. K.Sood, “HVDC and FACTS controllers- Applications of Static Converters in Power System”, Kluwer Academic Publishers, 2004.

17EE3036 POWER SYSTEM PLANNING AND RELIABILITY

Credits: 3:0:0

Course Objectives

- To impart the knowledge on basic load types & characteristics and methods of forecasting
- To provide knowledge on generation, transmission & distribution reliability evaluation
- To provide details of generation, transmission & distribution systems planning

Course Outcomes

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

- Describe power system planning and reliability concepts
- Categorize of electric energy consumers
- Apply reliability concepts to power systems
- Predict power system load demand
- Plan for generation, transmission and distribution systems
- Evaluate reliability indices for generation, transmission and distribution adequacy

Unit I - POWER SYSTEM PLANNING AND LOAD FORECASTING: Objectives of system planning: Long term and short term planning-stages in planning -Policy studies -Planning standardization studies- System and Network Reinforcement studies-Power System Planning under uncertainty-Reactive Power Planning-Load forecasting: Classification of loads- Objectives of forecasting- Load growth patterns and their importance in planning -Forecast methodology- Time Series –Regression- ARMA- AI based techniques-Energy forecasting-Non weather sensitive forecast-Weather sensitive forecast- Total forecast-Annual and monthly peak load forecast.

Unit II - POWER SYSTEM RELIABILITY: Basic Notions of Power System Reliability- sub systems, reliability indices, outage classification, value of reliability tools, Concepts and methodologies, power system structure, Reliability based planning in power systems, Effect of failures on power system, Planning criteria, Risk analysis in power system planning, multi-state systems. Basic Tools and Techniques- random processes methods & Markov models, Computation of power system reliability measures by using Markov reward models, Evaluation of reliability indices, Universal Generating Function (UGF) Method, Monte Carlo simulation.

Unit III - GENERATION PLANNING AND RELIABILITY: Objectives & Factors affecting Generation Planning, Generation Sources, Integrated Resource Planning, Generation System Model, Loss of Load (Calculation and Approaches), Outage Rate, Capacity Expansion, Scheduled Outage, Loss of Energy, Evaluation Methods. Interconnected System, Factors affecting interconnection under Emergency Assistance.

Unit IV - TRANSMISSION PLANNING AND RELIABILITY: Objectives of Transmission Planning, Network Reconfiguration, System and Load Point Indices, Data required for Composite System Reliability. Basic concepts on expansion planning- procedure followed for integrate transmission system planning, current practice in India-Capacitor placement problem in transmission system.

Unit V - DISTRIBUTION PLANNING AND RELIABILITY: Radial Networks – Introduction, Network Reconfiguration, capacitor placement-Evaluation Techniques, Interruption Indices, Effects of Lateral Distribution Protection, Effects of Disconnects, Effects of Protection Failure, Effects of Transferring Loads, Distribution Reliability Indices. Parallel & Meshed networks - Introduction, Basic Evaluation Techniques, Bus Bar Failure, Scheduled Maintenance, Temporary and Transient Failure, Weather Effects, Breaker Failure.

Reference Books:

1. Roy Billinton & Ronald N. Allan, “Reliability Evaluation of Power System”, 2nd edition, Springer Publication, 2013.
2. Hossein Seifi, Mohammad Sadegh Sepasian, “Electric Power System Planning: Issues, Algorithms and Solutions”, Springer Publication, 2011.
3. R. L. Sullivan, “Power System Planning”, McGraw Hill Publishing Company Ltd., 1977.

4. X. F. Wang, J.R McDonald, "Modern Power System Planning", McGraw Hill Book Company, 1994.
5. T. Gönen, "Electrical Power Distribution Engineering", CRC Press, 2014.
6. T. W. Berrie, "Electricity Economics & Planning", IET, London, 1992.

17EE3037 SMART GRID TECHNOLOGY

Credits: 3:0:0

Course Objectives

- To understand the concepts and design of Smart grid
- To Study the various communication and measurement technologies in smart grid
- To learn about renewable energy resources and storages integrated with smart grid.

Course Outcomes

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

- Refresh the concepts of electric Grid and its present developments
- Differentiate the information exchange in traditional grid and smart grid
- Implement different Smart Grid communication technologies.
- Analyze the role of power electronic devices in the network
- Asses the importance of the information security for smart grid
- Design the prototype model of the smart grid

Unit I - INTRODUCTION TO SMART GRID: Evolution of Electric Grid, Concept - Definitions and Need for Smart Grid - Smart grid drivers - functions, opportunities, challenges and benefits - Difference between conventional & Smart Grid - Concept of Resilient & Self Healing Grid - Present development & International policies in Smart Grid - Diverse perspectives from experts and global Smart Grid initiatives.

Unit II - DISTRIBUTION MANAGEMENT SYSTEM: Technology Drivers - Smart energy resources - Smart substations - Substation Automation - Feeder Automation - Transmission systems: EMS, FACTS and HVDC - Wide area monitoring - Protection and control - Distribution systems: DMS, Volt/VAR control - Fault Detection - Isolation and service restoration - Outage management - High-Efficiency Distribution Transformers - Phase Shifting Transformers - Plug in Hybrid Electric Vehicles (PHEV).

Unit III - SMART GRID COMMUNICATIONS: Local Area Network (LAN) - House Area Network (HAN) - Wide Area Network (WAN) - Wide area monitoring systems (WAMS) - Broadband over Power line (BPL) - IP based Protocols - Basics of Web Service and CLOUD computing to make Smart Grids smarter - Cyber Security for Smart Grid.

Unit IV - SMART METERS AND ADVANCED METERING INFRASTRUCTURE: Introduction to Smart Meters - Advanced Metering infrastructure (AMI) drivers and benefits - AMI protocols, standards and initiatives - AMI needs in the smart grid, Phasor Measurement Unit (PMU) - Intelligent Electronic Devices(IED) & their application for monitoring & protection.

Unit V - POWER ELECTRONICS IN SMART GRID: Introduction-Fault current limiting-Shunt Compensation: D-Statcom - Shunt compensator with energy storage - Series compensation - Power Quality Conditioners for Smart Grid - Anti islanding and smart grid protection.

Reference Books:

1. Stuart Borlase "Smart Grid: Infrastructure, Technology and Solutions", CRC Press 2012.
2. Janaka Ekanayake, Nick Jenkins, Kithsiri Liyanage, Jianzhong Wu, Akihiko Yokoyama,
3. "Smart Grid: Technology and Applications", Wiley, 2011.
4. James Momoh, " Smart Grid: Fundamentals of design and analysis ",John Wiley & sons Inc, IEEE press, 2012.
5. Fereidoon P. Sioshansi, "Smart Grid: Integrating Renewable, Distributed & Efficient Energy", Academic Press, 2012.
6. Clark W. Gellings, "The smart grid: Enabling energy efficiency and demand response", Fairmont Press Inc, 2009.

17EE3038 MATERIALS FOR SOLAR POWER

Credits 3:0:0

Course Objectives

- Study the different materials used in manufacturing process.
- Understand the physics of solar cell.
- Know the technology of manufacturing solar cell.

Course Outcomes

At the end of the course students will able to

- Understand the physical theory of solar cells.
- Analyse the material characteristics.
- Design and Construct a printed solar cell.
- Study the crystalline structure of the solar cell.
- Connect nanotechnology for the preparation of solar cell
- Prepare the thin film based solar cells.

Unit I - FUNDAMENTAL PHYSICAL LIMITS TO PHOTOVOLTAIC CONVERSION: Introduction, PN junction,Thermodynamic Limits, Limitations of Classical Devices,multi junction,Two level system model, Fundamental Limits of Some High-Efficiency Concepts,Quantam theary of solar cells.
Unit II - PHYSICAL CHARACTERISATION OF PHOTOVOLTAIC MATERIALS: Needs of characterisation, X-Ray Techniques, Electron Microscopy Methods, Spectroscopy Methods.
Unit III - CHRISTILINE SOLAR CELL: Homo-Hetro junction solar cell, multi junction solar cells, thin film solar cells, CIGS, Kesterites.
Unit IV - PRINTED SOLAR CELLS: Mateials morphology, Interfaces in Organic Photo voltaics, Tandem Technology, Electrode Requirements for Organic Solar Cells
Unit V - THIRD-GENERATION SOLAR CELLS: Introduction, Multiple-Energy-Level Approaches, Modification of the Solar Spectrum, Thermal Approaches, Nonreciprocal Devices, Quantum Antennae – Light as a Wave

Reference Books

1. Arthur Willoughby, “Solar Cell Materials: Developing Technologies”, John Wiley and Sons, 2010.
2. William D. Callister, Jr, “Materials Science and Engineering: An Introduction”, John Wiley, New York, 2010.
3. Srinivasan, “Engineering Materials and Metallurgy”, Tata McGraw-Hill Education Limited, 2nd Edition 2010.
4. Jenny Nelson, “The Physics of Solar Cells” Imperial College Press, 2003.
5. Tom Markvart, “Solar Cells: Materials, Manufacture and Operation” Elsevier, USA, 2nd Edition, 2013.

17EE3039 SOLAR ENERGY FORECASTING

Credits: 3:0:0

Course Objectives

- To understand the basics of assessing solar energy using satellite forecasts
- To learn the mathematical basics involved in forecasting of data
- To equip the student with the latest forecasting techniques

Course Outcomes

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

- Recognize the basic physics about solar radiation geometry
- Outline the technical aspects of various solar forecasting methods
- Analyze the configurations of widely used forecast models
- Utilize the various data sources for solar resource assessment
- Predict solar resources for managing the electrical power grid and its markets
- Develop accurate forecasting model.

Unit I - SOLAR RADIATION GEOMETRY: Solar radiation geometry - Earth-Sun angles - Solar day length – Sun path diagram -Solar radiation on the earth surface - Extraterrestrial radiation,-Terrestrial radiation-solar insolation-spectral energy distribution of solar radiation-Direct, diffuse and Global solar radiation-Measurement of solar radiation.

Unit II - SEMI-EMPIRICAL AND PHYSICALLY BASED SATELLITE METHODS: Semi-Empirical satellite models-Satellites and Spectral Bands- Computing Global Irradiance- Direct Normal Irradiance. Physically based satellite methods-Satellite Observing Systems-Cloud and Aerosol Detection-Relating Properties to Surface-Irradiance Parameters-Single-Step - Two-Step Methods - Solar-Radiation Datasets -NASA Global Surface Radiation Budget – Heliosat -NOAA Operational Programs.

Unit III - SOLAR FORECASTING METHODS: Physically based forecasting approaches - Satellite forecasts-Sky-imager forecasts-Stochastic-Learning Approaches- Forecasting solar irradiance with Numerical Weather Prediction models - Metrics for evaluation of solar-forecasting models- Case studies on meeting stakeholder needs.

Unit IV - SKY-IMAGING SYSTEM AND SATELLITE BASED FORECASTING: Sky-Imaging systems for short-term forecasting -Challenges in short-term Solar forecasting, Sky-Imaging hardware, Sky-Imagery analysis techniques-Satellite-based Irradiance forecasting -Overview of the satellite forecast process, Irradiance from satellite data (Meteosat Satellite and Heliosat Method), Cloud-Motion Vectors Evaluation of CMV forecasts

Unit V - STOCHASTIC-LEARNING METHODS FOR PREDICTING SOLAR RESOURCE: Persistence methods-Regression methods - autoregressive moving averages (ARMA) - autoregressive integrated moving averages ARIMA Models -k-Nearest-Neighbors (kNN) and Artificial Neural Networks (ANN)- genetic algorithms-Fuzzy logic (FL) and hybrids (GA/ANN, ANN-FL) -clear-sky model- Case studies of solar forecasting with the weather research and forecasting models in India.

Reference Books

1. Kleissl J., “Solar Energy Forecasting and Resource Assessment”, Academic Press, 1st Edition, 2013.
2. Richard Headen Inman, Jr., “Solar Forecasting Review”, M.S Thesis, University of California, San Diego, 2012.
3. Sophie Pelland, George Galanis, George Kallos, “Solar and photovoltaic forecasting through post-processing of the Global Environmental Multiscale Numerical Weather Prediction Model”, progressing in Photovoltaics: Research and Applications, 2011.
4. Yang Dazhi, “Solar Modeling and Forecast”, Report, National University of Singapore,2012.
5. Md Rahat Hossain, Amanullah Maung Than Oo, Shawkat Ali, A.B.M., “Hybrid Prediction Method for Solar Power Using Different Computational Intelligence Algorithms”, Smart Grid and Renewable Energy, Vol. 4, 2013, pp.76-87.
6. .Foster .R, Ghassemi M., Cota A., “Solar Energy”, CRC Press, 2010.

17EE3040 SOLAR CELL AND MODULE TECHNOLOGY

Credits 3:0:0

Course Objectives

- Study the various PV module
- Make detail study of grid connected PV module
- To study the performance of solar PV systems.

Course Outcomes

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

- Understand the physics of PV cells.
- Measure and characterize the PV module.
- Describe the uniqueness of different PV cells.
- Have a good understanding of semiconductors used for PV cell manufacturing.
- Describe and discuss the making, calibration of different solar cell devices.
- Make the organic solar cells with lessor cost.

Unit I – INTRODUCTION: The physics of solar cell-properties of semiconductors-PN Junction diode electrostatics-Solar cell fundamentals - Efficiency and band gap-spectral response-parasitic resistance effects

Unit II - MANUFACTURING OF SILICON: Production of metallurgical grade silicon production of semiconductor grade silicon-requirements of silicon for crystalline solar cells-routs to solar grade silicon-Bulk crystal growth and wagering.
Unit III - CRYSTALLINE SOLAR CELLS: PV-Crystalline silicon solar cells -manufacturing process-crystalline silicon photovoltaic modules-Thin film silicon solar cells-Amorphous silicon solar cells.
Unit IV - PREPARATION OF ORGANIC SOLAR CELLS: Dye sensitized and Organic solar cells-Organic Electronic Materials-fabrication-Rating, quantum solar cells. Application of nano technology in solar cells.
Unit V - MEASUREMENTS OF SOLAR CELLS: PV Performance-Current versus voltage measurements Primary reference cell calibration methods-spectral responsibility measurements-Module qualification and certification

Reference Books

1. Antonio Luque, Steven Hegedus, “Hand book of Photovoltaic Science and Engineering”, John Wiley& Sons Ltd, England, 2011.
2. Larry D. Partain, “Solar Cells and Their Applications”, John Wiley & Sons Ltd, England, 2010.
3. Tom Markvart, “Solar Cells: Materials, Manufacture and Operation”, Elsevier, USA, 2nd Edition, 2013.
4. JefPoortmans, Vladimir Arkhipov, “Thin Film Solar Cells: Fabrication, Characterization and Applications”, John Wiley & Sons, 2006
5. Arvind Shah, “Thin-Film Silicon Solar Cells”, First Edition, CRC Press 2010.
6. Chetan Singh Solanki, “Solar Photovoltaics: Fundamentals, Technologies and Applications” PHI Learning Private Ltd, 3rd Edition, 2015.

17EE3041 PTIMAL CONTROL OF WIND ENERGY SYSTEMS

Credits: 3:0:0

Course Objectives

- To understand the importance of optimal control in wind energy systems
- To impart the basics of modeling of wind energy conversion system
- To introduce the various parameters that need to controlled in wind energy systems

Course Outcomes

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

- Model Wind Energy Conversion Systems
- Design Control System for Grid connected operation
- Develop Optimal Control Strategies
- Analyze the Performance of Wind Power in Power Systems
- Apply Different Optimal Control Techniques for WECS
- Analyze Voltage Control capabilities of WECS

Unit I - WECS MODELLING: Electrical Generator Modeling – Drive Train Modeling – Power Electronics Converters and Grid Modeling – Linearization and Eigen value analysis – Case study
Unit II - WIND TURBINE CONTROL SYSTEMS: Control Objectives – Physical Fundamentals – Principles of WECS Optimal Control – Main Operation Strategies – Optimal control with Mixed Criterion – Gain Scheduling Control – Control of generators in WECS – Control System for Grid connected operation and Energy Quality Assessment.
Unit III - WECS OPTIMAL CONTROL WITH ENERGY EFFICIENCY CRITERION: MPPT strategies – PI control – ON/OFF control – Sliding mode control – Feedback Linearization Control – QFT Robust Control.
Unit IV - WECS OPTIMAL CONTROL WITH MIXED CRITERION: LQ control of WECS – Frequency separation principle – 2LFSP applied to WECS with Rigidly-coupled generator and flexibly- coupled generator.
Unit V - VOLTAGE AND REACTIVE POWER CONTROL: Voltage control – Voltage control capabilities of wind turbines – Voltage control capability and converter rating – Voltage regulation: VAR support on a wind dominated grid.

Reference Books

1. Iulian Munteanu, Antoneta Iuliana Bratcu, Nicolaos-Antonio Cutululis, Emil Ceang, “Optimal Control of Wind Energy Systems - Towards a Global Approach”, Springer-Verlag, London, 2008.

2. Thomas Ackermann, “Wind Power in Power Systems”, John Wiley & Sons Ltd., England, 2005.
3. Fernando D. Bianchi, Hernan De Battista, Ricardo J. Mantz, “Wind Turbine Control Systems: Principles, Modelling and Gain Scheduling Design”, Springer-Verlag, London, 2007.
4. Olimpo Anaya-Lara, Nick Jenkins, Janaka Ekanayake, Phill Cartwright, Mike Hughes, “Wind Energy Generation- Modelling and Control”, John Wiley & Sons Ltd., UK, 2009.
5. Siegfried Heier, “Grid Integration of Wind Energy Conversion System”, 2nd Edition, John Wiley & Sons Ltd., England, 2006.

17EE3042 WIND RESOURCE ASSESSMENT AND FORECASTING

Credits: 3:0:0

Course Objectives

- To understand the basics of assessing potential sites for wind farms
- To learn the mathematical basics involved in forecasting of data
- To equip the student with the latest forecasting techniques

Course Outcomes:

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

- Assess wind resource availability
- Develop forecasting models
- Do Wind Power Station operation and maintenance
- Measure and Analyze the wind power using different forecasting techniques
- Apply Different Methods in Forecasting Scenario
- Analyze Forecasting Using Artificial Intelligence Techniques

Unit I - WIND RESOURCE ASSESSMENT: Guiding Principles – Siting of monitoring systems – Measurement parameters – Monitoring station instrumentation – Installation of Monitoring stations – Station operation and maintenance - Data collection and handling – Data validation, processing and reporting – Cost and Labour requirements.

Unit II - FORECASTING PERSPECTIVE AND BASIC FORECASTING TOOLS: Overview of forecasting techniques – Basic steps in forecasting task – Time series and cross-sectional data- Graphical summaries – Numerical summaries – Measuring forecast accuracy – Prediction Intervals – Least squares estimates – Transformations and adjustments

Unit III - TIME SERIES DECOMPOSITION AND EXPONENTIAL SMOOTHING METHODS: Principles of decomposition – Moving averages – Local regression smoothing – Classical decomposition – Census Bureau method - STL decomposition – Forecasting and decomposition - Forecasting scenario - Averaging methods – Exponential smoothing methods – General aspects of smoothing methods.

Unit IV - FORECASTING TECHNIQUES: Simple Regression: Regression methods – non-linear relationships Multiple Regression: Regression with time series – Multiple regression and forecasting – Econometric models Box-Jenkins methodology of ARIMA models: Examining correlations in time series data – Examining stationarity of time series data - ARIMA models for time series data – Forecasting with ARIMA models

Unit V - ADVANCED FORECASTING MODELS: Regression with ARIMA errors – Dynamic regression models – Intervention analysis – Multivariate autoregressive models – State space models – Non-linear models – Neural network forecasting.

Reference Books

1. S. Makridakis, S. C. Wheelwright, R. J. Hyndman, “Forecasting – Methods and Applications”, Third Edition, Wiley-India Edition, Delhi, 2011
2. Wind Resource Assessment Handbook, AWS Scientific Inc., New York 1997.
3. Michael Brower, Daniel W. Bernadett, Kurt V. Elsholz, Matthew V. Filippelli, Michael J.Markus, Mark A. Taylor, Jeremy Tensen, “Wind Resource Assessment: A Practical Guide to Developing a Wind Project”, John Wiley & Sons, London, 2012.
4. J. Scott Armstrong, “Principles of Forecasting: A Handbook for Researchers and Practitioners”, Springer Science+Business Media Inc., USA, 2001.
5. Douglas C. Montgomery, Cheryl L. Jennings, Murat Kulahci, “Introduction to Time Series Analysis and Forecasting”, John Wiley & Sons, New Jersey, 2008.

17EE3043 ADVANCED CONTROL FOR INDUCTION GENERATORS

Credits: 3:0:0

Course Objectives

- To understand the transient and steady state modeling of induction generators.
- To give an in-depth knowledge about the different control techniques of induction generators.
- To enhance the students' perspective on optimized control of induction generators which are widely used in renewable energy systems.

Course Outcomes:

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

- Analyze the complex control concepts
- Ensure Energy Economy and Efficiency.
- Apply the optimization techniques for maximum performance
- Model and Simulate Induction Generators for different states
- Develop Scalar and Vector Control Schemes
- Apply Advance Control Techniques for Grid Integration.

Unit I - MODELING OF INDUCTION GENERATORS: Steady State Model of Induction Generator: Classical Steady State Representation – Generated Power – Induced Torque – Representation of Induction Generator Losses - Transient Model of Induction Generator: Induction Machine in Transient State – State Space Modeling – Partition of the SEIG State Matrix with an RLC load.

Unit II - OPERATION OF INDUCTION GENERATORS: Self-Excited Induction Generator: Performance, Voltage Regulation – Magnetizing Curves and Self Excitation – Mathematical Expression. Wound Rotor Induction Generator Systems: Features - Sub and Super synchronous modes - Operation

Unit III - SCALAR CONTROL OF INDUCTION GENERATORS: Scalar Control background – Scalar Control Schemes –Open control schemes – closed loop control schemes– Problems.

Unit IV - VECTOR CONTROL OF INDUCTION GENERATORS: Vector Control – Axis Transformation – Space Vector Notation – Field Oriented Control – direct vector control- indirect vector control- Problems

Unit V - OPTIMIZED CONTROL OF INDUCTION GENERATORS: Optimization Principles – Application of Hill Climbing Control (HCC) for Induction Generators- HCC based Maximum Power Search – Fuzzy Logic Controller based Maximum Power Search – Problems

Reference Books

1. Godoy Simões M., Farret F. A., "Renewable Energy Systems: Design and Analysis with Induction Generators," CRC Press, Boca Raton, 2007.
2. Vladislav Akhmatov, "Induction Generators for Wind Power", Multi-Science Publishing Company, UK, 2007.
3. Gilbert M. Masters, "Renewable and Efficient Electric Power Systems", John Wiley & Sons Inc., New Jersey, 2004.
4. Frede Blaabjerg, Zhe Chen, "Power Electronics for Modern Wind Turbines" Morgan & Claypool Publishers, USA, 2006.
5. Loi Lei Lai, Tze Fun Chan, "Distributed Generation: Induction and Permanent Magnet Generators", John Wiley & Sons, England, 2007.

17EE3044 GRID CONVERTERS FOR WIND POWER SYSTEMS

Credits: 3:0:0

Course Objectives:

- To illustrate key concepts about converter structures and grid requirements
- To enlighten the students about the latest power conversion and control technology in photovoltaic and wind power systems
- To provide in-depth understanding about grid synchronization

Course Outcomes:

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

- Outline the need and design of grid converters for wind power system
- Summarize the different converter structures and the stringent grid requirements
- Illustrate grid synchronization in three-phase power converters
- Analyze the topologies, modulation and control of grid converters for wind power applications.
- Formulate grid converter control strategies during grid faults
- Choose the appropriate grid filter design and current control.

Unit I - GRID CONVERTER STRUCTURES AND REQUIREMENTS FOR WIND TURBINE SYSTEMS: WTS power configurations – Grid power converter topologies – WTS control – Grid code evolution – Frequency and voltage deviation under normal operation – Active power control in normal operation – Reactive power control in normal operation – Behaviour under grid disturbances

Unit II - GRID SYNCHRONIZATION IN THREE-PHASE POWER CONVERTERS: Three-phase voltage vector under grid faults – Synchronous reference frame PLL under unbalanced and distorted grid conditions- Decoupled double synchronous reference frame PLL – Double second order generalized integrated FLL

Unit III - GRID CONVERTER CONTROL FOR WIND TURBINE SYSTEM: Model of the converter – AC voltage and DC voltage control – Voltage oriented control and direct power control – Stand-alone, micro-grid, droop control and grid supporting

Unit IV - CONTROL OF GRID CONVERTERS UNDER GRID FAULTS: Overview of control techniques for grid-connected converters under unbalanced grid voltage conditions – Control structures for unbalanced current injection – Power control under unbalanced grid conditions – Flexible power control with current limitation

Unit V - GRID FILTER DESIGN AND GRID CURRENT CONTROL: Filter topologies – Design considerations – LCL filters and grid consideration – Resonance problem and damping solutions – Nonlinear behavior of filter – Current harmonic requirements – Modulation techniques – Operating limits of the current-controlled converter – Case study

Reference Books:

1. Teodorescu R., Liserre M., Rodriguez P., “Grid Converters for Photovoltaic and Wind Power System”, John Wiley & Sons Ltd., UK, 2011.
2. Wu B., Lang Y., Zargari N., Kouro S., “Power Conversion and Control of Wind Energy”, John Wiley & Sons, New Jersey, 2011.
3. Zhong Q.C., Hornik T., “Control of Power Inverters in Renewable Energy and Smart Grid Integration”, John Wiley & Sons, UK, 2013.
4. Gevorkian P., “Large-Scale Solar Power System Design – An Engineering Guide for Grid-Connected Solar Power Generation”, Mc-Graw Hill, New York, 2011.
5. Vittal V., Ayyanar R., “Grid Integration and Dynamic Impact of Wind Energy”, Springer, New York, 2013.

17EE3045 DATA MINING FOR RENWABLE ENERGY SYSTEMS

Credit 3:0:0

Course Objectives

- To enlighten the students on the basic concepts of data mining.
- To improve the students’ competence in the algorithms and learning schemes of data mining.
- To enable the students to exploit the data mining techniques for research in renewable energy.

Course Outcomes

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

- understand the importance of data-driven performance optimization of renewable energy system.
- exploit the vast data base available in the renewable energy sector and devise ways to make renewable energy a competitive source of supply.
- Classify and analysis the different type of data
- Prediction of data with error measures
- Apply data mining for the prediction of power from renewable energy sources
- Find the various research opportunities provided by this field.

Unit I - INTRODUCTION: Data Mining – Kinds of Data – Functionalities – Classification – Primitives – Major Issues –Data Preprocessing – Descriptive Data Summarization - Data Cleaning – Data Integration and Transformation - Data Reduction
Unit II - DATA WAREHOUSE: AN OVERVIEW: Data Warehouse – Multidimensional Data Model – Data Warehouse Architecture – Data Warehouse Implementation – From Data Warehousing to Data Mining. Mining Frequent Patterns, Associations: Basic Concepts and a Road Map – Efficient and Scalable Frequent Item set -Mining Methods- Mining Multilevel Association Rules
Unit III - CLASSIFICATION AND PREDICTION: Issues regarding classification and prediction - Decision tree Induction - Bayesian Classification – Lazy Learners – Other Classification Methods – Prediction – Accuracy and Error Measures.
Unit IV - CLUSTER ANALYSIS: Types of Data – Categorization of Major Clustering Methods –Partitioning Methods – Hierarchical Methods. Mining Stream, Time-Series and Sequence Data Mining- Data Streams – Mining Time-series- Data- Mining Sequence Patterns in Transactional Databases
Unit V - APPLICATIONS IN RENEWABLE ENERGY TECHNOLOGY: Application of Data Mining in Wind Power System -Wind Power Prediction- Modeling and Forecasting of Solar Radiation Data - Analyzing Solar Power Plant Performance.

Reference Books

1. Jiawei Han, Micheline Kamber, "Data Mining: Concepts and Techniques", 2nd Edition, Morgan Kaufmann Publishers, San Francisco, 2006
2. Ian Witten, Eibe Frank, "Data Mining: Practical Machine Learning Tools and Techniques", 3rd Edition, Morgan Kaufmann Publishers, San Francisco 2011.
3. Sumathi S., S. N. Sivanandam, "Introduction to Data Mining and its Applications", Springer-Verlag Berlin Heidelberg, 2006.
4. David Hand, Heikki Mannila, Padhraic Smyth, "Principles of Data Mining", A Bradford Book, The MIT Press, Cambridge, Massachusetts London, England, 2001.
5. Michael J A Berry, Gordon S Linoff, "Data Mining Techniques", 2nd Edition, Wiley India, 2004.

17EE3046 POLICY AND REGULATORY ASPECTS OF RENEWABLE POWER GENERATION
Credits 3:0:0

Course Objectives

- Study the policy and regulatory framework to make renewable power generation economically viable.
- Understand the problems of high transmission and distribution (T&D) losses, frequent disruption in supply of grid power, practical problems and financial non-viability of the transmission grids.
- Students will be encouraged to simulate some case studies using RET Screen & HOMER software.

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

- State the regulations for the DG-Grid interconnection.
- Select the suitable type of DG-Grid interconnection.
- Use the policy frameworks for various renewable energy sources including distributed and decentralized energy solutions.
- Analyze the challenges associated with the deployment of these technologies.
- Evaluate the economic and technical viability of renewable power generation.
- Create awareness about the policies and benefits of renewable power generation.

Unit I - DISTRIBUTED GENERATION: Distributed versus traditional power systems- Need and advantage of Decentralized energy solutions- Renewable resource distributed generators-Solar thermal power generation, solar Photovoltaic power generation, Wind powered generation, other renewable generation resources.
Unit II - STATUARY REQUIREMENTS AND ACTIVITIES: Cost and economic evaluation-Renewable energy credit schemes, Statuary requirements and activities of various states -Tariff determination issue - National Solar Mission - Emergence of policy and regulatory framework for decentralized electricity (Gokak Committee report).
Unit III - ON GRID RENEWABLE ENERGY SYSTEMS: Grid interconnection options-the power grid-Regulations regarding grid interconnections of renewable energy systems -Pros and cons of grid interconnection-

Suitable type of DG-Grid Interconnection-Guidelines and policies- Electrification and on grid status/scenario (national and International) - Case study.

Unit IV - OFF GRID DISTRIBUTED SYSTEMS: Electrification and off grid status/scenario in India - Scope and challenges in implementing off grid solutions - Policy & regulatory Framework for rural electrification - Relevant policies and frameworks in other countries – Case study.

Unit V - OFF GRID PROGRAMS OF INDIA: Recent off grid programs started by Govt. of India for enhancing the rural electrification through off-grid solutions - DDG scheme under Rajiv Gandhi Grameen Vidyutikaran Yojana (RGGVY) - Remote Village Electrification Program - Village Energy Security Program (VESP) - Off grid Program under JNNSM Case study.

Reference Books:

1. Distributed Power Generation Planning and Evaluation, H.Lee Willis, Walter G. Scott, IET Power Marcel Dekker, Inc. (2000).
2. Comparative Study on Rural Electrification Policies in Emerging Economies: Keys To Successful Policies; International Energy Agency.
3. Best practices of the Alliance for Rural Electrification: what renewable energy can achieve in developing countries; Alliance for Rural Electrification.
4. Gokak Committee Report on DDG & Report on the Working Group on Power for Eleventh Plan (2007-12).

Journals and Magazines:

1. The Zambian ESCO project.
2. Sunlight Power Maroc (Morocco).
3. Solar Energy Supplies in Zimbabwe.
4. Off grid solutions applied in various parts of India (e.g. LaBL- SMU, NTPC DDG, VESP, DESI Power, Husk Power, etc).
5. SHP in Nepal and Sri Lanka
6. IDCOL/Grammen Shakti model in Bangladesh

17EE3047 OCEANIC ENERGY

Credits: 3:0:0

Course Objectives

- To provide necessary knowledge about the basics, design and analysis of two important oceanic energy components i.e., tidal and wave.
- To make the learner to understand the operation of tidal power plants and wave power plants
- To impart the basic knowledge about integration of tidal and wave power plants with grid

Course Outcomes

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

- Get the awareness about the possibilities of power generation from ocean
- Understand the different tidal power schemes, modes of operation
- Outline the different models with mathematical expressions
- Suggest new mechanisms to harvest energy from ocean
- Calculate the power obtained from the waves
- Design efficient tidal and wave power plants

Unit I - INTRODUCTION TO TIDAL ENERGY: Historical Development -Tidal phenomenon-Ocean tides - Types of tides -Propagation of tides in estuaries -Coriolis effect -Barrage effects –Tidal power potential and site selection -Hydroelectric versus Tidal-Electric Developments-Site potential estimation-Coefficient of the tide-Major factors influencing project economics-Site selection- Management and organization of investigations-Management-Organization- Feasibility studies

Unit II - TIDAL POWER SCHEMES, MODES OF OPERATION AND MODELS: Single-Basin development, Single-effect mode of operation- Single-basin development, Double-effect mode of operation, Pumping to augment tidal effect, Linked-basin developments - Paired-basin developments - Retiming of tidal energy - Basic data - General physiography of the estuary- Geology - Tides -Waves - Tidal currents - Suspended and mobile sediments – Ecosystem characteristics - Hydraulic and numerical models in feasibility investigations- Hydraulic models-

Numerical models for estuaries - Hybrid models - Modeling of barrier effects – Mathematical model for closure activities - Utility system planning and simulation

Unit III - TIDAL POWER PLANTS: Civil works -Dry versus wet Construction - Design parameters - Caisson design- Dikes- Construction schedules- Electromechanical equipment – Specific requirements for tidal generating equipment- Types of turbines - Generators – Electrical equipment – Transmission-Integration of output with electric utility systems - Absorption of raw tidal energy -Enhancing raw tidal energy output - System considerations

Unit IV - INTRODUCTION TO WAVE ENERGY: Wave structure- Wave power calculations- Global wave energy -Wave energy potential- Wave energy technologies- Wave concentration effects- Tapered channel - Oscillating water column- Mighty whale design

Unit V - WAVE POWER PLANTS: Turbines for wave energy - Ocean wave conversion system-Wave energy power distribution-Grid connection-Wave energy-Environmental impacts.

Reference Books

1. Robert H. Clark, "Elements of Tidal-Electric Engineering", 1st Edition, Wiley-IEEE Press, USA, 2007.
2. Boyle, "Renewable Energy", 2nd Edition, Oxford University Press, UK, 2004.
3. Jack Hardisty , "The Analysis of Tidal Stream Power", Wiley, 1st Edition, UK, 2009
4. Michael E. McCormick, "Ocean Wave Energy Conversion" Dover Publications, 1st Edition, USA, 2009
5. Joao Cruz, Ocean Wave Energy: Current Status and Future Perspectives, Springer, 1st Edition, Berlin, 2010.

17EE3048 GEOTHERMAL ENERGY

Credits: 3:0:0

Course Objectives:

- To develop an in-depth understanding of the issues associated with the development of geothermal energy
- To make the students to realize the current state of geothermal energy resources and technologies
- To impart the knowledge of exergy analysis applicable to geothermal systems

Course Outcomes:

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

- Have knowledge regarding geothermal energy resources and the ability to utilize that resource
- Demonstrate a good understanding of the role which geothermal energy plays in the energy sector
- Perform the modeling and simulation for the reservoir
- Outline the different types of geothermal power generating system
- Understand the hybrid energy conversion system
- Analyze geothermal energy resources based on exergy Efficiencies

Unit I - INTRODUCTION: Geology of geothermal regions -The earth and its atmosphere-Active geothermal regions-Model of a hydrothermal geothermal resource-Other types of geothermal resources-Hot dry rock, HDR-Geopressure-Magma energy -Exploration strategies and techniques -Objectives of an exploration program -Phases of an exploration program-Synthesis and interpretation

Unit II - GEOTHERMAL WELL AND RESERVOIR: Geothermal well drilling-Geothermal reservoir and well flow- Well testing - Desired information- Calcite scaling in well casings- Reservoir modeling and simulation

Unit III - GEOTHERMAL POWER GENERATING SYSTEMS: Single-Flash Steam power plants-Gathering system design considerations - Energy conversion system - Thermodynamics of the conversion process -Equipment list for single-flash plants -Double-Flash steam power plants - Gathering system design considerations -Energy conversion system -Thermodynamics of the conversion process -Scale potential in waste brine -Equipment list for double-flash plants –Drysteam power plants -Origins and nature of dry-steam resources -Steam gathering system – Energy conversion system -Equipment list for dry-steam plants -Binary cycle power plants -Basic binary systems - Working fluid selection -Advanced binary cycles -Equipment list for basic binary plants

Unit IV - ADVANCED GEOTHERMAL ENERGY CONVERSION SYSTEMS: Hybrid single-flash and double-flash systems -Hybrid flash-binary systems -Total-flow systems -Hybrid fossil geothermal systems - Combined heat and power plants -Hot dry rock (enhanced geothermal systems) Power plants for hypersaline brines

Unit V - EXERGY ANALYSIS APPLIED TO GEOTHERMAL POWER SYSTEMS: First law for open, steady systems - Second law for open, steady systems -Exergy -Exergy accounting for open, steady systems -Exergy efficiencies and applications to geothermal plants.

Reference Books:

1. Ronald DiPippo, Geothermal Power Plants: Principles, Applications and Case Studies and environmental impact, 2nd Edition, Elsevier Science, USA, 2008.
2. Boyle, "Renewable Energy", Oxford University Press, 2nd Edition, UK, 2004.
3. Ernst Huenges, Patrick Ledru, "Geothermal Energy Systems: Exploration, Development, and Utilization", Wiley, 1st Edition, Weinhim, 2010.
4. Harsh K. Gupta, Sukanta Roy, "Geothermal Energy: An Alternative Resource for the 21st Century" Elsevier Science; 1st Edition, The Netherlands, 2006.

17EE3049 ENERGY MODELLING, ECONOMICS AND PROJECT MANAGEMENT

Credits: 3:0:0

Course Objectives

- To impart greater understanding of energy modeling in renewable energy technology.
- To throw light on the economic aspects involved in renewable energy technology.
- To enlighten the students on the various techniques involved in project management.

Course Outcomes

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

- Gain clear perspective on energy economy.
- Forecast the energy demand and plan wisely.
- Perform the input and output analysis for the energy and the environment
- Analysis the energy demand and forecasting the demand by using different methods
- Calculate the cost of electrical energy for the stand-alone systems
- Become excellent managers of the energy resources.

Unit I - MODELS AND MODELING APPROACHES: Macroeconomic Concepts - Measurement of National Output - Investment Planning and Pricing - Economics of Energy Sources – Reserves and Cost Estimation.
Unit II - INPUT-OUTPUT ANALYSIS: Multiplier Analysis - Energy and Environmental Input / Output Analysis - Energy Aggregation –Econometric Energy Demand Modeling - Overview of Econometric Methods.
Unit III - ENERGY DEMAND ANALYSIS AND FORECASTING: Methodology of Energy Demand Analysis - Methodology for Energy Technology Forecasting -Methodology for Energy Forecasting - Sectoral Energy Demand Forecasting.
Unit IV - ECONOMICS OF STAND-ALONE POWER SYSTEMS: Solar Energy - Biomass Energy - Wind Energy and other Renewable Sources of Energy -Economics of Waste Heat Recovery and Cogeneration - Energy Conservation Economics.
Unit V - PROJECT MANAGEMENT – FINANCIAL ACCOUNTING: Cost Analysis – Budgetary Control - Financial Management - Techniques for Project Evaluation.

Reference Books

1. Munasinghe M., Meier P., "Energy Policy Analysis and Modeling", Cambridge University Press, New York, 2008.
2. Spyros Makridakis, Steven C. Wheelwright, Rob J. Hyndman, "Forecasting Methods and Applications", Wiley, Singapore, 2008.
3. James Stock, Mark Watson, "Introduction to Econometrics", Pearson Education, New Delhi, 2nd Edition, 2006.
4. Kurt Campbell, Jonathon Price, "The Global Politics of Energy", The Aspen University, Washington, 2008.
5. Bob Shivley, John Ferrare, "Understanding Today's Electricity Business", Enerdynamics, Laporte, 2010

14EE3050 WASTE TO ENERGY CONVERSION

Credits 3:0:0

Course Objectives

- To understand the waste processing techniques, its treatment and disposal
- To study the different conversion process involved.
- To understand the environmental and health impacts of waste to energy conversion.

Course Outcomes

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

- Identify different types of waste and its processing techniques.
- Understand the waste treatment and size reduction methods
- Illustrate the methods used in Recovering Energy from Waste and thereby help in developing a green society.
- Compare the waste to energy conversion done in different sectors.
- Explain the properties of biomass used in rural sector.
- Summarize about the eco-technological alternatives for waste to energy conversions and hence to perform different case studies.

Unit I – INTRODUCTION: Solid Waste -Definitions: Sources, types, compositions; Properties of Solid Waste - Municipal Solid Waste: Physical, chemical and biological property; Collection, transfer stations; Waste minimization and recycling of municipal waste

Unit II - WASTE TREATEMENT AND DISPOSAL SIZE REDUCTION: Incineration; Furnace type & design; Types of Incinerators – Fuel Economy - Medical / Pharmaceutical waste / Hazardous waste / Nuclear Waste incineration.; Environmental impacts; Measures of mitigate environmental effects due to incineration

Unit III - ENERGY GENERATION FROM WASTE TYPES: Biochemical Conversion: Sources of energy generation,Industrial waste, agro residues; Anaerobic Digestion: Biogas production. Methods of treatment and recovery from the industrial waste water – Case Studies in sugar, distillery, dairy, pulp and paper mill,fertilizer, steel industry, textile, petroleum refining, chemical and power plant.

Unit IV - RURAL APPLICATIONS OF BIOMASS: Combustion - Biomass –Physical -Chemical composition – properties of biomass – TGA – DSC characterization – Ash Characterization - Preparation of biomass – Size reduction – Briquetting of loose biomass-Briquetting machine

Unit V - WASTE TO ENERGY CONVERSION-CASE STUDIES: Design of waste to energy plants for cities, small townships and villages. Case studies of commercial waste to energy plants, - eco-technological alternatives for waste to energy conversions – Rules related to the handling, treatment and disposal of Municipal Solid Waste (MSW) and Biomedical Waste (BMW) in India

Reference Books:

1. Gary C. Young, "Municipal Solid Waste to Energy Conversion Processes: Economic, Technical, and Renewable Comparisons", John Wiley & Sons, 2010.
2. Naomi Klinghoffer,Mardo Castaldi,"Waste to Energy Conversion" Woodhead Publishing,15th May 2013.
3. Christian Furedy, Alison Doig, "Recovering Energy from Waste Various Aspects", Science Publishers, Inc. Enfield (NH) USA, 2002.
4. Robert Green, "From Waste to Energy", Cherry Lake Publishing limited, USA, 2009.
5. Dieter D., Angelika S., "Biogas from Waste and Renewable Resources", Wiley-VCH Verlag GmbH & Company, Germany, 2010.

17EE3051 TURBINES FOR RENEWABLE ENERGY SYSTEMS

Credits 3:0:0

Course Objectives

- The students will be exposed to different turbines for renewable energy
- Designing turbines for different power generation schemes using the renewable energy will be highlighted
- Any flaws and faults related to turbines and its design will be discussed

Course Outcomes

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

- Understand the concept of energy conversion
- Classify the different types of turbines, its behavior under various conditions.
- Design of turbines for different power generations
- Model the different types of turbines for the renewable power generations.
- Identify the different types of faults occurred while designing the turbines
- An exposure to drawbacks and faults associated with the existing system**.**

Unit I - INTRODUCTION TO TURBINE DESIGN: Concept of Energy conversion – Types of Turbines – Turbines for Power Generation – Solar Energy based, Wind Energy, Hydro Energy, Tidal Energy, OTEC and Geothermal Energies- Introduction. General Turbine design aspects.
Unit II - TURBINE DESIGN FOR SOLAR BASED POWER GENERATION: Solar based power generation types- organic fluid based low temperature system, solar tower based high temperature system- Turbine Models used – designing – Drawbacks and faults related to turbines- Problems.
Unit III - WIND TURBINE DESIGN: Horizontal and vertical axis wind turbines- design- problems related to design - Faults related to wind turbines- softwares for turbine design-overview
Unit IV - TURBINES FOR HYDRO POWER GENERATION: Introduction to hydro power generation- conventional, pumped storage - Different types of hydro turbine designs- Francis, Pelton, Kaplon turbines - Design problems.
Unit V - TURBINES FOR GEOTHERMAL AND OCEAN ENERGY: Turbine for Geothermal plant- Turbine design for Tidal power- Turbines for Ocean thermal energy conversion systems. Design issues- problems

Reference Books

1. David.M. Eggleston., "Wind Turbine Engineering design", Amazon publications, 1st Edition, 1987.
2. Peter Jamieson., "Innovation in Wind turbine design" Wiley, 1st Edition, 2011.
3. Jeremy Thake., "The Micro-Hydro Pelton Turbine Manual: Design, Manufacture and Installation for Small-Scale Hydro-Power", Practical Action Publisher, 2001
4. Shylakhin P., "Steam Turbines: Theory and Design", University Press of the Pacific, 2005.

17EE3052 SOLAR THERMAL ENERGY CONVERSION

Credits: 3:0:0

Course Objectives
- To provide a comprehensive engineering basics for solar thermal system and its design.
- To understand the different technologies of solar thermal systems.
- To get know about the different types of solar heating & cooling.

Course Outcomes
At the end of the course, the student will be able to
- Describe the radiative properties and the purpose of selective surfaces in solar thermal energy harvesting.
- Choose the right type of solar collector for an application.
- Analyze the performance of different solar collectors.
- Model a solar thermal system using simulation tools.
- Calculate the thermal load and suggest a suitable energy storage system.
- Design a solar thermal energy system application for the desired requirements.

Unit I - RADIATIVE PROPERTIES AND CHARACTERISTICS OF MATERIALS: Thermal radiation fundamentals - Reflection from ideal specular, ideal diffuse and real surfaces - Selective Surfaces: Ideal coating characteristics, Types and applications - Anti-reflective coating - Reflecting Surfaces and transparent materials – Solar radiation – Instruments for measuring solar radiation and sunshine.
Unit II - SOLAR COLLECTORS: Solar Collectors & its Classification - Stationary Collectors - Flat Plate Collectors: Liquid Flat Plate Collectors, Air flat-plate Collectors - Compound parabolic collectors - Evacuated tube collectors - Sun tracking concentrating collectors: Parabolic trough collectors, Linear Fresnel reflector, Parabolic dish reflector, Heliostat field collector - Comparison of various designs - Testing methods.
Unit III - MODELING AND ANALYSIS OF SOLAR COLLECTORS: Thermal analysis of collectors - Flat-plate collectors performance, Concentrating collectors performance - Performance of solar collectors - Modelling of

solar systems - TRNSYS simulation program, F-Chart method and program, Artificial neural networks in solar energy systems modelling and prediction - Limitations of simulations - Economic analysis.

Unit IV - SOLAR THERMAL ENERGY STORAGE: Solar Process loads and solar collector output – Energy storage in solar process systems - Classification - Sensible storage: Water storage, Packed Pebble storage, Storage Walls - Latent heat storage - Thermo-chemical storage – Battery Storage - Design of storage system.

Unit V - SOLAR THERMAL APPLICATIONS: Solar water heating systems, Solar space heating and cooling - Methods of modeling and design of solar heating system - Cooling requirements of buildings – Solar Refrigeration – Solar Desiccant cooling - Industrial Process heat – Solar Desalination system – Solar thermal Power system – Solar furnaces – Solar Pond – Solar Cooker.

Reference Books

1. Duffie J.A., Beckman W.A., Solar Engineering of Thermal Processes, John Wiley & Sons, New York, 2013.
2. Kalogirou S. A., “Solar thermal collectors and applications,” Progress in Energy and Combustion Science, Elsevier Journal, Vol. 30, pp. 231–295, 2004.
3. Yogi Goswami D., Frank Kreith, “Energy Conversion”, CRC Press, New York, 2007.
4. "ASHRAE Handbook Authors and Revisers Guide", ASHRAE Inc., Atlanta, 2007.
5. Yogi Goswami D., Frank Kreith, “Principles of Solar Engineering”, 3rd Edition, CRC Press, 2015.

17EE3053 BIOMASS ENERGY

Credits 3:0:0

Course Objectives:

Ability to

- classify the biomass resources and biomass conversion processes
- construct a small size gasifier and biogas plant
- explain the alcohol production method from biomass

Course Outcomes

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

- list the thermo chemical conversion process of biomass
- design a community biogas plant
- select a biogas plant for the given application
- develop a small size biomass gasifier
- explain the application of bio-fuels
- demonstrate the power generation techniques using biomass waste

Unit I - ENERGY FROM BIOMASS: Biomass resources, energy plantation, design and management of energy plantation, advantages of energy plantation, plants proposed for energy plantation, photosynthesis, biomass conversion technologies, thermo chemical conversion, direct combustion, biochemical conversion, biodegradability.

Unit II - BIOGAS GENERATION: Classification of biogas plants, biogas generation, anaerobic digestion, floating drum plant, fixed dome type plant, continuous and batch type, Janta biogas plant, deen bandhu biogas plant, khadi and village industries type biogas plant, ferro-cement digester biogas plant, biogas from plant wastes, wet and dry fermentation, problem in straw fermentation, pilot plants using plant wastes, community biogas plants, materials used for biogas generation, additives, factors affecting bio-digestion.

Unit III - DIGESTER DESIGN: Design based on methane production rate, design based on end user requirements, scaling of biogas plants, digester sizing, methods for maintaining biogas production, problems related to biogas plants, starting a biogas plant, filling a digester for starting, fuel properties of biogas, selection of site for a biogas plant.

Unit IV - UTILIZATION OF BIOGAS: Modification of SI and CI engine, biogas use in stationary power plants, mobile power plants, use of biogas in refrigerators, gas turbines, economic viability of biogas technology, biogas technology scenario in India, purification, scrubbing, compression and storage of biogas, biogas burners.

GASIFIER: Gasification process, gasification of wood, wood gas purification and shift conversion, gasification equipment, use of wood gas in engines, classification of biomass gasifiers, fixed bed gasifier, fluidized bed gasifier, applications of the gasifier, problems in development of gasifiers.

Unit V - ELECTRICITY PRODUCTION FROM BIOMASS WASTES: Pyrolysis, pyrolysis yields from the dry wood, types of pyrolysis, biodiesel from vegetable oil and pyrolysis oil, use of biodiesel in engine, alcohol fuels, ethanol production from wood and sugar cane, methanol production, electricity production from municipal solid wastes, animal wastes, plant residues, pulp and paper industry wastes, distillery waste, high rate digester for industrial waste water treatment.

Reference Books

1. G.D.Rai, Non Conventional Energy Sources, Eighth reprint, 2013, khanna publishers, 2013
2. Nijaguna, B.T, "Biogas Technology", New Age International Private Ltd, New Delhi, 1stEdition, 2009.
3. N.H.Ravindranath, Hall D.O., "Biomass, Energy and Environment", Reprinted Edition, Oxford University Press, Oxford, 2002.
4. Chawla O.P., "Advances in biogas technology", Publications and Information Division, Indian Council of Agricultural Research, New Delhi, 2009.
5. 5.Mital, K.M,"Biogas Systems: Principles and Applications", 1st Edition, New Age International Private Ltd, New Delhi, 2009.

LIST OF COURSES

Sl.No	Course Code	Name of the Course	Credits
1	16EE1001	Electricity For Engineers	3:0:0
2	16EE2001	AC Machines Laboratory	0:0:2
3	16EE2002	DC Machines and Transformers Laboratory	0:0:1
4	16EE2003	Electrical Measurements & Control System Laboratory	0:0:1
5	16EE2004	Electric Drives and Control Laboratory	0:0:1
6	16EE2005	Smart Grid Laboratory	0:0:1
7	16EE2006	Power Electronics Application to Renewable Energy Laboratory	0:0:2
8	16EE2007	Automotive Electrical and Electronics	3:0:0
9	16EE2008	Electric Drives for Mechatronics Systems	3:0:0
10	16EE3001	Control and Drives for Solar Tracking Systems	3:0:0
11	16EE3002	Power Electronics for High Power Applications	3:0:0
12	16EE3003	Advanced Electric Drives and Control Laboratory	0:0:1

REVISED VERSION OF COURSES

S.No	Sub. Code	Version	Name of the Course	Credits
1	14EE1001	1.1	Basic Electrical Engineering	3:0:0
2	14EE2001	1.1	Electric Circuits and Networks	3:1:0
3	14EE2002	1.1	Electric Circuit Analysis	3:1:0
4	14EE2003	1.1	Network Analysis and Synthesis	3:1:0
5	14EE2004	1.1	Electromagnetic Fields	3:1:0
6	14EE2005	1.1	DC Machines and Transformers	3:1:0
7	14EE2006	1.1	DC Machines and Transformers Laboratory	0:0:2
8	14EE2007	1.1	Induction and Synchronous Machines	3:1:0
9	14EE2008	1.1	AC Machines and Controls Laboratory	0:0:2
10	14EE2009	1.1	Electrical Machine Design	3:1:0
11	14EE2010	1.1	Power Electronics	3:0:0
12	14EE2011	1.1	Power Electronics Laboratory	0:0:2
13	14EE2012	1.1	Electric Drives and Control	3:0:0
14	14EE2013	1.1	Transmission and Distribution	3:1:0
15	14EE2014	1.1	Power System Analysis	3:1:0
16	14EE2015	1.1	Computer Aided Power System Analysis Laboratory	0:0:2
17	14EE2016	1.1	Power System Protection and Switchgear	3:0:0
18	14EE2017	1.1	Linear, Digital IC and Measurements Laboratory	0:0:2
19	14EE2018	1.1	Energy Systems	3:0:0
20	14EE2019	1.1	Special Electrical Machines	3:0:0
21	14EE2020	1.1	Automotive Electronics	3:0:0
22	14EE2021	1.1	Illumination Engineering	3:0:0
23	14EE2022	1.1	Power System Stability	3:0:0
24	14EE2023	1.1	Power System Operation and Control	3:0:0
25	14EE2024	1.1	Basics of Electric and Hybrid Vehicle	3:0:0
26	14EE2025	1.1	Fundamentals of Electrical Safety	3:0:0
27	14EE2026	1.1	High Voltage Engineering	3:0:0
28	14EE2027	1.1	HVDC and FACTS	3:0:0
29	14EE2028	1.1	Building Automation	3:0:0
30	14EE2029	1.1	Design Laboratory	0:0:1

31	14EE2030	1.1	Power System Simulation Laboratory	0:0:2
32	14EE2031	1.1	Renewable Energy – I	3:0:0
33	14EE2032	1.1	Renewable Energy – II	3:0:0
34	14EE2033	1.1	Power Quality	3:0:0
35	14EE2034	1.1	Power System Reliability	3:0:0
36	14EE2035	1.1	Switched Mode Power Supplies	3:0:0
37	14EE2036	1.1	Smart Grid	3:0:0
38	14EE2037	1.1	Computer Aided Graphics for Electrical Engineers	0:0:2
39	14EE2038	1.1	Advanced Topics in Power Electronics	3:0:0
40	14EE3001	1.1	Power Semiconductor Devices	3:0:0
41	14EE3002	1.1	Power Converter Analysis – I	3:0:0
42	14EE3003	1.1	Power Converter Analysis – II	3:0:0
43	14EE3004	1.1	Solid State DC Drives	3:0:0
44	14EE3005	1.1	Solid State AC Drives	3:0:0
45	14EE3006	1.1	Waste To Energy Conversion	3:0:0
46	14EE3007	1.1	Generalized Theory of Electrical Machines	3:0:0
47	14EE3008	1.1	Special Machines and Controllers	3:0:0
48	14EE3009	1.1	Power Electronics Laboratory	0:0:2
49	14EE3010	1.1	Electric Drives and Control Laboratory	0:0:2
50	14EE3011	1.1	Photovoltaic Systems	3:0:0
51	14EE3012	1.1	Power Electronic Circuits	3:0:0
52	14EE3013	1.1	Energy Engineering	3:0:0
53	14EE3014	1.1	Wind Energy	3:0:0
54	14EE3015	1.1	Hydrogen and Fuel Cells	3:0:0
55	14EE3016	1.1	Energy Management and Audit	3:0:0
56	14EE3017	1.1	Energy Modeling, Economics and Project Management	3:0:0
57	14EE3018	1.1	Solar Energy Laboratory	0:0:2
58	14EE3019	1.1	Wind Energy Laboratory	0:0:2
59	14EE3020	1.1	Power Engineering Simulation Laboratory	0:0:2
60	14EE3021	1.1	Flexible AC Transmission Systems	3:0:0
61	14EE3022	1.1	HVDC Transmission	3:0:0
62	14EE3023	1.1	Industrial Power System Analysis And Design	3:0:0
63	14EE3024	1.1	Distributed Generation	3:0:0
64	14EE3025	1.1	Communications And Control In Smart Grid	3:0:0
65	14EE3026	1.1	Electrical Transients in Power Systems	3:0:0
66	14EE3028	1.1	Power System Planning And Reliability	3:0:0
67	14EE3029	1.1	Electric and Hybrid Vehicles	3:0:0
68	14EE3030	1.1	Modelling And Design of Electric And Hybrid Vehicle	3:0:0
69	14EE3031	1.1	Power Management For HEV	3:0:0
70	14EE3032	1.1	Hybrid-Electric Vehicle Powertrains	3:0:0
71	14EE3033	1.1	Vehicle Energy Storage Systems	3:0:0
72	14EE3034	1.1	Electric Vehicle Battery Technology	3:0:0
73	14EE3035	1.1	Modeling of Power Converters	3:0:0
74	14EE3036	1.1	Power Electronics in Wind and Solar Power Conversion	3:0:0
75	14EE3037	1.1	DSP Based Control of Power Electronics and Drives	3:0:0
76	14EE3038	1.1	Power Quality	3:0:0

77	14EE3039	1.1	Tidal Energy	3:0:0
78	14EE3040	1.1	Simulation of Power Electronic Systems	3:0:0
79	14EE3041	1.1	Power Electronics Applications to Power System	3:0:0
80	14EE3042	1.1	Neuro-Fuzzy Controller for Electric Drives	3:0:0
81	14EE3043	1.1	Advanced Control Techniques for Induction Generators	3:0:0
82	14EE3044	1.1	Optimal Control of Wind Energy Systems	3:0:0
83	14EE3045	1.1	Wind Resource Assessment and Forecasting Methods	3:0:0
84	14EE3046	1.1	Turbines for Renewable Energy System	3:0:0
85	14EE3047	1.1	Data Mining for Renewable Energy Technologies	3:0:0
86	14EE3048	1.1	Grid Converters For Wind Power Systems	3:0:0
87	14EE3049	1.1	Offshore Wind Power	3:0:0
88	14EE3050	1.1	Wind Power In Power Systems	3:0:0
89	14EE3051	1.1	Solar Cell And Module Technology	3:0:0
90	14EE3052	1.1	PV System Design And Installation	3:0:0
91	14EE3053	1.1	Materials For Solar Power	3:0:0
92	14EE3054	1.1	Passive Solar Architecture	3:0:0
93	14EE3055	1.1	Oceanic Energy	3:0:0
94	14EE3056	1.1	Geothermal Energy	3:0:0
95	14EE3057	1.1	Policy And Regulatory Aspects Of Renewable Power	3:0:0
96	14EE3058	1.1	Nuclear Engineering	3:0:0
97	14EE3059	1.1	Hydro Power Technology	3:0:0
98	14EE3060	1.1	Design and Development of Wind Turbines	3:0:0

16EE1001 ELECTRICITY FOR ENGINEERS

Credits: 3:0:0

Course Objective

- To understand the functioning of electric grid and home power supply.
- To explore the impact of electric motors in various fields.
- To impart the basic knowledge and recent advancements in instrumentation technology.

Course Outcome

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

- Identify the type of electrical machine used for a particular application.
- Understand the various sensing, conditioning and display devices.
- Appreciate the impact of electricity in everyday life and strive to use it judiciously.

Course Description

Electric Grid: Concept of current, voltage, power and energy, Schematic diagram, Conventional Power Plants,Non-conventional Sources, Transmission Systems, Distribution Systems – Substations, Transformers, Smart Grids.

Home Power Supply: Domestic Wiring, Energy Meter (Digital/Smart), EB Tariff, Energy Saving Methods, BEE, Star Rating for Electrical Appliances, Fluorescent lamp, CFL, LED. Batteries-Chargers, Home UPS, Stabilizers. Heating application – Electric heaters. Smart homes (Burglar alarm, gas leakage detection), Electrical Safety.

Electrical Motors: Construction and Working of a General Electrical Motor, Applications of Motors: Home appliances (Fan, Laptop, Hair dryer, Mixer, Grinder, Air conditioner, Washing machine, Refrigerators), Machine Tools (Lathe, CNC machines), Agriculture (Water pump), Textile industry, Medical (Motorized catheters, Implanted blood pumps), Nano motors - Robotics and Automation. Electricity in Transportation: Electric Train, Electric Car, Electric bike, Solar Powered Airplane. Instrumentation Technology: Sensors: Overhead tank water level indicator, Washing Machines - Altitude and Pressure measurement in Aircrafts – Gyro and accelerometers in Space crafts – Biomedical Instruments: X-ray machine, blood pressure measurement, ultrasound scanner –Agricultural Instruments: Soil moisture measurement, Ground water level monitoring, Automatic irrigation system- Food processing (Biscuit making)

References:

1. A. H. Robbins, W. C. Miller, "Circuit Analysis: Theory and Practice", Fifth Edition, Delmar Cengage Learning, New York, 2013.
2. Robert.B. Northrop, "Introduction to Instrumentation and Measurements", CRC press, Taylor and Francis group, Second Edition, 2011.
3. S. F. Bush, "Smart Grid: Communication-Enabled Intelligence for the Electric Power Grid", John Wiley & Sons, New York, 2014.
4. J. Larminie, J. Lowry, "Electric Vehicle Technology Explained", John Wiley & Sons, New York, 2013.
5. Haitham Abu-Rub, Mariusz Malinowski, Kamal Al-Haddad, "Power electronics for Renewable Energy Systems, Transportation and Industrial Applications, John Wiley & Sons Limited, Sussex, 2014.

16EE2001 AC MACHINES LABORATORY

Credits 0:0:2
Corequisite: 14EE2007 Induction and Synchronous Machines

Course Objective:

- To prepare students to understand, demonstrate and analyze the concepts of AC Machines.

Course Outcomes:
The students will be able to

- Analyze the operation of AC machine under different loading conditions.
- Perform the testing of the AC machine.

Course Description:
The laboratory will demonstrate the student about the operation and performance analysis of a AC Machines and derive the transfer function for an electromechanical system.

Experiments:
The faculty conducting the laboratory will prepare a list of 12 experiments and get the approval of HOD/Director and notify it at the beginning of each semester.

16EE2002 DC MACHINES AND TRANSFORMERS LABORATORY

Credits: 0:0:1
Corequisite: 14EE2005 DC Machines and Transformers

Course Objectives:

- Examine the relationship between the electrical and mechanical parameters of a DC electric machine and Transformer.
- To analyze the various control methods for the electrical machines.

- To gain knowledge about the losses and its influence in the performance of the electrical machines.

Course Outcomes:

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

- Find the mathematical model of DC machine.
- Determine/predetermine the loss calculation of DC motors and Generators.
- Analyze the operation of electric machines under different loading conditions.

Course Description:

The laboratory will demonstrate the student to

- Develop practical skills for measuring electrical and mechanical quantities (Current, voltage, power, efficiency, regulation, torque, speed)
- Describe performance and control characteristics of DC machines and Transformers.
- Analyze the method of testing to derive the equivalent circuit of a given machine.

Experiments:

The faculty conducting the laboratory will prepare a list of 06 experiments and get the approval of HOD/Director and notify it at the beginning of each semester.

16EE2003 ELECTRICAL MEASUREMENTS & CONTROL SYSTEM LABORATORY

Credit: 0:0:1

Course Objectives

- To learn about the measurement techniques for various electrical quantities
- To know of about power quality assessment
- To learn about the modeling of various electrical machines and their parameters determination

Course Outcomes

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

- Measure different electrical quantities with appropriate measurement techniques
- Assess power quality using power quality analyzer
- Determine the model parameters of various electrical machines and to design simple controllers

Course Description

This laboratory demonstrates the students about measurement of any parameters using suitable instruments and control system experiments.

Experiments:

The faculty conducting the laboratory will prepare a list of 06 experiments and get the approval of HOD/Director and notify it at the beginning of each semester.

16EE2004 ELECTRIC DRIVES AND CONTROL LABORATORY

Credits: 0:0:1

Course Objectives:

- To understand the operation and control strategies of electric drives.

Course Outcomes:

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

- Choose right drive based on the joint torque-speed characteristics of the load.

- Possess an understanding of feedback control theory.
- Develop control algorithms for electric drives which achieve the regulation of torque, speed, or position in the above machines.

Course Description:
The lab will consist of giving the students hands-on experience with electric drives (AC and DC), power converter and control algorithms for electric drives.
Experiments:
The faculty conducting the laboratory will prepare a list of 6 experiments and get the approval of HOD/Director and notify it at the beginning of each semester.

16EE2005 SMART GRID LABORATORY

Credits 0:0:1
Pre requisite : 14EE2014 Power system Analysis

Course Objective
- To Learn the physical model of the power system network
- To Understand the concept of information and communication technology
- To Study the basic principle of renewable energy integration to smart grid

Course Outcomes:
At the end of the course, the student will be able to
- Implement the concept of smart grid
- Establish the various control strategies for smart grid network.
- Interpret and manage the volumes of data

Course Description:
The Laboratory will demonstrate the smart grid functions like two way communication, Data collection and Monitoring, Pricing and load scheduling, demand management system.
Experiments:
The faculty conducting the laboratory will prepare a list of 6 experiments and get the approval of HOD/Director and notify it at the beginning of each semester.

16EE2006 POWER ELECTRONICS APPLICATION TO RENEWABLE ENERGY LABORATORY

Credits 0:0:2
Prerequisite: 14EE2010 Power Electronics

Course Objective:
- To study the role of power electronics in photovoltaic energy conversion and wind energy conversion systems.
- To learn the grid integration of renewable energy conversion systems.

Course Outcome:
At the end of the course, the student will be able to
- design and test suitable power converters for solar and wind based systems.
- become proficient with simulation skills for the analysis of power electronic circuits for renewable energy systems.

Course Description:
This laboratory demonstrates the students the usage of Power Electronics in Solar and Wind Energy based systems.

Experiments:
The faculty conducting the laboratory will prepare a list of 12 experiments and get the approval of HOD/Director and notify it at the beginning of each semester.

16EE2007 AUTOMOTIVE ELECTRICAL AND ELECTRONICS SYSTEMS

Credits: 3:0:0

Course Objective:
- To learn the automotive electrical and electronic systems
- To learn about electrical energy supply system for the vehicle
- To understand the advanced comfort and safety systems available for automobiles

Course Outcome:
At the end of the course the students will be able to
- Gain fundamental knowledge about various electrical and electronics components that are used in automobiles
- Explain the functioning of various accessories of automobiles
- Describe the various comfort and safety system

Description:
Electrical energy supply in the vehicles, Electrical energy management, Two-battery vehicle electrical system, - Battery maintenance, Alternators: Operating principle, Voltage regulation, Overvoltage protection, Characteristic curves, Starter batteries: Function and requirements, Operating principle, Battery characteristics, Battery-Charging systems, Starter Motor design, types and operations- Electromagnetic compatibility (EMC) and interference suppression- Symbols and circuit diagrams, Earthing, Positive and negative Relays, Automotive sensors and actuators, Electronic components in the vehicle, Ignition systems, Electronic fuel control, Interior and Exterior Lighting, Dashboard instruments-Windscreen washers and wipers, Horns, Chassis electrical systems -Seats, mirrors and sun-roofs, Central locking and electric windows, Cruise control, In-car multimedia, Advanced comfort and safety systems – Advanced Braking Systems- Automotive networking

Reference Books:

1. William Ribbens, “Understanding Automotive Electronics”, Butterworth-Heinemann, 7th Edition, 2012.
2. James D.Halderman, “Automotive electricity and Electronics”, Prentice Hall, 4th Edition, 2010.
3. Tom Denton, “Automobile Electrical and Electronic Systems”, Elsevier Butterworth-Heinemann, 3rd Edition, 2004.
4. Robert Bosch, “Automotive Hand Book”, SAE , 5th Edition, 2000.
5. Kholi.P.L, “Automotive Electrical Equipment”, Tata McGraw-Hill Private Ltd., New Delhi, 2000.

16EE2008 ELECTRIC DRIVES FOR MECHATRONICS SYSTEMS

Credits: 3:0:0

Course Objective:
To impart knowledge on
- The importance characteristics of Drives.
- The operating principles of DC & AC Drives.

- The applications of Special Machine Drives.

Course Outcome:

- Determine the dynamic parameters of electrical drive systems.
- Rate performance for electrical drive systems under different load conditions.
- Identify control strategies for AC and DC drive systems.

Description:

Electric Drives – an introduction – advantages and Choice of Electric drive – Dynamics of electric drives - torque equation - Speed & Torque conventions – equivalent valves of drive parameters – Control of electric drives - Modes of operation, Closed loop control of drives - PLL control – Selection of Motor power rating - Thermal model - Motor rating – DC motor drives and its performance – Control Strategies - Single and three phase converter fed DC drives and Chopper fed drives - IM and its performance - Stepper motor and switched reluctance motor – Solar and Battery powered drives.

Reference Books:

1. Gopal K Dubey, "Fundamentals of Electrical Drives", Narosa Publishing House, 2nd Edition, Alpha Science International Limitied, New Delhi, 2010.
2. Bose, B.K., "Modern Power Electronics and AC Drives", Prentice Hall of India, Private Limited, 1st Edition, New Delhi, 2009.
3. Ion Boldea, Nasar S. A., "Electric Drives", C.R.C Press, New York, 2nd Edition, 2005.
4. VedamSubramanyam, "Electric Drives: Concepts and Applications", Tata McGraw- Hill Education India Private Limited, New Delhi, 2nd Edition, 2010.
5. Mohamed A. El-sharkawi, Mohamed A. El, "Fundamentals of Electric Drives", Cengage Engineering Publisher, Washington DC, 1st Edition, 2009.

16EE3001 CONTROL AND DRIVES FOR SOLAR TRACKING SYSTEMS

Credits: 3:0:0

Course Objectives:

- To understand the concept of control and drives for solar tracking systems
- To implement the control system for solar energy applications
- To use the advanced controllers for solar power plant

Course Outcomes:

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

- Investigate and Select the appropriate controllers for the solar tracking system.
- Analyze the Electronic realization of various controllers.
- Prioritise and select the advanced controller for solar power plants.

Course Description:

Controller Principles: Basic concepts of process control, discontinuous and continuous mode operation. Introduction to proportional, integral and derivative control. Design, characteristics and response of controllers. Electronic Realization, Selection of controllers, need for process controller, controller tuning and evaluation criteria. P/I and I/P converters. - Model Representation:Types of error - Convergence and stability - Models of electromechanical system, solar photo voltaic cell and DC motor. Transient and steady state response of system, MATLAB Simulation, Embedded System and Applications, Control of solar plants: repetitive control, Internal Mode control (IMC), Iterative learning control (ILC), Model based predictive control strategies, frequency domain control and robust optimal control. Introduction to fuzzy logic control and LABVIEW

References:

1. Eduardo F. Camacho, Manuel Berenguel, Francisco R. Rubio, Diego Martinez, "Control of Solar Energy Systems", Springer, 2012.
2. Johnson C.D., "Process control and instrumentation Technology", 8th Edition., Pearson, 2006
3. Palm W.J., "Introduction to Matlab for Engineers", 3rd Edition, Tata McGraw-Hill Book co, 2010.
4. Meyer W.J., "Concepts of Mathematical Modeling", Dover Publ., 2004.
5. Dym C.L., "Principles of Mathematical Modeling", 2nd Edition, Academic Press, 2004.
6. Pulle, Duco. W.J,Darnell, Pete, " Applied Control of Electric Drives" Springer International Publishing, Switzerland, 1st Edition, 2015.
7. Parimita Mohanty, Tariq Muneer, Mohan Kolhe, "Solar Photovoltaic System Application" Springer international publishing, Switzerland, 1st Edition, 2015.

16EE3002 POWER ELECTRONICS FOR HIGH POWER APPLICATIONS

Credit: 3:0:0

Course Objectives:

- To learn the characteristics of power semiconductors for high power ratings
- To gain the knowledge on self-commutating technology
- To know the present state and future prospects of CSC & VSC static power converters

Course Outcomes:

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

- Model and Simulate High Power Converter Dynamics
- Apply CSC and VSC techniques
- Realize UHV – VSC and UHV – CSC Transmission

Course Description:

Introduction- State of the large power semiconductor technology- Self-commutating conversion (SCC), Principles of Self-Commutating Conversion- Basic VSC operation- Main converter components - Three-phase voltage source conversion, Multilevel Voltage Source Conversion, Multilevel Reinjection, Modelling and Control of Converter Dynamics, Ultra High-Voltage VSC Transmission, Ultra High-Voltage Self-Commutating CSC Transmission.

References:

1. Jos Arrillaga, Yonghe H. Liu, Neville R. Watson, Nicholas J. Murray, Self-Commutating Converters for High Power Applications, John Wiley & Sons, Ltd, 2009
2. Dorin O. Neacsu - Power-Switching Converters: Medium and High Power, Taylor & Francis Group, 2006
3. Bin Wu- High-Power Converters and AC Drives, John Wiley & Sons, Ltd, 2006
4. Dorin O. Neacsu- Switching Power Converters: Medium and High Power, Second Edition, Taylor & Francis Group, 2010
5. Md. Rabiul Islam, Youguang Guo, Jianguo Zhu - Power Converters for Medium Voltage Networks, Springer – Verlag, 2014.

16EE3003 ADVANCED ELECTRIC DRIVES AND CONTROL LABORATORY

Credits: 0:0:1
Corequisite: 14EE3004 Solid State DC Drives
14EE3005 Solid State AC Drives

Course Objectives:

- To understand the operation and control of advanced electric drives.

Course Outcomes:

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

- Design the advanced converter for the drive application.
- Choose suitable control technique for the control of the drive.
- Configure and program the DSP controller for the control application.

Course Description:

The lab will consist of giving the students hands-on experience with advanced electric drives (AC and Special Machines), power converter, and control algorithms for electric drives.

Experiments:

The faculty conducting the laboratory will prepare a list of 6 experiments and get the approval of HOD/Director and notify it at the beginning of each semester.

14EE1001 BASIC ELECTRICAL ENGINEERING

Credits: 3:0:0 **(Version 1.1)**

Course Objectives:

- To gain the basic knowledge about the Electric and Magnetic circuits.
- To understand the Power Generation , Transmission and Distribution methods.
- To understand the working of various Electrical Machines and to know about various measuring instruments, wiring and earthing.

Course Outcomes:

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

- Analyze simple electric and magnetic circuits.
- Identify the type of electrical machine used for a particular application.
- Categorize the measuring instruments and wiring circuit requirement based on the necessity.

Course Description:

Electrical Quantities –Circuit Elements and sources – Ohm's Law and Kirchhoff's laws – Basics of Electric Circuits – Basics of Magnetic Circuits – Introduction to Alternating Quantities – Sources of Electrical Energy – Transmission and Distribution – Introduction to Three phase system – Working principle, operation and application of DC & AC Generator and Motor, Transformer - Classification of Instruments – Principle of Analog instrument – Moving Coil instrument – Moving Iron Instrument – Induction type Energy meter – Earthing &Wiring.

References:

1. Muraleedharan K. A, Muthusubramanian R & Salivahanan S, "Basic Electrical, Electronics & Computer Engineering", Tata McGraw- Hill Limited, New Delhi, 2014.
2. Jegathesan .V, VinothKumar.K, Saravanakumar.R, "Basic Electrical & Electronics Engineering", Wiley India Private Limited, New Delhi, 2011.

3. Surajit Chattopadhyay, Samarjit Sengupta, “Basic Electrical Engineering”, Narosa Publishing House Private Ltd, New Delhi, 1st Edition, 2010.
4. Mehta,V.K, Rohit Mehta, “Principles of Electrical Engineering”, S. Chand Group, 1st Edition, 2007.

14EE2001 ELECTRIC CIRCUITS AND NETWORKS

Credits: 3:1:0 **(Version 1.1)**
Co-requisite: 14MA2003 Mathematical Transforms
14MA2004 Laplace Transforms, Fourier Series and Transforms

Course Objectives:

- To gain knowledge on circuit elements, circuit laws and network reduction.
- To know the basic concepts of coupled circuits, three phase circuits and power measurement.
- To study the transient response of series and parallel electrical circuits.

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

- Analyze electrical circuits by applying circuit laws and theorems.
- Investigate the time domain and frequency domain behavior of electrical circuits
- Design filters and attenuators for simple applications.

Course Description:
Basic Circuit Laws – Network reduction – Source transformation – Mesh and Nodal analysis - Star Delta Conversion – Network Theorems – Series and Parallel Resonance – Frequency Response – Analysis of coupled circuits – Tuned Circuits – Analysis of Three phase balanced and unbalanced circuits with star and delta connected loads – Power Measurement – Time domain and S domain analysis of networks – Poles and Zeroes of Network Function – Transient Response of RL, RC and RLC Circuits for DC input and AC with Sinusoidal Input – Z, Y, H, ABCD and image parameters of two port networks-Design of passive filters.

References:

1. William H. Hayt Jr, Jack E. Kemmerly and Steven M. Durbin, “Engineering Circuits Analysis”, Tata McGraw Hill Publishing Company Limited, 6th Edition, New Delhi, 2003.
2. Joseph A. Edminister, Mahmood Nahri, “Electric Circuits”, Schaum’s series, Tata McGraw-Hill Publishing Company Limited, New Delhi, 2001.
3. Sudhakar A., Shyam Mohan S.P., “Circuits and Network Analysis and Synthesis”, Tata McGraw Hill Publishing Company Limited, New Delhi, 2007.
4. Kuo F.F., “Network Analysis and Synthesis”, Wiley India Private Limited, New Delhi, 2nd Edition, 2006.
5. Ghosh, “Circuits Theory & Networks”, Tata McGraw Hill Private Limited, New Delhi, 2011.

14EE2002 ELECTRIC CIRCUIT ANALYSIS

Credits: 3:1:0 **(Version 1.1)**
Co-requisite: 14MA2003 Mathematical Transforms

Course Objectives :

- To understand basic circuit laws and theorems.
- To understand matrix method of solving circuit.
- To understand the concepts of phasors

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

- Apply different theorems for the analysis of linear electric circuits.

- Apply linear algebra techniques to solve electric circuits.
- Perform Steady State analysis of AC circuits.

Course Description:

Circuit components: passive and active components, Ohms law - Kirchhoff's Laws - Star delta transformation - voltage and current division rule, Steady State Analysis of DC and AC Circuits - Network Topology - Formation of matrix equations and analysis of complex circuits using mesh and node analysis – Network Theorems and its applications - Phasor - sinusoidal steady state response - power and power factor – resonance.

References :

1. Sudhakar, A., Shyam Mohan S.P., "Circuits and Network Analysis and Synthesis", Tata McGraw Hill Publishing Company Limited, 3rd Edition, 2007.
2. Chakrabarti. A "Circuit Theory (Analysis and Synthesis)", DhanpatRai and Company, 6th Edition, 2010.
3. William H. Hayt Jr, Jack E. Kemmerly, Steven M. Durbin, "Engineering Circuits Analysis", Tata McGraw Hill Publishing Company Limited, 6th Edition, New Delhi, 2003.
4. John Bird, 'Electrical Circuit Theory and Technology' Newnes an imprint of Elsevier, 4th Edition, 2010.
5. Joseph A. Edminister, Mahmood Nahri, "Electric Circuits", Schaum's series, Tata McGraw-Hill Publishing Company Limited, New Delhi, 2001.

14EE2003 NETWORK ANALYSIS AND SYNTHESIS

Credits: 3:1:0 **(Version 1.1)**

Co-requisite: 14MA2003 Mathematical Transforms

Course Objectives:

- To understand time domain and frequency domain analysis of electrical networks.
- To know the concepts of three phase circuits.
- To understand the concept network synthesis.

Course Outcomes:

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

- Analyze electrical networks by time domain and frequency domain analysis.
- Analyze three phase balanced and unbalanced circuits.
- Synthesize a network from the given mathematical model.

Course Description:

S Domain Analysis-Poles and Zeros of network functions-Time domain response from pole zero plots. Three phase balanced and unbalanced circuits – Mutual Inductance – ideal transformer. Transient Analysis of RL, RC, RLC circuits for DC and sinusoidal excitation using Laplace Transform. Two Port networks and Filters-Z,Y,h,g,T and inverse T parameters-Design of constant K,m derived and composite filters -.Network Synthesis-Hurwitz polynomials--Synthesis of RL,RC,LC and one port networks.

References :

1. Sudhakar A. Shyammohan, "Circuits and Networks Analysis and Synthesis" Tata McGraw Hill Publishing company limited, New Delhi, 3rd Edition, 2007.
2. Umesh Sinha, "Network Analysis and Synthesis," SathyaPrakasan Publishers Limited, New Delhi, 2012.
3. W.H Hayt, JE Kemmerly, SM Durbin, "Engineering Circuit Analysis", Tata McGraw Hill Publishing Company Limited, New Delhi, 6th Edition, 2006.

4. Allan H. Robbins, Wilheln C Miller, "Circuit Analysis, Principles of Applications", 1st Indian reprint 2008.
5. William D. Stanley, "Network Analysis with Applications", Dorling Kindersley India Private Limited, New Delhi, 4th Edition, 2nd Reprint, 2009.

14EE2004 ELECTROMAGNETIC FIELDS

Credits: 3:1:0 **(Version 1.1)**
Corequisite: 14MA2001 Vector Calculus and Complex Analysis

Course Objectives:
- To understand the concept of charge, current and fields.
- To gain knowledge on electromagnetic field distribution for various configurations.
- To know the basics of electromagnetic waves.

Course Outcomes:
At the end of the course, the student will be able to
- Solve the Electro Magnetic Field problems.
- Calculate and plot electromagnetic field distribution for various configurations.
- Explain the concept of EM waves and their propagation through various medium.

Course Description:
Vector Algebra – Coordinate Systems – Vector Calculus -Coulomb's Law, Electric Field Intensity, Electric Field due to various charge configurations-Electric Potential, Electric Flux, Electric Flux Density, Electrostatic Energy, Capacitance - Current Density, Magnetic Flux, Magnetic Flux Density, Magnetic Field Intensity, Magnetic Field due to various current loop configurations- Ampere's Law, Force and Torque – Inductance -Displacement Current, Eddy Current - Faraday's Law – Lenz's Law , Transformer and Motional emfs - Maxwell's Equations - Generation, Propagation of Waves in Dielectrics, Conductors and Transmission lines, Power and the Poynting Vector.

References:
1. William H.Hayt Jr., John A.Buck, "Engineering Electro Magnetics", Tata McGraw- Hill Education India Private Limited, New Delhi, 3rd Edition, 2007.
2. Joseph. A.Edminister, "Theory and Problems of Electro Magnetics", Schaum's Outline Series, Tata Mc Graw- Hill Publishing Company Limited, New Delhi, 2nd Edition, 2005.
3. Clayton R.Paul, Keith W.Whites, Syed A. Nasar, "Introduction to Electromagnetic Fields", Tata McGraw-Hill Publishing Company Ltd., New Delhi, 2008
4. Bhag Singh Guru, Huseyin R. Hiziroglu, "Electromagnetic Field Theory Fundamentals", Cambridge University Press, UK, 2004.
5. Sunil Bhooshan, "Fundamentals of Engineering Electromagnetics", Oxford University Press, New Delhi, 1st Edition, 2012.

14EE2005 DC MACHINES AND TRANSFORMERS

Credits: 3:1:0 **(Version 1.1)**
Prerequisite: 14EE2001 Electric Circuits and Networks

Course Objectives:
- To know the concept of rotating machines and the principle of electromechanical energy conversion in single and multiple excited systems.
- To gain knowledge on the concepts of Transformer.
- To know different methods of testing and control of DC Machines and Transformer.

Course Outcomes:

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

- Analyze the characteristics of DC Machines and Transformer.
- Predetermine the performance of a DC Machines and Transformer.
- Select the Machine for suitable applications.

Course Description:

Electro-mechanical energy conversion - energy and co-energy – singly and doubly excited systems - Principle of operation, Construction, No load characteristic, Load characteristics of various types of DC Generators – Applications - Principle of operation, Electrical and Mechanical characteristics, Speed control, Losses, efficiency and predetermination of efficiency of DC Motor – Applications - Principle of operation, EMF equation, Phasor diagrams - Equivalent circuit - Voltage regulation, Regulation curve, Losses, Efficiency of a transformer - Tests on transformer-Auto transformer – Principle of operation – comparison with two winding transformer – Three phase transformer.

References:

1. Arthur Eugene Fitzgerald, Charles Kingsley Jr, Stephen D. Umans, "Electric Machinery", Mc Graw – Hill Professional Series , New York, 6th Edition, 2002.
2. Kothari D.P., Nagrath I.J., "Electric Machines", Tata McGraw- Hill Education India Private Limited, New Delhi, 4th Edition, 2010.
3. Murugesh Kumar, K., "DC Machines and Transformers", Vikas Publishing House Private Limited., New Delhi, 2nd Edition, 2004.
4. Cotton, H., "Advanced Electrical Technology", A.H Wheeler and Company Publications, London, 1990.
5. Rajput R.K., "Direct Current Machines", Lakshmi Publications, New Delhi, 4th Edition, 2007.

14EE2006 DC MACHINES AND TRANSFORMERS LABORATORY

Credits: 0:0:2 **(Version 1.1)**

Corequisite: 14EE2005 DC Machines and Transformers

Course Objectives:

- To examine the relationship between the electrical and mechanical parameters of a DC machines
- To know the various control methods for the DC machines.
- To gain knowledge about the losses and its influence in the performance of the DC machine and transformer.

Course Outcomes:

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

- Find the mathematical model of DC machine.
- Determine/predetermine the loss calculation of DC motors and Generators.
- Analyze the operation of electric machines under various loading conditions.

Course Description:

The laboratory will demonstrate the student to

- Develop practical skills for measuring electrical and mechanical quantities (Current, voltage, power, efficiency, regulation, torque, speed)
- Describe performance and control characteristics of DC machines and Transformers.
- Analyze the method of testing to derive the equivalent circuit of a given machine.

Experiments:
The faculty conducting the laboratory will prepare a list of 12 experiments and get the approval of HOD/Director and notify it at the beginning of each semester.

14EE2007 INDUCTION AND SYNCHRONOUS MACHINES

Credits: 3:1:0 **(Version 1.1)**
Prerequisite: 14EE2005 DC Machines and Transformers

Course Objective:
- To gain knowledge on the concepts of AC rotating Machines.
- To know about the control techniques of AC rotating Machines.
- To understand the operation of a Synchronous machine with an Infinite bus bar.

Course Outcome:
At the end of the course, the student will be able to
- Explain the Construction and working principle of AC Rotating machines.
- Use knowledge of Synchronous machine for proper interfacing with an Infinite bus bar.
- Demonstrate knowledge on selecting the type of AC machines required for an application

Course Description:
Alternating Current Machine Windings, Construction of A.C Machines, Three Phase Induction Motor, Equivalent Circuit, Performance characteristics, Speed Control and Starting methods – Induction generator – Doubly Fed Induction Generator - Single Phase Induction Motor and Linear Induction Motor, Stepper Motor - Alternator - Principle of operation, Voltage regulation, Power expression, Parallel operation of Alternator, Operation of alternator on Infinite Bus bar, Two Reaction Theory - Synchronous Motor – Principle of Operation, Starting methods, Effect of field excitation- Hunting.

References:

1. Arthur Eugene Fitzgerald, Charles Kingsley, Stephen D. Umans, “Electric Machinery”, McGraw Hill Professional Series, New York, 6th Edition, 2002.
2. Alexander, S. Langsdorf, “Theory of Alternating Current Machinery”, Tata McGraw Hill Education India Private Limited, New Delhi, 2nd Edition, 2009.
3. Murugesh Kumar, K, “Induction and Synchronous Machines”, Vikas Publishing House Limited, New Delhi, 4th Reprint, 2009.
4. Kothari D.P., Nagrath I.J., “Electrical Machines”, Tata McGraw Hill Education India Private Limited, New Delhi, 3rd Edition, 2004.
5. Gupta, B.R., Vandana, Singhal, “Fundamentals of Electric Machines”, New Age International Publishers Limited, New Delhi, 2nd Edition, 2002.

14EE2008 AC MACHINES LABORATORY

Credits: 0:0:2 **(Version 1.1)**
Corequisite: 14EE2007 Induction and Synchronous Machines

Course Objective:
- To understand, demonstrate and analyze the concepts of AC Machines.

Course Outcome:
At the end of the course, the student will be able to
- Analyze the operation of AC machine under different loading conditions.
- Perform the testing of the AC machine.

Course Description:
The laboratory will demonstrate the student about the operation and performance analysis of a AC Machines and derive the transfer function for an electromechanical system.
Experiments:
The faculty conducting the laboratory will prepare a list of 12 experiments and get the approval of HOD/Director and notify it at the beginning of each semester.

14EE2009 ELECTRICAL MACHINE DESIGN

Credits: 3:1:0 **(Version 1.1)**
Prerequisites: 14EE2005 DC Machines and Transformers
14EE2007 Induction and Synchronous Machines

Course Objectives:
- To gain knowledge on the design aspects of Electrical Machines.
- To study the design procedure of DC and AC machines.
- To know the analysis of electrical machines.

Course Outcomes:
At the end of the course, the student will be able to
- Apply the concept of electric and magnetic circuits to design the electrical machines.
- Design a DC, AC machines and Transformes for a given specification.
- Perform the FEM analysis for the machines.

Course Description:
Major Consideration – Main Dimensions – Choice of Specific Electric and Magnetic Loading – Output Equation – Selection of number of Poles – Design of Armature, Field Winding, Field Pole, Commutator and Brushes of DC Machines – Design of Yoke, Core and Winding for Core and Shell type Transformer – Design of Tank and Cooling tube of Transformers – Main dimensions of Induction Motors - Design of Length of Air gap – Design of Squirrel cage and Wound Rotor – Design of Salient Pole Machines – Armature and Rotor Design – Estimation of Air gap length – Design of Damper winding – Design of Turbo Alternators – Design of Field Winding and Rotor – Introduction to Finite Element Methods – Analysis of Induction motor and Transformer.

References:

1. Sawhney, A.K., "A Course in Electrical Machine Design", Dhanpat Rai & Sons, New Delhi, 2011.
2. Sen, S.K., "Principles of Electrical Machine Designs with Computer Programs", Oxford and IBH Publishing Company Private Ltd., New Delhi, Second Edition, 2009.
3. A.Shanmugasundaram, G.Gangadharan, R.Palani "Electrical Machine Design Data Book", New Age International Pvt. Ltd., New Delhi, Reprint 2007.
4. Deshpande M.V., "Design and Testing of Electrical Machines", Prentice Hall India, New Delhi, 3rd Edition, 2009.
5. Nicola Bianchi, "Electrical Machine Analysis using Finite Elements", CRC Press, Boca Raton, 2005.

14EE2010 POWER ELECTRONICS

Credits: 3:0:0 **(Version 1.1)**

Course Objectives:
- To learn the Static and Dynamic characteristics of Power Semiconductor Devices.
- To study the principles of various power converters and their control strategies.

- To gain knowledge on various converters for domestic and industrial applications.

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

- Identify passive and active power electronic devices for the control, conversion, and protection in various applications.
- Analyze, design and test various power electronics converters based on requirement.
- Apply the knowledge on power electronics in developing renewable energy systems.

Course Description:
Power Diodes – Power Transistors – Power MOSFET – IGBT - SCR – TRIACS - GTOs - IGCT - MCT – AC to DC Converter – Single and Three phase-controlled – Full wave and Half wave - Dual converters - AC Voltage controller – Cycloconverter – Chopper - Single and Three phase Inverter Circuits – Series inverter - Control circuits requirements - PWM techniques for DC to AC converters –Control using Microprocessors, Microcontrollers and DSP – Applications: Motor drive applications: DC Motor Drives – AC voltage controller and inverter fed induction motor drives – UPS – HVDC systems – Renewable Energy Applications – Tap changing of Transformers.

References:

1. Rashid, M.H., "Power Electronics – Circuits, Devices and Applications", Pearson Education India Series Private Limited, New Delhi, 3rd Edition, 2003.
2. Mohan, Ned. et.al, "Power Electronics Converters, Applications and Design", Wiley India Private Limited, New Delhi, 3rd Edition 2007.
3. Philip T. Krein, "Elements of Power Electronics", Oxford University Press Incorporation, New York, 2008.
4. Joseph Vithayathil, "Power Electronics: Principles and Applications", McGraw Hill Education India, New Delhi, 2010.
5. Jayant Baliga B., "Fundamentals of Power Semiconductor Devices", Springer-Verlag Publication, New Delhi, 1st Edition, 2008.
6. Dr. Bhimbra, " Power Electronics", Khanna Publishers, New Delhi, 2014.

14EE2011 POWER ELECTRONICS LABORATORY

Credits: 0:0:2 **(Version 1.1)**
Corequisite: 14EE2010 Power Electronics

Course Objectives:

- To understand the steady state and switching behavior of semiconductor devices operated as power switches.
- To test the operation of various power electronic converters.

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

- Interpret the data sheet specifications of power semiconductor devices.
- Design, test and analyze suitable power, control and isolation circuits for an application.
- Become proficient with computer skills (e.g., MATLAB, PSIM and MULTISIM) for the simulation analysis of power electronic circuits.

Course Description:
This laboratory demonstrates the student to analyze the important operating characteristics of power electronic circuits and power semiconductor devices. Emphasis is on devices, circuits, gating methods and power quality.

Experiments:
The faculty conducting the laboratory will prepare a list of 12 experiments and get the approval of HOD/Director and notify it at the beginning of each semester.

14EE2012 ELECTRIC DRIVES AND CONTROL

Credits: 3:0:0 **(Version 1.1)**
Prerequisite: 14EE2010 Power Electronics

Course Objectives:
- To gain the fundamental knowledge on dynamics in electrical drives.
- To gain the knowledge of control techniques for electrical drives.
- To study the performance of various DC & AC drives.

Course Outcomes:
At the end of the course, the student will be able to
- Select the motors for a particular applications
- Analyze the converter characteristic for drive applications.
- Choose suitable control techniques for drives.

Course Description:
Electric Drives and its types - Choice of Electric drive - Fundamental torque equation - Speed & Torque Characteristics - Modes of operation, Closed loop control of drives - PLL control - Thermal model - Motor rating – DC motors and its performance – Control Strategies - Single and three phase converter fed DC drives and Chopper fed drives - IM and its performance - Control strategies, VSI and CSI control – Rotor resistance control – Slip power recovery - Synchronous motor and their performance – Control Strategies – PMAC and BLDC motor Drives – Stepper motor.

References:
1. Dubey, G.K., “Fundamentals of Electrical Drives”, Narosa Publishing House, New Delhi, 2nd Edition, 2010.
2. Bose, B.K., “Modern Power Electronics and AC Drives”, Prentice Hall of India, Private Limited, New Delhi, 1st Edition, 2009.
3. Ion Boldea, Nasar S. A., “Electric Drives”, C.R.C Press, New York, 2nd Edition, 2005.
4. Vedam Subramanyam, “Electric Drives: Concepts and Applications”, Tata McGraw- Hill Education India Private Limited, New Delhi, 2nd Edition, 2010.
5. Mohamed A. El-sharkawi, Mohamed A. El, “ Fundamentals of Electric Drives” Cengage Engineering, New Delhi, 1st Edition, 2009

14EE2013 TRANSMISSION AND DISTRIBUTION

Credits: 3:1:0 **(Version 1.1)**

Course Objectives:
- To understand Power systems structure.
- To study different parameters of transmission and distribution systems.
- Know the basic components of Distribution System.

Course Outcomes:
At the end of the course, the student will be able to
- Analyze the performance of power plants.

- Model the transmission line and determine the model parameters.
- Calculate voltage drops in DC and AC distribution systems.

Course Description:

Basic structure of power system; demand of electrical system – base load, peak load; controlling power balance between generator and load, advantages of interconnected system - Evaluation of Transmission line parameters, types of conductors, representation of transmission line, inductance calculation of single/three phase lines, concept of GMD and GMR, transposition of lines, bundled conductors, skin effect, proximity effect, capacitance calculation of single/three phase lines, Analysis of transmission lines – representation, short/medium/long transmission lines, nominal T/π network, ABCD parameters, surge impedance, Ferranti effect - Insulators for overhead transmission lines - Insulated cables – capacitance of single/three core cable, dielectric loss; Sag - D.C and A.C. distribution, radial and ring main distribution, single line diagram, substation layout, substation equipments.

References Books:

1. Mehta, V.K., Rohit Mehta, “Principles of Power Systems”, S.Chand& Company Private Limited, New Delhi, 14th Edition, 2009.
2. Singh S.N, “Electric Power Generation, Transmission and Distribution”, PHI Learning Private Limited, New Delhi, 2nd Edition, 2009.
3. Soni, M.L., Gupta, P.V., Bhatnagar U.S. Chakrabarthi A., “A Text Book on Power System Engineering”, Dhanpat Rai& Sons Company Private Limited, New Delhi, 2008.
4. Uppal, S.L., “Electrical Power”, Khanna Publishers Limited, New Delhi, 13th Edition, 2002.
5. Lucas M. Faulkenberry, Walfter Coffer, “Electrical Power Distribution and Transmission”, Prentice Hall Limited, 1st Edition, 1996.

14EE2014 POWER SYSTEM ANALYSIS

Credits: 3:1:0 **(Version 1.1)**

Prerequisites: 14EE2013 Transmission and Distribution

Course Objectives:

- To understand the operation of electric power systems.
- To understand the fault, power flow and stability analysis in a power system.
- To learn the economic operation of power system.

Course Outcomes:

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

- Represent the power system and to model power system with its components.
- Perform load flow, fault and stability analysis.
- Optimize the operation of power plants.

Course Description:

Need for system analysis, overall modeling of Power system-one line diagram-per unit representation. Formation of bus impedance matrix-symmetrical and unsymmetrical fault analysis-Formulation of load flow problem-solution by Gauss seidal, Newton Raphson and FDLF method- Economical scheduling of thermal plant - Unit commitment – Elementary idea of optimal load scheduling of Hydro - Thermal plants-Steady state and Transient stability - Swing equation and its solution by Modified Euler and Runge- Kutta methods- Equal area criterion-Definitions and standards of power qualities

References:

1. Hadi Saadat, “Power System Analysis”, Tata McGraw-Hill Education India Private Limited, New Delhi, 11th Reprint 2007.

2. D. P. Kothari, I. J. Nagrath, " Modern Power System Analysis", Tata McGraw-Hill Education India Private Limited, New Delhi, 2008
3. Gupta, B.R., "Power System Analysis and Design", S.Chand & Company Limited, New Delhi, 2005.
4. Weedy B.M., Cory B.J., "Electric Power Systems", John Wiley & Sons Limited, England, 4th Edition, November 2001.
5. Wadhwa C. L., "Electrical Power Systems", New Age International Private Limited, New Delhi, 6th Edition, 2010.

14EE2015 COMPUTER AIDED POWER SYSTEMS ANALYSIS LABORATORY

Credits: 0:0:2 **(Version 1.1)**

Co requisite: 14EE2014 Power System Analysis

Course Objectives:

- To compute the bus impedance/admittance matrices in power system network.
- To learn the load flow methods in an interconnected system.
- To understand the fault analysis and stability analysis in a power system.

Course Outcomes:

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

- Formulate the bus admittance / impedance of a power system network.
- Perform load flow studies and interpret the results.
- Do the fault and stability analysis of a power system and interpret the results.

Course Description:

This laboratory demonstrates the students the usage of simulation software tool for design and control of a Power System.

Experiments:

The faculty conducting the laboratory will prepare a list of 12 experiments and get the approval of HOD/Director and notify it at the beginning of each semester.

14EE2016 POWER SYSTEM PROTECTION AND SWITCHGEARS

Credits: 3:0:0 **(Version 1.1)**

Course Objectives:

- To learn the causes of abnormal operating conditions in the power system apparatus.
- To understand the functions of relays and protection schemes for various apparatus.
- To know the problems caused due to circuit interruption by a circuit breaker and relay and to know the importance of earthing

Course Outcomes:

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

- Select the appropriate relays and circuit breaker depending on the need.
- Design the feasible protection schemes for various Electrical apparatus.
- Apply the insulation coordination and earthing protection for power systems.

Course Description:

Principles and need for protective schemes –types of fault –types of relays – Torque equation –Testing of relays –Introduction to static relays - Microprocessor and computer based protective relaying. Alternator, transformer, Busbar and motor protection using relays – Feeder Protection - Elementary principles of arc extinction -Types of Circuit Breakers, Rating - Testing of circuit breakers, Switching surges - Lightning phenomenon, Types of lightening arresters and surge absorber - Solid resistance and reactance earthing - Arc suppression coil - Earthing transformers –Earth wires - Earthing of appliances- Insulation co-ordination.

References:

1. Sunil, S.Rao, "Switchgear Protection and Power Systems", Khanna Publishers Limited, New Delhi, 12th Edition, 2008.
2. Badri Ram, Vishwakarma D N., "Power System Protection and Switchgear", Tata McGraw- Hill Education India Private Limited, New Delhi, 22nd Reprint, 2007.
3. Mehta, V.K., Rohit Mehta, "Principles of Power Systems", S.Chand & Company Private Limited, New Delhi, 14th Edition, 2009.
4. Soni, M.L., Gupta, P.V., Bhatnagar, U.S. and Chakrabarti, A., "A Text Book on Power Systems Engineering", Dhanpat Rai& Sons Company Limited, New Delhi, 2003.
5. Bhuvanesh A Oza, Nirmal Kumar C Nair, Rashesh P Mehta and Vijay H Makwana., "Power System Protection and Switchgear", Tata McGraw- Hill Education India Private Limited, New Delhi. 2010.

14EE2017 LINEAR, DIGITAL IC AND MEASUREMENTS LABORATORY

Credits: 0:0:2 **(Version 1.1)**

Co requisite: 14EC2008 Linear Integrated Circuits

Course Objectives:

- To learn the applications of linear and digital integrated circuits and their design aspects
- To provide the knowledge of measuring instruments, transducers and the bridge circuits and their usefulness in measurements.
- To illustrate the calibration of deflection type instruments.

Course Outcomes:

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

- Design and analyze linear and digital integrated circuits.
- Use the bridge circuits, transducers and other instruments for measuring purpose.
- Calibrate and test the deflection type measuring instruments.

Course Description:

This laboratory demonstrates the students the usage of Linear, Digital ICs and measurement of any parameters using suitable instruments.

Experiments:

The faculty conducting the laboratory will prepare a list of 12 experiments and get the approval of HOD/Director and notify it at the beginning of each semester

14EE2018 ENERGY SYSTEMS

Credits: 3:0:0 **(Version 1.1)**

Course Objectives:

- To understand electrical energy conservation, energy auditing and power quality.
- To know the principle and design of illumination systems and methods of heating and welding.
- To learn electric traction systems and their performance.

Course Outcomes:

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

- Know the electrical energy conservation, energy auditing and power quality.
- Study the principle and design of illumination systems and methods of heating and welding.
- Understand electric traction systems and their performance.

Course Description:

Review of power generation – Effect of distributed generation on power system operation – Economic aspects of power generation – load and load duration curves - Economics of power factor improvement – power capacitors – power quality - Importance of electrical energy conservation – methods – energy efficient equipment's – Introduction to energy auditing – Importance of lighting – properties of good lighting scheme – laws of illumination – photometry - lighting calculations – basic design of illumination – lighting schemes – energy efficiency lamps. Role of electric heating for industrial applications – Brief introduction to electric welding – welding generator, welding transformer and the characteristics – Requirement of Electric traction – supply systems – mechanics of train movement – traction motors and control – braking – recent trends in electric traction.

References:

1. Gupta J.B., "Utilization of Electric Power and Electric Traction", S.K. Kataria and Sons, 2009.
2. Partab H., "Art and Science of Utilization of Electrical Energy", Dhanpat Rai and Company, New Delhi, 2012.
3. Open Shaw Taylor E., "Utilization of Electric Energy in SI Units.", Orient Longman Ltd, New Delhi, 11th Reprint, 2011.
4. Khan B.H., "Non-Conventional Energy Resources", Tata Mc-Graw Hill Publishing Company Ltd, New Delhi, 2009.
5. Rai G.D., "Non Conventional Energy Sources", Khanna Publishers, New Delhi, 2011.

14EE2019 SPECIAL ELECTRICAL MACHINES

Credits: 3:0:0 **(Version 1.1)**

Prerequisite: 14EE2005 DC Machines and Transformers
14EE2007 Induction and Synchronous Machines

Course Objectives:

- To gain knowledge on construction and working of various special electrical machines.
- To study the characteristics of various special electrical machines.
- To learn the control techniques for the operation of special electrical machines.

Course Outcomes:

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

- Select an energy efficient linear or rotary motor based on the characteristics of the load & application.
- Incorporate the correct control technique to the machine for efficient operation.
- Analyze the behavior of the machine for the applied control technique.

Course Description:

Constructional features – Types – Axial and Radial flux motors – Operating principles – Variable Reluctance and Hybrid Motors – Synchronous Reluctance (SYNREL) Motors – Voltage and Torque Equations - Phasor diagram – Characteristics - Constructional features of stepper motor – Principle of operation – Variable reluctance motor – Hybrid motor – Single and multi-stack configurations – Torque equations – Modes of excitations – Characteristics – Drive circuits – Microprocessor control of stepping motors – Closed loop control – Switched Reluctance Motor (SRM) – Converter Circuits – control techniques - Principle of operation of Permanent Magnet Brushless DC Motor – Types –EMF and torque equations –Commutation - Power controllers – Motor characteristics and control - Linear Induction Motor (LIM) Classification – Construction – Principle of operation – Concept of Current sheet – Goodness factor – DC Linear Motor (DCLM) types –Circuit equation – DCLM control applications.

References:

1. Venkataratnam K., "Special Electric Machines", Taylor and Francis, London, 2008.
2. Miller, T.J.E. "Brushless Permanent Magnet and Reluctance Motor Drives", Clarendon Press, Oxford, 1989.
3. Kenjo, T, "Stepping Motors and their Microprocessor control", Clarendon Press, Oxford, 1989.
4. Kenjo, T, Naganori, S, "Permanent Magnet and Brushless DC motors", Clarendon Press,Oxford, 1989.
5. Simmi P. Burman, 'Special Electrical Machines', S.K.Kataria& Sons, New Delhi, 2nd Edition, 2013
6. K.Vinoth Kumar., "Special Electrical Machines", Dhanpat Rai & Sons, New Delhi, 2013.

14EE2020 AUTOMOTIVE ELECTRONICS

Credits: 3:0:0 **(Version 1.1)**

Course Objectives:

- To understand various automotive sensors and actuators.
- To understand engine cranking system and control.
- To understand various driver assistance and safety systems.

Course Outcomes:

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

- Select the sensors and actuators for an automotive application.
- State various engine control techniques and its requirement.
- Explain the procedure of integration of various components to create an automotive system.

Course Description:

Basic sensor arrangement – Various sensors in vehicle, Actuators for Vehicle, Control Models, Engine Cranking System, Ignition system - Block diagram of starting system - Condition at Starting, Construction and working of starter motor - Advance driver navigation and information system, Collision Avoidance Radar Warning Systems- ABS - Electronic Steering Control and Electronic Suspension - Low Tyre Pressure Warning Systems - Insulated & earth return systems - Head light & Side light, Trafficator, Electrical Fuel Pump, Horn, Wiper system

References:

1. William B.Ribbens, "Understanding Automotive Electronics", Butterworth, HeinemannWoburn, New York, 6th Edition, 2003.
2. James D. Halderman and Chase D. Mitchell, "Diagnosis and Troubleshooting ofAutomotive Electric, Electronic, and Computer Systems", Prentice Hall, New Jersey, 4thEdition, 2006.
3. James D. Halderman and Chase D. Mitchell, "Automotive Electricity and Electronics",Prentice Hall of India, New Delhi, 2004.
4. P L Kohli, "Automotive Electrical Equipment", Tata McGraw- Hill Education IndiaPrivate Limited, New Delhi, 2008.
5. Joseph Heitner, "Automotive Mechanics", Affiliated East – West Private Limited, 2nd Edition, 2012.

14EE2021 ILLUMINATION ENGINEERING

Credits: 3:0:0 **(Version 1.1)**

Course Objectives:

- To know the basic concepts of illumination.
- To learn about different lighting accessories
- To understand the concept of lighting system maintenance, basic lighting, energy audit and economic analysis of lighting.

Course Outcomes:

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

- Perform indoor & outdoor lighting design calculations.
- Determine appropriate lighting control techniques and equipment to a sample project.
- Design energy efficient lighting systems and to assess the energy and cost required for energy.

Course Description:

Eye & vision – Light & Lighting – Light & Vision –, Light & Color – Basic Concepts and Units – Photometry – Measurement and Quality of Lighting – Daylight – use of light tubes - Incandescent – Electric Discharge – Fluorescent – Arc lamps – Lasers – Neon signs – LED-LCD displays – Luminaries – Wiring-Calculation and Measurement-Polar curves– Lighting calculations– Illumination from point, line and surface sources – Photometry and Spectrometry - photocells - Lighting design procedure for Industrial – Residential – Office – Departmental stores – Indoor stadium – Theatres – Hospitals. Environment and glare – Lighting Design procedure for Flood – Street – Aviation and Transport lighting – Lighting for Displays and Signaling. Energy and cost consideration.

References:

1. Leon Gaster, John Stewart Dow, “Modern Illuminants And Illuminating Engineering”, Nabu Press, Washington DC, 1st Edition, 2010.
2. Jack L. Lindsey, “Applied Illumination Engineering”, Prentice Hall of India, 3rd Sub Edition, New Delhi, 2008.
3. Cady, “Illuminating Engineering”, General Books, USA, 2010.
4. Kamlesh Roy, “Illuminating Engineering”, Laxmi Publications, 2nd Edition, 2006
5. William Edward Barrows, “Electrical Illuminating Engineering”, Bibliolife Publishers, USA,2010.
6. IES Lighting Handbook, 10th Edition, 2011

14EE2022 POWER SYSTEM STABILITY

Credits: 3:0:0 **(Version 1.1)**

Prerequisite: 14EE2014 Power System Analysis

Course Objectives:

- To know the concept of stability in a Power System.
- To understand the importance of stability under different conditions like transient and steady state in the power system.
- To learn the methods of improving power system stability.

Course Outcomes:

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

- Realize the disturbances in the power system under various operating conditions.
- Analyze transient and steady state stability of a power system.
- Describe the methods of improving the power system stability.

Course Description:
Concept of Power system stability - Importance of Stability studies - Steady state and Transient state-Modeling of Synchronous machines for stability studies-two machine system and Clarke diagram –factors influencing stability limit-Single and two machine systems – Swing equation – Solution of swing equation by Modified Euler and Runge-kutta method – Equal area criterion and its application – stability of multi-machine system-Factor affecting transient stability – Methods of improving stability-power system stabilizer and its design-Application of computers for stability studies – Voltage Stability.

References:

1. Kundur P., "Power System Stability and Control", EPRI Power System Engineering Series, McGraw-Hill Education Series, New York, 1st Edition, 2006.
2. Padiyar K.R., "Power System Dynamics, Stability and Control", BS Publications, Hyderabad, 2nd Edition, 2008.
3. Peter W., Saucer, Pai M.A., "Power System Dynamics and Stability, Pearson Education (Singapore), 9th Edition, 2007.
4. Kothari D.P., "Modern Power System Analysis", Tata McGraw-Hill Education India Private Limited, New Delhi, 3rd Edition, 2004.
5. Elgerd O.I., "Electric Energy System Theory: An Introduction", Tata McGraw-Hill Education India Private Limited, New Delhi, 23rd Reprint, 2004.
6. Arrillaga J, Watson N.R., "Computer Modeling of Electrical Power Systems", John Wiley & Sons Limited, New Jersey, 2003.

14EE2023 POWER SYSTEM OPERATION AND CONTROL

Credits: 3:0:0 **(Version 1.1)**
Prerequisite: 14EE2014 Power System Analysis

Course Objectives:
- To understand the need for voltage and frequency regulation in power system.
- To know the concept of power system security and control.
- To learn the economic operation of power system.

Course Outcomes:
At the end of the course, the student will be able to
- Explain the importance of maintaining the frequency and voltage within the safe range.
- Describe power system monitoring and control methods.
- Optimize the economic operation for power generating units.

Course Description:
Need for voltage and frequency regulation in power system - System load characteristics - Basic P-F and Q-V control loops - Load frequency control of single area system-static and dynamic response - Typical excitation system – Modeling of AVR–Static and Dynamic analysis – Real power and Reactive Power improvement methods. Static state estimation of power systems- treatment of bad data-network Observability and pseudo measurements - Energy control center functions – System hardware configuration SCADA system – Security monitoring and control – System states and their transition - Various controls for secure operation – Tariff – Unit Commitment - Economic Dispatch.
References:

1. Olle I. Elgerd, "Electric Energy System Theory - An Introduction", Tata Mc Graw-Hill Education India Private Limited, New Delhi, 2nd Edition, 2012.
2. Kundur P., "Power System Stability and Control", EPRI Power System Engineering Series, Mc Graw- Hill Education India Private Limited, New York, 1st Edition, 2006.

3. Allen J.Wood, Bruce F.Woolenbarg, “Power Generation, Operation and Control”, John Wiley & Sons Inc., New Jersey, 3rd Edition, 2013.
4. Jizhong Zhu, “Optimization of Power System Operation” John Wiley & Sons Inc., New Jersey, 2009.
5. Kothari. D.P., Nagrath. I.J., “Modern Power system analysis” Tata Mc Graw-Hill Education India Private Limited, New Delhi, 4th Edition, 2011

14EE2024 BASICS OF ELECTRIC AND HYBRID VEHICLE

Credits: 3:0:0 **(Version 1.1)**

Course Objectives:

- To understand the concept of electric and hybrid vehicle
- To study the various drive train configurations.
- To learn about various energy sources available for electric vehicle and hybrid electric vehicle.

Course Outcomes:

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

- Describe various drive-trains.
- Interpret the performance characteristics of various electric drives used for vehicle application.
- Compare different energy storage options for electric vehicle and hybrid electric vehicle.

Course Description:

Introduction to Hybrid Electric Vehicles: History of hybrid and electric vehicles, Basics of Conventional Vehicles (performance, power source, transmission characteristics) – Hybrid Electric Drive-trains - various hybrid drive-train topologies - power flow control in hybrid drive train topologies, fuel efficiency analysis - Electric Drive-trains: Basic concept of electric traction, various electric drive-train topologies, power flow control in electric drive-train topologies -Electric Propulsion unit - Configuration and control of DC Motor and Induction Motor Drives –Configuration and control of Permanent Magnet Motor and SRM drives, Energy Storage: Battery, Fuel Cell, Super Capacitor, Flywheel, Hybridization of different energy storage devices - Sizing the drive system - Energy Management Strategies.

References:

1. Iqbal Husain, “Electric and Hybrid Vehicles Design Fundamentals”, CRC Press, New York, USA. 2010.
2. Mehrdad Ehsani ,Yimin Gao, Sebastien E. Gay, Ali Emadi, “Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals, Theory, and Design”, CRC press, New York, USA, 2008
3. Seth Leitman, Bob Brant, “Build Your Own Electric Vehicle”, Professional Edition: McGraw-Hill, New York, 2008.
4. James Larminie, John Lowry, “Electric Vehicle Technology Explained”, Wiley publications, India, 2007.
5. Austin Hughes, “Electric Motors and Drives: Fundamentals, Types and Applications”, McGraw-Hill, New York, USA, 2006.
6. Carl Vogel, “Build Your Own Electric Motorcycle”, McGraw-Hill, New York, USA, 2009.
7. David Linden, Thomas B. Reddy, “Handbook of Batteries”, McGraw-Hill, New York, USA, 2008

14EE2025 FUNDAMENTALS OF ELECTRICAL SAFETY

Credits: 3:0:0 **(Version 1.1)**

Course Objectives:

- To know the various reasons for electrical accidents
- To gain knowledge on national and international standards on electrical safety.
- To study about various methods available to ensure electrical safety.

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

- Adapt electrical safety standards and use proper electrical safety devices and methods.
- Relate the safety rules and regulations, and describe the awareness of hazards in the work place.
- Explain electromagnetic interference and the use of personal protective equipment.

Course Description:
Energy radiation and electromagnetic interference – Working principles of electrical equipment-Indian electricity act and rules-statutory requirements from electrical inspectorate-international standards on electrical safety – first aid-cardio pulmonary resuscitation (CPR) - Energy leakage-clearances and insulation-voltage classification-heating effects - electrical causes of fire and explosion-ionization-spark and arc-ignition energy-control-Lightning hazards – Fuse – circuit breakers and overload relays – protection against over voltage and under voltage – safe limits of amperage – voltage –safe distance from lines-capacity - Earth fault protection-earthing standards - FRLS insulation- grounding-equipment grounding earth - leakage circuit breaker (ELCB) - Classification of hazardous zones-intrinsically safe and explosion proof electrical apparatus-increase safe equipment-their selection for different zones-temperature classification-grouping of gases-use of barriers and isolators-equipment certifying agencies.

References:

1. Massimo A. G. Mitolo, "Electrical Safety of Low-Voltage Systems", McGraw-Hill, USA, 2008.
2. John Cadick, Mary Capelli-Schellpfeffer, Dennis K. Neitzel, 'Electrical Safety Hand book, McGraw-Hill, New York, USA, 2005.
3. Indian Electricity Act and Rules, Government of India.
4. Power Engineers – Hand book of TNEB, Chennai, 2001.
5. Fordham Cooper, W., "Electrical Safety Engineering" Butterworth and Company, London, 1986.
6. Wayne C. Turner, Steve Doty, "Energy Management hand book", The Fair Mont press, Georgia, 2006.
7. Albert Thumann, William J.Younger, TerryNiehus, "Handbook of Energy Audits", CRC Press Newyork, 2009.
8. Palmer Hickman, "Electrical Safety-Related Work Practices", Jones & Bartlett Publishers, London, 2009.

14EE2026 HIGH VOLTAGE ENGINEERING

Credits: 3:0:0 **(Version 1.1)**

Course Objectives:

- To study the effect of over-voltages in power system and in dielectrics.
- To learn the theory behind the generation and measurements of high voltages and currents.
- To understand various testing involved in high voltage engineering.

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

- Analyze the over-voltage protection techniques and also to analyze the effect of over voltage in dielectrics.
- Investigate the techniques used for the generation and measurement of high voltages and currents.
- Relate the methods used for the testing of various parts of high voltage power system.

Course Description:
Introduction - Transients in Simple Circuits - Insulation Co-ordination and Overvoltage Protection - Ground Wires - Surge Protection of Rotating Machine - Mechanism of Breakdown in various medium – Half Wave Rectifier Circuit - Cockroft-Walton Voltage Multiplier Circuit - Electrostatic Generator - Generation of High A.C. Voltages - Impulse Generator Circuits - Sphere Gap - Uniform Field Spark Gap - Rod Gap - Electrostatic Voltmeter - Generating Voltmeter - The Chubb-Fortescue Method - Impulse Voltage Measurements using Voltage Dividers - Measurement of High D.C. and Impulse Currents - Testing of Overhead Line Insulators - Testing of Cables - Testing of Bushings - Testing of Power Capacitors - Testing of Power Transformers - Testing of Circuit Breakers - Test Voltage

References:

1. Wadhwa C.L., High Voltage Engineering, New Age International Private Limited, 2^{nd} Edition, New Delhi, 2007
2. Naidu M.S., Kamaraju V., “High Voltage Engineering”, Tata McGraw Hill, 3^{rd} Edition, 2004.
3. Kuffel E., Zaengl W.S., “High Voltage Engineering Fundamentals”, Pergamon press, Oxford, London, 2^{nd} Edition, 2000.
4. Hugh M Ryan, “High Voltage Engineering and Testing”, The Institution of Electrical Engineers, London, United Kingdom, 2^{nd} Edition, 2001
5. Subir Ray, “An Introduction to High Voltage Engineering”, PHI Learning Private Ltd, Delhi. 2^{nd} Edition, 2013.

14EE2027 HVDC AND FACTS

Credits: 3:0:0 **(Version 1.1)**

Course Objectives:
- To explore the high voltage power system
- To gain knowledge of various controllers used in HVDC transmission system and FACTS.
- To learn the applications of FACTS controllers

Course Outcomes:
At the end of the course, the student will be able to
- Compare HVDC and HVAC transmission system.
- Examine various control schemes for transmission and distribution systems.
- Explain the operation and applications of various FACTS devices.

Course Description:
Types of HVDC Systems, Scheme of HVDC Transmission , Comparison of HVAC and HVDC Transmission , Principles of Control, Rectifier Control , Power Reversal in a DC Link, VDCOL Characteristics , System Control Hierarchy – Inverter Control , Pulse Phase Control – Starting and Stopping of a DC Link, VSC HVDC Transmission System. Flexible AC Transmission System: FACTS Controllers; Course Description, VSC based Controllers, , Applications of FACTS Controllers in Transmission System, Applications of FACTS Controllers in Distribution System, Static VAR Compensator(SVC); TCSC, Static Synchronous Compensator (STATCOM), Unified Power Flow Controller (UPFC) – Introduction to latest FACTS controllers.

References:

1. Padiyar K.R., “HVDC Power Transmission System”, New Age International Publishers, 2^{nd} Edition, 2010.
2. Padiyar K.R., “FACTS Controllers in Power Transmission and Distribution”, New Age International Publishers, 2007

3. Kamakshaiah S., Kamaraju V., "HVDC Transmission" Tata McGraw Hill Education Private Ltd., New Delhi, 4th reprint 2013.
4. Narain G. Hingorani, "Understanding FACTS -Concepts and Technology of Flexible AC Transmission Systems", Standard Publishers Distributors, Delhi, 2001.
5. Mohan Mathur.R., Rajiv. K.Varma, "Thyristor – Based Facts Controllers for Electrical Transmission Systems", IEEE press and John Wiley & Sons, Inc, 2000.

14EE2028 BUILDING AUTOMATION

Credits: 3:0:0 **(Version 1.1)**

Course Objectives:

- To understand the building automation and its management system.
- To study about the security and safety systems in smart building.
- To understand integrated system in building automation.

Course Outcomes:

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

- Apply the automation system with networking facility in building.
- Demonstrate the energy conservation methodologies for a modern commercial building.
- Suggest suitable possibilities to integrate system and its managements for intelligent building.

Course Description:

Introduction – Features – Characteristics and Drawbacks of Building Automation system – Building Management System – Energy Meters Types – Meter Networking – Monitoring Energy Parameters, Analysis of Power Quality – Energy Conservation-Introduction to safety – Fire Development Stages and various security system – Introduction to video management - CCTV Camera Basics – Digital Video Recording, Video Management System – Integrated Systems.

References:

1. Shengwei Wang, "Intelligent Buildings and Building Automation", Spons Architecture Price Book, New York, 1st Edition, 2009.
2. Jong-jin Kim, "Intelligent Buildings", Butterworth-Heinemann, Illustrated Edition, London, 2006.
3. Derek Clements - Croome, "Intelligent Buildings: Design Management and Operation", Thomas Telford Ltd., UK, Illustrated Edition, 2nd Edition 2013.
4. In Partnership with Nijatc, "Building Automation: Control Devices and Applications", Amer Technical Publishers, New York, 1st Edition, 2008.
5. Reinhold A. Carlson, Robert A. Di Giandomenico, "Understanding Building Automation Systems (Direct Digital Control, Energy Management, Life Safety, Security, Access Control, Lighting, Building Management Programs)", R.S. Means Company Incorporation, 1991.

14EE2029 DESIGN LABORATORY

Credits: 0:0:1 **(Version 1.1)**

Course Objectives:

- To know about the circuit design aspects.
- To gain knowledge of various hardware implementation techniques.

Course Outcomes:

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

- Select Electrical, Electronics and Power Electronics components based on the data sheet.

- Design and fabricate the electrical and electronics circuits for a project.

Course Description:
This laboratory demonstrates the students about the stages of developing a project.

Experiments:
The faculty conducting the laboratory will prepare a list of 6 experiments and get the approval of HOD/Director and notify it at the beginning of each semester.

14EE2030 POWER SYSTEM SIMULATION LABORATORY

Credits: 0:0:2 **(Version 1.1)**

Course Objectives:
- To get exposed to the usage of Modern Simulation Software for Electrical Engineering in simulating power system

Course Outcomes:
At the end of the course, the student will be able to
- Observe the performance of the designed circuit/system.
- Compare the behavior of the system under various changes in parameters
- Improve the performance of the simulated circuit/system.

Course Description:
This laboratory demonstrates the students about the implementation and control of any electrical engineering problems using modern simulation softwares.

Experiments:
The faculty conducting the laboratory will prepare a list of 12 experiments and get the approval of HOD/Director and notify it at the beginning of each semester.

14EE2031 RENEWABLE ENERGY – I

Credits: 3:0:0 **(Version 1.1)**

Course Objectives:
- To gain knowledge on basics of Solar PV, Wind energy and Hybrid energy Systems
- To understand the characteristics and Parameters of renewable energy systems
- To learn the performance of Grid connected renewable systems from real time case studies

Course Outcomes:
At the end of the course, the student will be able to
- Model PV Cells and Panel Modules and to determine the PV Panel maximum power.
- Apply proper power electronic topology in PV and wind power circuit.
- Assess wind resource and suggest type of wind energy conversion system.

Course Description:
PV Energy Basics - Electrical Efficiency – Construction of PV Cells and Panel Modules – PV modules and strings – Mismatch losses – Models of PV cells – Output Characteristics of a PV cell – Approximate Determination of the PV Panel Parameters – Determination of the PV Panel Maximum Power – Temperature effects – Parameters of PV cells – Inverters for PV – Energy storage for PV – Power Electronic Topologies in PV Systems – Stand-alone PV Systems – Grid connected PV systems –

Maximum Power Point Tracking – Wind Energy : Introduction – types of wind machines – Cpλ - Curve & Betz limits – Aerodynamics of wind turbine rotor – wind resource assessment – Standalone Wind Energy Conversion Systems – Grid Connected Wind Energy Conversion Systems – Hybrid Systems – Case studies.

References:

1. Rai G. D., "Non conventional Energy Sources", Khanna Publishers, New Delhi, 2007.
2. Sukhatme, S.P., "Solar Energy", Tata McGraw - Hill Education India Private Limited, New Delhi, 2006.
3. John Twidell, Tony Wier, "Renewable Energy Sources", Taylor & Francis Publishers, New York, 2005.
4. Godfrey Boyle, "Renewable Energy: Power for a Sustainable Future", Oxford University Press, NewYork, 2nd Edition, 2004.
5. Bob Everett, Godfrey Boyle, Stephen Peake, Janet Ramage, "Energy Systems and Sustainability Power for a Sustainable Future", Oxford University Press, NewYork, 2nd Edition, 2004.

14EE2032 RENEWABLE ENERGY – II

Credits: 3:0:0 **(Version 1.1)**

Course Objectives:

- To learn the basics of Biomass , Hydro, Geothermal, Wave and Oceanic energies
- To understand the concept of fuel cell.
- To study the characteristics and classification of Hydro power systems.

Course Outcomes:

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

- Explain the biomass conversion process.
- Describe the use of hydrogen in producing energy.
- Outline the various energy producing schemes.

Course Description:

Biomass resources and their classification - chemical constituents and physicochemical characteristics of biomass - Biomass conversion processes (Thermo chemical conversion, biochemical conversion & chemical conversion) – Bio-gasifier – Biogas plants - Hydrogen: Thermodynamics and electrochemical principles - production methods – Biophotolysis - Storage gaseous, cryogenic and metal hydride and transportation – Fuel Cells – Hydro systems - Hydro System resources – types of hydro turbine – small hydro systems; Geothermal, wave energy, ocean energy – Case studies.

References:

1. Khan B.H., "Non-Conventional Energy Resources", Tata Mc-Graw Hill Publishing Company Ltd, New Delhi 2006.
2. Rai G. D., "Non conventional Energy Sources", Khanna Publishers, New Delhi, 2007.
3. Thomas .b. Johansson, Henry Kelly, Amulya K.N .Reddy, Robert .H. Williams, "Renewable Energy Sources for Fuels and Electricity", Island Press, Washington DC, 2009.
4. Anthony San Pietro, "Biochemical and Photosynthetic aspects of Energy Production", Academic Press, 1983**.**
5. Khandelwal K.C, Mahdi S.S., Biogas Technology - A Practical Handbook, Tata Mc Graw Hill, 1986.

14EE2033 HARMONICS AND POWER QUALITY

Credits: 3:0:0 **(Version 1.1)**

Course Objectives:

- To impart knowledge about electric power quality phenomena.
- To gain knowledge about Harmonic sources , definitions & standards and its impacts.
- To learn about PQC, DVR and UPQC systems.

Course Outcomes:

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

- Assess the power quality.
- Devise suitable harmonic elimination technique to improve power quality.
- Follow the International standards of power quality.

Course Description:

Electric power quality phenomena- IEC and IEEE definitions - power quality disturbances-voltage fluctuations-transients-unbalance-waveform distortion-power frequency variations - Voltage variations – Voltage sags and short interruptions flicker-longer duration variations sources range and impact on sensitive circuits-standards solutions and mitigations equipment and techniques – Transients – origin and classifications – capacitor switching transient – lightning-load switching – impact on users – protection – mitigation – Electrostatic Discharge - Harmonics – sources – definitions & standards – impacts - calculation and simulation - Harmonic power flow - mitigation and control techniques – filtering – passive and active – Power Quality conditioners – shunt and series compensators – Dynamic Voltage restorer – Unified Power Quality Conditioners.

References:

1. Roger C. Dugan, Mark F. McGranaghan, Surya Santoso , H. Wayne Beaty, “ Electrical Power Systems Quality”, McGraw Hill, New York, 3rd Edition, 2012
2. Arrillaga J., Watson N.R., Chen S., “Power System Quality Assessment”, Wiley Publications Limited, New York, 2000.
3. Bollens M.H.J., “Understanding Power Quality Problems: Voltage Sags and Interruptions”, IEEE Press, New York, 2000.
4. Heydt G.T., “Electric Power Quality, Stars in a Circle Publications, Indiana, 2nd Edition, 1994.
5. Sankaran C., “Power Quality”, C.R.C Press, New York, 2001.

14EE2034 POWER SYSTEM RELIABILITY

Credits: 3:0:0 **(Version 1.1)**

Prerequisite: 14EE2013 Transmission and Distribution

Course Objectives:

- To study the reliability evaluation.
- To understand the basic reliability indices.
- To understand the importance of reliability

Course Outcomes:

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

- Apply the probability concepts to network modelling.
- Evaluate the transmission and distribution system reliability.
- Develop reliability evaluation methods.

Course Description:
Basic Probability Theory: Review of probability concepts, probability distributions, application of binomial distribution to engineering problems, network modeling and system reliability evaluation using probability distributions, frequency and duration techniques. Generation, Transmission and Distribution System Reliability Evaluation: Concept of LOLP and E(DNS), evaluation of these indices for isolated systems.

References:

1. Roy Billinton, Ronald N. Allan, "Reliability Assessment of Large Electric Power Systems (Power Electronics and Power Systems)", Kluwer Academic Publishers, 2013.
2. Alessendro Birolini, "Reliability Engineering: Theory and Practice", Springer India Limited, New Delhi, 6th Edition, 2010.
3. Roy Billinton, "Power System Reliability Evaluation", Springer (India) Private Limited, New Delhi, 2006.
4. Endrenyi J., "Reliability Modeling in Electrical Power Systems", Wiley & Sons, Australia, 1978.

14EE2035 SWITCHED MODE POWER SUPPLIES

Credits: 3:0:0 **(Version 1.1)**
Prerequisite: 14EE2010 Power Electronics

Course Objectives:
- To understand the basics of Switched Mode Power Supplies.
- To study the control behind the switching mode power supplies.
- To know the various hardware modules available.

Course Outcomes:
At the end of the course, the student will be able to
- Design proper protective scheme against EMI and fabricate a power source using static switches.
- Select components, power semiconductor devices and controller IC in a converter.
- Plan new techniques to make the power source more energy efficient

Course Description:
Introduction - Topologies of SMPS – Buck –Boost – Buck boost – Cuk – Polarity inverting topologies – Push pull and forward converters half bridge and full bridge – Fly back converters Voltage fed and current fed topologies EMI issues - Magnetic Circuits and design – Transformer design - Inductor design - Power semiconductor selection and its drive circuit design – snubber circuits. Design and closing the feedback loop – Voltage Mode Control of SMPS - Transfer Function and Frequency response of Error Amp. Transconductance Error Amps . PWM Control ICs (SG 3525,TL 494,MC34060 etc.) Current Mode Control and its advantages. Current Mode Vs Voltage Mode. Current Mode PWM Control IC(eg. UC3842). Active front end – power factor correction – High frequency power source for fluorescent lamps - power supplies for portable electronic gadgets – Resonant Converters: Principle of operation – modes of operation – quasi resonant operation- advantages.

References:

1. Abraham I Pressman, "Switching Power Supply Design", Mc-Graw Hill Publishing Company. 3rd Edition, New York, 2009.
2. Keith H Billings, "Switch Mode Power Supply Handbook", Mc-Graw Hill Publishing Company, New York, 1989.
3. Sanjaya Maniktala, "Switching power supplies A to Z", Elsevier Incorporation, Oxford, UK, 2006.

4. Daniel M Mitchell, "DC-DC Switching Regulator Analysis", McGraw Hill Publishing Company, 3rd Edition, US, 2011.
5. Ned Mohan et.al, "Power Electronics", John Wiley and Sons, New York, 2003.
6. Otmar Kilgenstein, "Switched Mode Power Supplies in Practice", John Wiley and Sons, 1989
7. Mark J Nave, "Power Line Filter Design for Switched-Mode Power Supplies", Van Nostrand Reinhold, New York, 2nd Edition, 2010.

14EE2036 SMART GRID

Credits: 3:0:0 **(Version 1.1)**

Prerequisite: 14EE2013 Transmission and Distribution

Course Objectives:

- To understand the structure and functional units of a smart grid
- To learn the communication technologies in smart grid
- To understand the impacts and the various issues associated with integration of renewable resources to the grid.

Course Outcomes:

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

- Explain the concept and need of smart grid network.
- Apply various communication technologies for smart grid network.
- Analyze the role of various power electronic modules in the network

Course Description:

Introduction to Smart Grid -Need of smart grid- Smart grid communications: Two way digital communications paradigm, power line communication- Information security for smart grid-Smart metering – Distribution management systems- Pricing and Energy Consumption Scheduling-Renewable Energy resource interconnection issues-Wide Area Measurements-Power electronics in the smart grid-Energy Storage-Future of smart grid

References Books:

1. Janaka Ekanayake, Nick Jenkins "Smart Grid Technology and applications", John Wiley & Sons Ltd, 2012.
2. A.Mazer, "Electric Power Planning for Regulated and Deregulated Markets", John Wiley & Sons, 2007.
3. Ali Keyhani , "Design of Smart Power Grid Renewable Energy Systems", John Wiley & Sons, 2011
4. Nouredine Hadjsaid, Jean-Claude Sabonnadiere, "Smart Grids", John Wiley & Sons Ltd, May 2012.

14EE2037 COMPUTER AIDED GRAPHICS FOR ELECTRICAL ENGINEERS

Credits: 0:0:2 **(Version 1.1)**

Course Objective:

- To understand the usage of computer graphics for electrical engineering.

Course Outcomes:

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

- Draw layout diagram for electrical installations.
- Draw the cross-sectional view of Electrical Machines.
- Draw the PCB layout of Electronic Circuits.

Course Description:
This laboratory demonstrates the students about the usage of Computer Graphics for Electrical Engineering.
Experiments:
The faculty conducting the laboratory will prepare a list of 12 experiments and get the approval of HOD/Director and notify it at the beginning of each semester.

14EE2038 ADVANCED TOPICS IN POWER ELECTRONICS

Credits: 3:0:0 **(Version 1.1)**
Prerequisite: 14EE2010 Power Electronics

Course Objectives:
- To get exposed to new emerging devices in the field of Power Electronics.
- To study the advanced inverters for the control of Electric Drives.
- To gain knowledge on protection of power electronic devices.

Course Outcomes:
At the end of the course, the student will be able to
- Analyze the power devices based on the requirement of control.
- Select suitable power electronic controller for control applications.
- Construct power electronic circuits.

Course Description:
Review of devices – Power Diode – Power BJT – Power MOSFET – Power IGBT – Power IGCT – FCT – RCT – MCT – emerging devices - input and output characteristics - Gate drive circuits and their limitations and effects of turn-on and turn-off characteristics - Thermal models and the cooling of devices - Experimental circuit protection - Multilevel concept – diode clamped – flying capacitor – cascade type multilevel inverters - Comparison of multilevel inverters - application of multilevel inverters – PWM techniques for MLI – Single phase & Three phase Impedance source inverters – Matrix Converters - Series and parallel resonant inverters - voltage control of resonant inverters – Class E resonant inverter – resonant DC – link inverters.

References:

1. Muhammad H. Rashid, “Power Electronics - Circuits, Devices and Applications”, Pearson Education, New Delhi, 2011.
2. Ned Mohan, et.al, “Power Electronics converters, Applications and Design”, Wiley India, New Delhi, 3rd Edition 2007.
3. JayantBaliga B., “Fundamentals Of Power Semiconductor Devices”, Springer-Verlag Publications, New Delhi, 1st Edition, 2008
4. Robert Perret, “Power Electronics Semiconductor Devices”, Wiley-ISTE Publications, New Delhi, New Edition, 2009.
5. Bhimbra P.S., “Power Electronics”, Khanna Publishers Ltd., New Delhi, 2011.

14EE3001 POWER SEMICONDUCTOR DEVICES

Credits: 3:0:0 **(Version 1.1)**

Course Objectives:

- To understand various static and dynamic performances of static switches.
- To familiarize the student on switching and steady state characteristics of power electronic devices.
- To study about the control circuits and switching losses in power devices.

Course Outcomes:

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

- Apply the design criteria based on power, efficiency, ripple voltage and current, harmonic distortions, power factor in electrical systems.
- Select the devices and interpreting their characteristic applicability for power electronics circuits.
- Design the switching circuits using power semiconductor devices.

Course Description:

Status of development of power semiconductor devices - Types of static Switches, Static and dynamic performance – Power Diodes – Switching and steady state characteristics – Series and parallel operation – Thyristors – Switching and steady state characteristics – Switching techniques: Hard and Soft Switching – Series and parallel operation – Family of Thyristors, Power Integrated Circuit, Intelligent Power Modules - Power Transistors – Static and switching characteristics - Power MOSFETS, IGBT, GTO – Switching characteristics – Heat Sink Design – Recent Power Electronic Devices.

References:

1. Muhammad H. Rashid, "Power Electronics - Circuits, Devices and Applications", Pearson Education, New Delhi, 2011.
2. Ned Mohan, et.al, "Power Electronics converters, Applications and Design", Wiley India, New Delhi, 3rd Edition 2007.
3. JayantBaliga B., "Fundamentals Of Power Semiconductor Devices", Springer-Verlag Publications, New Delhi, 1st Edition, 2008.
4. Robert Perret, "Power Electronics Semiconductor Devices", Wiley-ISTE Publications, New Delhi, New Edition, 2009.
5. Bhimbra P.S., "Power Electronics", Khanna Publishers Ltd., New Delhi, 2014.

14EE3002 POWER CONVERTERS ANALYSIS – I

Credits: 3:0:0 **(Version 1.1)**

Course Objectives:

- To gain in depth knowledge of AC-DC converters.
- To study the behavior of various types of choppers.
- To learn about the controllers for various power converters.

Course Outcomes:

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

- Compare the operation and application of different types of converters
- Choose and design particular converter for a specific application.
- Understand the controllers for single phase and three phase power converters

Course Description:

Half controlled and fully controlled converters with RL, RLE loads - Dual converter - Effect of source impedance - Single Phase Series Converter operation - twelve pulse converter - Analysis of buck, boost, buck-boost and Cuk Regulators - Single phase and three phase controllers, PWM Control, Matrix Converter – Single phase and three phase cycloconverters, Applications – Resonant Converters

References:

1. Muhammad H. Rashid, "Power Electronics - Circuits, Devices and Applications", Pearson Education, New Delhi, 2011.
2. Ned Mohan, et.al, "Power Electronics converters, Applications and Design", Wiley India, New Delhi, 3rd Edition 2007.
3. Joseph Vithayathil, "Power Electronics: Principles and Applications", Tata McGraw- Hill Education India Private Limited, New Delhi, 2010.
4. VedamSubrahmanyam, "Power Electronics", New Age International (P) Limited, New Delhi, Revised 2nd Edition, 2011.
5. Muhammad H. Rashid, "Power Electronics Handbook: Devices, Circuits, and Applications", Butterworth-Heinemann, 2010.
6. Bhimbra P.S., "Power Electronics", Khanna Publishers Ltd., New Delhi, 2012.

14EE3003 POWER CONVERTERS ANALYSIS – II

Credits: 3:0:0 **(Version 1.1)**

Course Objectives:

- To gain in depth knowledge of the voltage source and current source inverters.
- To learn to control the output using modulation index of inverters
- To study the design procedure of the inverters for particular application.

Course Outcomes:

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

- Analyze the Inverter circuits and select them for the suitable applications.
- Choose the control technique for a particular inverter.
- Explain the operation of various types of inverter circuits.

Course Description:

Principle of operation of half and full bridge inverters – Performance parameters – Design of Inverters – Voltage control of using PWM techniques – Harmonic Elimination techniques - 180° and 120° conduction mode operation – Sinusoidal PWM – Space vector modulation techniques - Single phase CSI with ideal switches, Capacitor Commutated and Auto sequential commutated inverter, Comparison of CSI and VSI - Multilevel concept, Diode clamped, Flying capacitor and Cascade type multilevel inverters, Comparison and Applications - Series and parallel resonant inverters – Voltage control – Class E resonant inverter – Resonant DC-link inverters.

References:

1. Muhammad H. Rashid, "Power Electronics - Circuits, Devices and Applications",Pearson Education, New Delhi, 2011.
2. Ned Mohan, et.al, "Power Electronics converters, Applications and Design", Wiley India, New Delhi, 3rd Edition 2007.
3. Joseph Vithayathil, "Power Electronics: Principles and Applications", Tata McGrawHill Education India Private Limited, New Delhi, 2010.
4. VedamSubrahmanyam, "Power Electronics", New Age International Private Limited, New Delhi, Revised 2nd Edition, 2011.
5. Muhammad H. Rashid, "Power Electronics Handbook: Devices, Circuits, and Applications", Butterworth-Heinemann, 2010.

6. BhimbraP.S., “Power Electronics”, Khanna Publishers Limited, New Delhi, 2012.

14EE3004 SOLID STATE DC DRIVES

Credits: 3:0:0 **(Version 1.1)**
Prerequisite: 14EE3002 Power Converter Analysis –I

Course Objectives:
- To gain knowledge on the basic concept of DC machines
- To study the concept of phase controlled rectifier for DC drives.
- To analyze the concept of DC drive by using chopper.

Course Outcomes:
At the end of the course, the student will be able to
- Analyze different control techniques of DC Drives.
- Select suitable DC Drive for different requirements
- Simulate DC drives with different control methods for specific applications.

Course Description:
Dynamics of Electrical Drives-Torque Equation- Speed Torque Characteristics -Braking-Components and classifications of load torque-Moment of inertia -Multi quadrant Operation-Speed control - Analysis of series and separately excited DC motors with single-phase and three phase converters - Modelling of DC motor-Transfer function of subsystem-Design of controllers-Simulation of one quadrant DC drive-Application of DC drive with converter-Class A, B, C, D and E chopper controlled DC motor – Chopper based implementation of braking schemes – Modeling of drive elements – Closed loop control of Drives, Dynamic Simulation of converter and chopper fed DC drive - Application of DC drive with Choppers.

References:
1. Gopal K Dubey, “Fundamentals of Electric Drives”, Narosa Publishing House, 2nd Edition, New Delhi, 2015.
2. Pillai S.K., “Analysis of Thyristor Power Conditioned Motors”, University Press, 2005.
3. Krishnan. R, “Electric Motor Drives: Modeling, Analysis and Control”, Prentice Hall of India Private Limited, New Delhi, 2009.
4. Sen P.C., “Thyristor DC Drives”, John Wiley, New York, 1981.
5. Vedam Subrahanyam, “Electric Drives: Concepts & Applications”, McGraw-Hill Education, New Delhi, 2010.
6. Paul C.Krause, Oleg Wasynczuk, Scott D.Sudhoff, “Analysis of Electric Machinery and Drive System”,3rd Edition, Wiley India Pvt Ltd, IEEE Press, NewDelhi,2013.

14EE3005 SOLID STATE AC DRIVES

Credits: 3:0:0 **(Version 1.1)**
Prerequisite: 14EE3003 Power Converter Analysis –II

Course Objectives:
- To gain knowledge on the speed torque characteristics of asynchronous machine.
- To study scalar control technique for AC Drives.
- To learn the concept of field oriented control of AC Drives.

Course Outcomes:
At the end of the course, the student will be able to
- Analyze different control techniques of AC Drives

- Select suitable AC Drive for different requirements
- Apply appropriate control method for specific application

Course Description:
Induction Motor Drives: Variable voltage, constant frequency operation – Variable frequency operation, constant Volt/Hz operation. Drive operating regions, variable stator current operation, different braking Methods-AC voltage controller circuit – six step inverter voltage control-closed loop variable frequency PWM inverter with dynamic braking-CSI fed IM variable frequency drives-Static rotor resistance control - injection of voltage in the rotor circuit – Static Scherbius drives -power factor considerations – modified Kramer drives-Field oriented control of induction machines– DC drive analogy – Direct and Indirect methods – Flux vector estimation - Direct torque control of Induction Machines – Torque expression with stator and rotor fluxes, DTC control strategy- Synchronous motor drive-Power factor control– starting and braking, self control –Load commutated Synchronous motor drives - Brush and Brushless excitation - Sensor-less Vector Control of AC Drives.

References:

1. Bimal K Bose, "Modern Power Electronics and AC Drives", Pearson Education Asia 2002.
2. Vedam Subramanyam, "Electric Drives – Concepts and Applications", Tata McGraw Hill Publishing Limited, New Delhi, 2nd Edition, 2011.
3. Gopal K Dubey, "Power Semiconductor controlled Drives", Prentice Hall Inc., New Jersey, 1989.
4. W.Leonhard, "Control of Electrical Drives", Springer – Verlag Berlin Heidelberg, NewYork, 3rd Edition, 2001.
5. Murphy J.M.D and Turnbull, "Thyristor Control of AC Motors", Pergamon Press, Oxford, 1988.
6. R.Krishnan, "Electric Motor Drives – Modeling, Analysis and Control", Prentice-Hall of India Private Ltd., New Delhi, 2003.

14EE3006 WASTE TO ENERGY CONVERSION

Credits: 3:0:0 **(Version 1.1)**

Course Objectives:
- To understand the waste processing techniques, its treatment and disposal
- To study the different conversion process involved.
- To understand the environmental and health impacts of waste to energy conversion.

Course Outcomes:
At the end of the course, the student will be able to
- Identify different types of waste and its processing techniques.
- Explain the energy recovery process from waste and thereby help in developing a green society.
- Design waste to energy plants for cities.

Course Description:
Municipal Solid Waste (MSW) - Industrial waste and Biomedical Waste (BMW) - waste processing-size reduction, separation; waste minimization and recycling of MSW; Life Cycle Analysis (LCA), Material Recovery Facilities (MRF)-Aerobic composting – incineration - land fill - preliminary design of landfills – pyrolysis - gasification of waste using gasifiers - briquetting, - strategies for reducing environmental impacts - Anaerobic digestion of sewage and municipal wastes - direct combustion of MSW - refuse derived solid fuel - industrial waste, - agro residues - anaerobic digestion biogas production - land fill gas generation and utilization - present status of technologies for conversion of waste into energy - design of waste to energy plants for cities, small townships and villages – case studies of commercial waste to energy plants, - eco-technological alternatives for waste to energy conversions – Rules related to the handling, treatment and disposal of MSW and BMW in India.

References:

1. Gary C. Young, "Municipal Solid Waste to Energy Conversion Processes: Economic, Technical, and Renewable Comparisons", John Wiley & Sons, 2010.
2. Christian Furedy, Alison Doig, "Recovering Energy from Waste Various Aspects", Science Publishers, Inc. Enfield (NH) USA, 2002.
3. Shah, Kanti L., "Basics of Solid & Hazardous Waste Management Technology", Prentice Hall, 2000.
4. Parker, Colin, Roberts, "Energy from Waste - An Evaluation of Conversion Technologies", Elsevier Applied Science Publisher, London, 1985.
5. Robert Green, "From Waste to Energy", Cherry Lake Publishing limited, USA, 2009.
6. Dieter D., Angelika S., "Biogas from Waste and Renewable Resources", Wiley-VCH Verlag GmbH & Company, Germany, 2010.

14EE3007 GENERALIZED THEORY OF ELECTRICAL MACHINES

Credits: 3:0:0 **(Version 1.1)**

Course Objectives:

- To understand various reference frames.
- To gain knowledge on the modeling of electrical Machines.
- To understand the steady state and transient analysis of electrical machines.

Course Outcomes:

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

- Analyze the generalized representation of machines using two axis model.
- Describe the steady state analysis and transient analysis of various machines.
- Simulate the electrical machines using MATLAB.

Course Description:

Basic two pole machines - Transformer with movable secondary –Transformer voltage and speed voltage - Kron's Primitive Machine - Analysis of Electrical Machines - Invariance of power - Transformations from displaced brush axis – three phases to two phase – Rotating axis to stationary axes-Transformed impedance matrix - Generalized Representation of DC Machine - Generator and motor operation - Operation with displaced brushes - Steady state and transient analysis - Sudden short circuit - Sudden application of inertia load - Electric braking of DC motors – Circuit Model of a Three-phase Induction Machine – Machine Model in Arbitrary dq0 Reference frame – dq0 stationary and Synchronous Reference frames –Steady state model – Transient Model – Mathematical Model of Synchronous Machines – Transformation to the Rotor's dq0 Reference frame – Flux Linkages in terms of Winding Currents – Referring rotor Quantities to the stator – Voltage Equations in the rotor's qd0 Reference frame –Electromagnetic Torque – Steady State Operation – Transient Operation – MATLAB Simulation.

References:

1. Bimbhra P.S., "Generalized Theory of Electrical Machines", Khanna Publishers Limited,New Delhi, 5th Edition, 2011.
2. Chee-Mun Ong., "Dynamic Simulation of Electric Machinery using Matlab/Simulink", Prentice Hall PTR, Upper Saddle River, New Jersey, 1998.
3. Bandyopadhyay M. N., "Electrical Machines: Theory and Practice" PHI Learning, NewDelhi, 2007.
4. Gupta J B." Theory & Performance of Electrical Machines", S. K. Kataria & Sons, New Delhi, 2011.

5. Paul C.Krause, Oleg Wasynczuk, Scott D.Sudhoff., "Analysis of Electric Machinery and Drive Systems", Wiley India Private Ltd, New Delhi, 2nd Edition, 2010.

14EE3008 SPECIAL MACHINES AND CONTROLLERS

Credits: 3:0:0 **(Version 1.1)**

Course Objectives:

- To gain the knowledge on construction and working of various special electrical machines.
- To learn about the characteristics of various special electrical machines.
- To study the control techniques for the operation of special electrical machines.

Course Outcomes:

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

- Describe the working and the characteristics of a special machine drive.
- Incorporate the correct control technique and analyze the behaviour of the machine for efficient operation.
- Suggest suitable energy efficient special machine for a specified application.

Course Description:

Constructional features of Stepper motor – variable reluctance motor – Hybrid motor – Single and Multi stack configurations – torque equation –characteristics –Open loop and Closed loop control– applications - Constructional features of Switched Reluctance Motor –Torque equation – Power Converters – Torque Speed characteristics – Voltage, Current and Single Pulse Control Techniques – Torque Control – applications - Principle of operation of Permanent Magnet Brushless DC Motor – types –magnetic circuit analysis – EMF and Torque equations – Power Controllers – Motor characteristics and control - Principle of operation of Permanent Magnet Synchronous Motor – EMF and torque equations – reactance – phasor diagram – power controllers - converter - torque speed characteristics - microprocessor based control - Linear Induction Motor (LIM) Classification – Construction – Principle of operation – Concept of Current sheet – Goodness factor – DC Linear Motor (DCLM) types –Circuit equation – DCLM control applications.

References:

1. Venkataratnam K., "Special Electric Machines", CRC Press, Boca Raton, U.S.A., 2008.
2. R.Krishnan, "Switched Reluctance Motor Drives: Modeling, Simulation, Analysis, Design, and Applications", CRC Press, BocaRaton, U.S.A., 2001.
3. Miller, T.J.E. "Brushless Permanent Magnet and Reluctance Motor Drives", Clarendon Press, Oxford, 1989.
4. Kenjo, T, "Stepping Motors and Their Microprocessor Control", Clarendon Press, Oxford, 1989.
5. Naser A, Boldea I, "Linear Electric Motors: Theory, Design And Practical Application", Prentice Hall Inc., New Jersey, 1987
6. Kenjo, T, Naganori, S "Permanent Magnet and Brushless DC Motors", Clarendon Press, Oxford, 1989.

14EE3009 POWER ELECTRONICS LABORATORY

Credits: 0:0:1 **(Version 1.1)**

Corequisite: 14EE3002 Power Converter Analysis – I &
14EE3003 Power Converter Analysis – II

Course Objectives:

- To demonstrate the principles of operation and design procedures of various power electronic converters.

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

- Know hardware and measurement techniques used in power electronic systems
- Analyze the applications of power electronic converters.

Course Description:
This laboratory demonstrates the students the simulation and design of various converters.
Experiments:
The faculty conducting the laboratory will prepare a list of 6 experiments and get the approval of HOD/Director and notify it at the beginning of each semester.

14EE3010 ELECTRIC DRIVES AND CONTROL LABORATORY

Credits: 0:0:1 **(Version 1.1)**
Co-requisite: 14EE3004 Solid State DC Drives
14EE3005 Solid State AC Drives

Course Objectives:

- To learn the operation of electric drive systems and the associated controllers.

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

- Understand how power electronic converters and inverters operate.
- Possess an understanding of feedback control theory.
- Develop control algorithms for electric drives which achieve the regulation of torque, speed, or position in the above machines.

Course Description:
The lab will consist of giving the students hands-on experience with electric drives (AC and DC), power converter, and control algorithms for electric drives.
Experiments:
The faculty conducting the laboratory will prepare a list of 6 experiments and get the approval of HOD/Director and notify it at the beginning of each semester.

14EE3011 PHOTOVOLTAIC SYSTEMS

Credits: 3:0:0 **(Version 1.1)**

Course Objectives:

- To gain knowledge of modeling, design and analysis of different PV systems
- To learn the maximum power extraction from PV systems
- To understand the power conditioning of PV system's power output.

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

- Model and analyze different photovoltaic systems
- Extract the maximum power output from PV systems through different methods
- Design efficient stand alone and grid connected PV power systems

Course Description:
Historical development of PV-Overview of PV usage-Solar Radiation and spectrum of sun- geometric and atmospheric effects of Sunlight-Photovoltaic effect. Solar cells and arrays- Structure and characteristics- modeling of solar-PV Generators- Energy storage alternatives for PV Systems-Types –

Modeling - Inverter control topologies for standalone and grid connected system-Power conditioning and maximum power point tracking (MPPT)- Active systems.

References:

1. Castaner L., Silvestre S., “Modeling Photovoltaic Systems Using PSpice”, John Wiley & Sons, England, 2002.
2. Komp R.J., “Practical Photovoltaics: Electricity from solar cells”, Aatec Publications, Michigan, 2001.
3. Patel M. R., “Wind and Solar Power Systems Design, Analysis, and Operation”, CRC Press, New York, 2005.
4. Jenny Nelson, “The physics of solar cells”, Imperial College Press, London, 2003.
5. Goetzberger, Hoffmann V. U., “Photovoltaic Solar Energy Generation”, Springer-Verlag, Berlin, 2005.

14EE3012 POWER ELECTRONIC CIRCUITS

Credits: 3:0:0 **(Version 1.1)**

Course Objectives:

- To gain the knowledge of various conversion techniques of electrical energy using power electronic components.
- To understand the significance of the characteristics of various power semiconductor switches
- To understand various modulation and control techniques for power electronic circuits

Course Outcomes:

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

- Establish the link between efficient conversion of power .
- Design various power electronic converters.
- Design controllers for power electronic converters.

Course Description:

Semiconductor power switching devices used in power electronic circuits - AC to DC Converters - Single phase and three phase bridge Rectifiers - Evaluation of performance parameter - Design of converter circuits –Control circuit strategies - DC Choppers - Switching mode regulators - Chopper circuit design - Single phase and Three phase bridge inverters - CSI - Resonant Switch – Quasi-Resonant Converters – Multi resonant Converters - Principle of phase control - Principle of operation – single phase and three phase Cycloconverters – Control circuit strategies.

References:

1. Rashid M.H., “Power Electronics Circuits, Devices and Applications”, Prentice Hall India, New Delhi, 2003.
2. Sen P.C., “Modern Power Electronics”, Tata McGraw Hill Education India Private Limited, New Delhi, 2004.
3. Ned Mohan, Tore M. Undeland, William P, Robbins, “Power Electronics: Converters, Applications, and Design”, John Wiley and Sons Inc., New York, 2003.
4. Joseph Vithayathil, “Power Electronics”, New Age International Private Limited, New Delhi, 2010.
5. Singh M.D., Khanchandani K B, “Power Electronics”, Tata McGraw Hill Education India Private Limited, New Delhi, 2nd Edition, 2006.

14EE3013 ENERGY ENGINEERING

Credits: 3:0:0 **(Version 1.1)**

Course Objectives:

- To gain knowledge on energy scenario and conservation.
- To know about different ways of energy harvesting from natural resources.
- To understand the evolution of smart grid and its components

Course Outcomes:

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

- Apply different strategies to conserve the energy.
- Propose different ways of harvesting energy from renewable energy sources.
- Identify the functionalities of smart grid components.

Course Description:

Introduction to Energy and its conservation, Origin of fossil fuels, National and Global Energy Scenario, Various Renewable Energy Systems, Funding agencies - Kyoto Protocol, Environmental Degradation due to Energy Production and Utilization; Evolution of Smart Grids – Smart Grid Components – Risks to Smart Grid – Wireless Sensor Networks and its Applications – Introduction to Deregulation.

References:

1. Vaclav Smil, Energy: A Beginner's Guide, One world Publications, Oxford, 2006.
2. Stuart Borlase, “Smart Grids: Infrastructure, Technology, and Solutions” Taylor and Francis, Boca Raton, 2012.
3. NarendraJadhav, Rajiv Ranjan, SujanHajra, “Re-Emerging India - A Global Perceptive”, The ICFAI University Press, Hyderabad, 2005.
4. Eric Jeffs, “Green energy: sustainable electricity supply with low environmental impact” CRC Press, USA, 2010.
5. Kishore V. V.N., “Renewable Energy Engineering and Technology Principles and Practice”, Earthscan Publications Ltd, UK, 2009.
6. Steve Doty, Wayne C. Turner, “Energy Management Handbook” Fairmont Press, Lilburn, 8th Edition, 2012.

14EE3014 WIND ENERGY

Credits: 3:0:0 **(Version 1.1)**

Course Objectives:

- To gain detailed understanding of the issues associated with the development of wind energy for electrical energy supply
- To study the aerodynamic design of wind turbines
- To understand the issues of location and grid connection of wind energy power plants

Course Outcomes:

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

- Assess the possibility of wind turbine generator deployment in a given geographical location
- Design the wind turbine blade rotor based on aerodynamics
- Propose grid interconnection strategy and hybridization of wind energy system with other energy sources

Course Description:

Power Contained in Wind, Principal Wind Turbine Components, Materials & Topologies, Wind Turbine Power Curve, Economic Assessment of Wind Energy Systems, Value of Wind Energy - General

Characteristics of Wind Resource & Atmospheric Boundary Layer, Wind Data Analysis and Resource Estimation, Wind Turbine Energy Production Estimates, Wind Prediction and Forecasting, Wind Measurement and Instrumentation, Wind Turbine Siting, Installation & Operational Issues, Offshore Wind Energy, Environmental impacts of Wind Energy Systems - Airfoils and Concepts of Aerodynamics, Blade Design for Modern Wind Turbines, Momentum Theory and Blade Element Theory, Generalized Rotor Design Procedure, Classification of Schemes with Variable-speed Turbines, Induction Generators, Stand-alone configurations, Wind Turbine Control System, Wind Turbines and Wind Farms in Electrical Grids, Hybrid Power Systems.

References:

1. Manwell, J.F., McGowan, J.G. and Rogers A.L., "Wind Energy Explained – Theory, Design and Application", Second Edition, John Wiley & Sons, UK, 2010.
2. Bhadra S. N., Kastha D., Banerjee S,. "Wind Electrical Systems", Oxford University Press, New Delhi, 2013.
3. Heier, S., "Grid Integration of Wind Energy", Third Edition, John Wiley & Sons, UK, 2014.
4. Burton, T., Sharpe, D., Jenkins N. and Bossanyi, E., "Wind Energy Handbook", Second Edition, John Wiley & Sons, UK, 2011.
5. Ackermann, T., "Wind Power in Power Systems", Second Edition, John Wiley& Sons, UK, 2012.
6. Olimpo Anaya-Lara, Nick Jenkins, Janaka Ekanayake ,Phill Cartwright, Michael Hughes, "Wind Energy Generation: Modelling and Control", John Wiley& Sons, UK, 2009.

14EE3015 HYDROGEN AND FUEL CELLS

Credits: 3:0:0 **(Version 1.1)**

Course Objectives:
- To learn the different production and storage technology
- To understand the advanced fuel cell technologies
- To know the prospects of hydrogen/fuel cell utilization for future energy requirements.

Course Outcomes:
At the end of the course, the student will be able to
- Explain the hydrogen production methodologies, possible applications and various storage options.
- Describe the working of a typical fuel cell, its types and to elaborate on its thermodynamics and kinetics
- Analyze the cost effectiveness and eco-friendliness of Hydrogen and Fuel Cells.

Course Description:
Hydrogen – physical and chemical properties– Production of hydrogen- Hydrogen storage options – Hydrogen transmission systems – Applications of Hydrogen – History, principle, working of a fuel cell – thermodynamics and kinetics of fuel cell process – performance evaluation of fuel cell – comparison on battery vs fuel cell- Types of fuel cells –relative merits and demerits – Microbial Fuel Cell - Fuel cell usage for domestic power systems – large scale power generation – Automobile, Space. Economic and environmental analysis on usage of Hydrogen and Fuel cell – Future trends in fuel cells.

References:

1. Bent Sorensen, "Hydrogen and Fuel Cells: Emerging Technologies and Applications", Elsevier Science Technology, United Kingdom, 2005
2. Rebecca L., Busby, "Hydrogen and Fuel Cells: A Comprehensive Guide", Penn Well Corporation, USA, 2005

3. Jeremy Rifkin, “The Hydrogen Economy”, Penguin Group, New York, 2002
4. Viswanathan B., AuliceScibioh M, “Fuel Cells – Principles and Applications”, Universities Press, India, 2006.
5. Thomas B. Johansson, Henry Kelly, AmulyaK.N. Reddy, Robert.H. Williams, “Renewable Energy Sources for Fuels and Electricity”, Island Press, Washington DC, 2009.
6. Bruce E. Logan, “Microbial fuel cells”, John Wiley & Sons, Inc., Hoboken, New Jersey, 2008

14EE3016 ENERGY MANAGEMENT AND AUDIT

Credits: 3:0:0 **(Version 1.1)**
Prerequisite: 14EE3013 Energy Engineering

Course Objectives:

- To acquire knowledge on various energy management techniques.
- To provide in-depth knowledge on the energy auditing techniques.
- To know about energy related policies.

Course Outcomes:

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

- Perform energy audits
- Identify energy conservation and opportunities in Electrical and Thermal utilities.
- Suggest new energy saving methods

Course Description:

Energy Management in Electrical Utilities and Thermal Utilities – Definition of energy audit – Needs – Types - Approaches; Energy Audit Instruments, Duties and Responsibilities of Energy Auditors. Action Planning: Key Elements, Force Field Analysis, Energy Policy- Purpose, Perspective, Contents, Formulation, Ratification; Location of Energy Management, Case studies.

References:

1. Clive Beggs, “Energy: Management, Supply and Conservation” Abingdon, Oxon, UK, Routledge, 2013.
2. Albert Thumann, William J. Younger, Terry Niehus, “Handbook of Energy Audits” Lilburn, GA: Fairmont Press; Boca Raton, FL: Distributed by Taylor & Francis, ©2013.
3. Steve Doty, Wayne C. Turner, “Energy Management Handbook” Fairmont Press, Lilburn, 8th Edition, 2012.
4. Barney L. Capehart, Wayne C. Turner, William J. Kennedy, “Guide to Energy Management”, Fairmont Press, Lilburn, 2008.
5. MoncefKrarti, “Energy Audit of Building Systems: An Engineering Approach” Taylor & Francis, Boca Raton, 2010.
6. http://www.em-ea.org/gbook1.asp

14EE3017 ENERGY MODELLING, ECONOMICS AND PROJECT MANAGEMENT

Credits: 3:0:0 **(Version 1.1)**
Prerequisite: 14EE3013 Energy Engineering

Course Objectives:

- To understand about energy modeling in renewable energy technology.
- To learn about the economic aspects involved in renewable energy technology.

- To get in-depth knowledge on the various techniques involved in project management and financial management.

Course Outcomes:

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

- Predict energy demand by using various forecasting techniques.
- Estimate the cost of electricity produced from different renewable energy sources.
- Perform financial analysis and project evaluation to assess the feasibility of renewable energy projects.

Course Description:

Modelling Approaches, Input-Output Analysis, Energy Demand Analysis and Forecasting – Economics of Renewable Sources of Energy, Waste Heat Recovery and Cogeneration - Energy Conservation Economics - Cost Analysis – Budgetary Control - Financial Management - Techniques for Project Evaluation.

References:

1. Munasinghe M., Meier P., "Energy Policy Analysis and Modeling", Cambridge University Press, New York, 2008.
2. Spyros Makridakis, Steven C. Wheelwright, Rob J. Hyndman, "Forecasting Methods and Applications", Wiley, Singapore, 2008.
3. James Stock, Mark Watson, "Introduction to Econometrics", Pearson Education, 3rd Edition, New Delhi, 2010.
4. Kurt Campbell, Jonathon Price, "The Global Politics of Energy", The Aspen University, Washington, 2008.
5. Bob Shivley, John Ferrare, "Understanding Today's Electricity Business", Enerdynamics, Laporte, 2010.

14EE3018 SOLAR ENERGY LABORATORY

Credits: 0:0:1 **(Version 1.1)**

Co requisite: 14EE3011 Photovoltaic Systems

Course Objectives:

- To know the maximum power extraction from solar PV system through sun tracking and maximum power point tracking.
- To understand the carrier life time measurement procedures and its effect on the performance of PV cell
- To gain knowledge through hands on training on stand alone and grid tied PV systems

Course Outcomes:

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

- Suggest a suitable sun tracking methodology based on the location.
- Design an efficient PV system considering the different types of loads
- Propose suitable control algorithm for maximum power extraction

Course Description:

This laboratory demonstrates the students to study the characteristics of a PV cell, PV array and control the PV array for maximum power point tracking.

Experiments:

The faculty conducting the laboratory will prepare a list of 6 experiments and get the approval of HOD/Director and notify it at the beginning of each semester.

14EE3019 WIND ENERGY LABORATORY

Credits: 0:0:1 **(Version 1.1)**

Corequisite: 14EE3014Wind Energy

Course Objectives:

- To study the various wind power forecasting techniques.
- To gain knowledge on control algorithms for maximum power operation.
- To know the modeling techniques for wind power system.

Course Outcomes:

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

- Assess the wind resources at a site.
- Model a suitable wind power system and implement a suitable controller for maximum wind power.
- Test the wind turbine generator system using wind tunnels

Course Description:

This laboratory demonstrates the students the modeling and control of a wind power system.

Experiments:

The faculty conducting the laboratory will prepare a list of 6 experiments and get the approval of HOD/Director and notify it at the beginning of each semester.

14EE3020 POWER ENGINEERING SIMULATION LABORATORY

Credits: 0:0:1 **(Version 1.1)**

Course Objectives:

- To simulate power electronic circuit to solve power engineering problem.

Course Outcomes:

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

- Simulate circuit for an application using technical software.
- Solve the power engineering problems by programming.

Course Description:

This laboratory demonstrates the students the usage of technical softwares like MATLAB/SIMULINK, PSIM, PSCAD etc.

Experiments:

The faculty conducting the laboratory will prepare a list of 6 experiments and get the approval of HOD/Director and notify it at the beginning of each semester

14EE3021 FLEXIBLE AC TRANSMISSION SYSTEMS

Credits: 3:0:0 **(Version 1.1)**

Course Objectives:

- To understand the concept of FACTS.
- To study about the characteristics of various FACTS controllers.
- To learn the implementation of various FACTS controllers

Course Outcomes:

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

- Model FACTS devices.

- Select the suitable FACTS device to enhance the security, capacity and flexibility of Power transmission systems.
- Select location for FACTS devices.

Course Description:
Concept and general system considerations of flexible alternating current Transmission Systems (FACTS). A review of power semiconductor devices Static shunt and series compensators such as SVC, STATCOM, GCSC, TSSC, TCSC and SSSC. Static voltage and phase angle regulation using TCVR and TCPAR. Unified and Interline Power Flow Controllers. Special Purpose FACTS Controllers: NGH-SSR Damping Scheme and Thyristor-Controlled Braking Resistor. Application Examples.Modern FACTS Devices-location of FACTS Devices.

References:

1. Narain G. Hingorani, "Understanding FACTS", Standard Publishers Distributors, New Delhi, 1st Edition, 2001
2. Xiao-ping Zhang, Christian Rehtanz, Bikash Pal, "Flexible AC Transmission Systems: Modelling and Control", Springer-verlag Publisher, New Delhi, 1st Edition, 2006.
3. Padiyar.K.R., "Facts Controllers In Power Transmission and Distribution", Anshan Publisher, Kent (United Kingdom), 1stEdition, 2009.
4. Song Yong Hua, "Flexible AC Transmission Systems", Shankar's Book Agency Pvt. Ltd., Kolkata, 2009.
5. R. Mohan Mathur, Rajiv K. Varma, Mathur, "Thyristor-Based FACTS Controllers for Electrical Transmission Systems", IEEE Computer Society Press, New Delhi, Annotated Edition, 2002.

14EE3022 HVDC TRANSMISSION

Credits: 3:0:0 **(Version 1.1)**

Course Objectives:
- To understand HVDC system, converters and various means of controls.
- To study various malfunctioning of the HVDC system.
- To know the basics of various faults and protection schemes in HVDC.

Course Outcomes:
At the end of the course, the student will be able to
- Examine HVDC transmission system based on various types of converters.
- Analyze various controllers used in HVDC transmission system.
- Investigate various converter faults and protection schemes.

Course Description:
Introduction – Comparison of AC and DC Transmission – Applications of DC Transmission – Planning for HVDC Transmission – Modern Trends in HVDC Technology – Operating Problems – HVDC Transmission Based on Voltage Sourced Converters - Line Commutated Converter – Voltage Source Converter – Analysis of Line Commutated Converter, Bridge Characteristics, Twelve Pulse Converter, Detailed Analysis – Capacitor Commutated Converters – Analysis of VSC - Principles of DC Link Control – Converter Control Characteristics – System Control Hierarchy – Firing Angle Control – CEA Control – Starting and Stopping of a DC Link – Power Control – Higher Level Controllers – Tele Communication Requirements – Control of VSC - Converter Faults – Protection against Overcurrents, Overvoltages in a Converter Station, Surge Arrestors, Protection against Overvoltages – Protection against Faults in VSC.

References:
1. Erich Uhlmann, “Power Transmission by Direct Current”, Springer International Edition, 2004.
2. Padiyar. K. R, “HVDC Power Transmission Systems”, New Age International Publishers Private Ltd., New Delhi, 2012.
3. Neville R. Watson, Y. H. Liu, J. ArrillagaArrilaga J., “Flexible Power Transmission: The HVDC Options”, John Wiley & Sons, 2007.
4. Chan-ki Kim, Vijay K. Sood, Gil-soo Jang, Seong-joo Lim, Seok-jin Lee, “HVDC Transmission: Power Conversion Applications In Power Systems”, John Wiley (IEEE Press), 2009.
5. Kamakshaiah. S, Kamaraju. V, “HVDC Transmission”, Tata McGraw Hill Education Pvt. Ltd., New Delhi, 2011.
6. Jos Arrillaga, High Voltage Direct Current Transmission, The Institution of Electrical Engineers, London,United Kingdom, Second Edition, 1998.

14EE3023 INDUSTRIAL POWER SYSTEM ANALYSIS AND DESIGN

Credits: 3:0:0 **(Version 1.1)**

Course Objectives:
- To understand operational and maintenance requirements of power system
- To understand the terminologies used in the context of an electrical distribution system.
- To study about Power Factor Correction, Harmonic analysis, Flicker, Grounding problems in power system.

Course Outcomes:
At the end of the course, the student will be able to
- Apply the appropriate industry recognized design standards
- Use simple "rules of thumb" to estimate the performance and economics of an electrical distribution systems design
- Design an industrial power system with appropriate safety.

Course Description:
Power Factor Correction Studies-Frequency Scan Analysis-Voltage Magnification Analysis-Sustained Over voltages-Switching Surge Analysis-Harmonic Analysis: Harmonic Sources-System Response to Harmonics- Harmonic Filters-Harmonic Evaluation-Flicker Analysis: Sources of Flicker-Flicker Criteria-Data for Flicker analysis- Minimizing the Flicker Effects-Summary-Ground Grid Calculations- Improving the Performance of the Grounding Grids

References:
1. Ramasamy Natarajan, “Computer-Aided Power System Analysis”, Marcel Dekker Inc., CRC Press, New York, 2002.
2. Shoaib Khan, Sheeba Khan, “Industrial Power system”, CRC press, Boca Raton, 2007. Duncan GloverJ., Mulukutla S. Sarma, Thomas Overbye,“Power System Analysis and Design”, Thomson Learning Group, Canada, 5th Edition, 2011.
3. Dunki - Jacobs J.R., Shields F.J., Conrad St. Pierre, “Industrial Power system Grounding Design Handbook”, Electric Power Consultants, 2007.
4. Hemant Joshi, “Residential, Commercial and Industrial Electrical System”,Tata McGraw Hill Education Private Limited, New Delhi, 2005.

14EE3024 DISTRIBUTED GENERATION

Credits: 3:0:0 **(Version 1.1)**

Course Objectives:

- To understand the concept of distributed generation
- To study the power architecture and control strategies related to Distributed Generation
- To learn the impact of distributed generation on the grid

Course Outcomes:

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

- Describe the operating principle of various Distributed Generation technologies
- Design the power electronics interface circuits and the associated control
- Investigate the impact of DG on the microgrid environment and to suggest mitigating techniques.

Course Description:

Distributed Generation (DG) - Overview and technology trends - The electric grid vs. Microgrids-Distributed Generation units. Microturbines, reciprocating engines, wind generators, photovoltaic generators, fuel cells and other technologies- Power electronics interfaces: AC-DC and DC-AC-Power architectures: distributed and centralized. DC and AC distribution-Controls: distributed, autonomous and centralized systems-Grid interconnection. Issues, planning, advantages and disadvantages both for the grid and the microgrid.

References:

1. N. Jenkins, J.B. Ekanayake and G.Strbac, Distributed Generation, IET Press, UK, 2010
2. Math H. Bollen, Fainan Hassan, Integration of Distributed Generation in the Power System, Wiley-IEEE Press, July 2011
3. Suleiman M. Sharkh, Mohammad A. Abu-Sara, Georgios I. Orfanoudakis, Babar Hussain, Power Electronic Converters for Microgrids, Wiley-IEEE Press, March 2012
4. Qing-Chang Zhong, Tomas Hornik, Control of Power Inverters in Renewable Energy and Smart Grid Integration, IEEE Press, January 2013.
5. Nikos Hatziargyriou, Microgrids Architectures and Control, Wiley-IEEE Press John Wiley and Sons Ltd, UK, 2014

14EE3025 COMMUNICATIONS AND CONTROL IN SMART GRID

Credits: 3:0:0 **(Version 1.1)**

Course Objectives:

- To learn about smart Grid communication systems.
- To learn about advanced metering with cyber security.
- To know about various controlling parameters of electric power through communication systems.

Course Outcomes:

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

- Design and Implement the concept of a smart grid.
- Integrate the latest communication system with smart grid.
- Develop customized cyber security system and advanced metering.

Course Description:

Smart Grid Definition-Smart Grid Communications: Two-way Digital Communications Paradigm- Power Line Communications- Wide Area Measurement-smart meters and Automated Meter Reading Infrastructure (AMRI)- Pricing and Energy Consumption Scheduling- Phasor Measurement Units-Communications Infrastructure- Cyber Security Challenges in Smart Grid – SCADA – DCS.

References:

1. Ekram Hossain, Zhu Han,H. Vincent Pool, " Smart Grid Communications and Networking", Cambridge University Press, 2012.
2. James Mamoh, "Smart Grid : Fundamentals of Design and Analysis", IEEE press, 2nd Edition, 2007
3. JanakaEkanyake, " Smart Grid Technology and application", John Wiley,2012
4. Communications Requirements Of Smart Grid Technologies-Hand book, Department of Energy, United States , 2007
5. Kothari D.P., Nagrath I.J., " Modern Power Ssytem Analysis, Tata McrawHill education, 2003

14EE3026 ELECTRICAL TRANSIENTS IN POWER SYSTEMS

Credits: 3:0:0 **(Version 1.1)**

Course Objectives:

- To gain knowledge in the sources and effects of lightning, switching and temporary over-voltages
- To study the transient behavior of Power system equipments
- To understand the model of power system equipment for transient over voltages

Course Outcomes:

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

- Model And Simulate The Behavior Of Power System Equipments Under Transient Conditions
- Analyze, Recognize And Mitigate The Transients In Electrical Systems
- Explain the methods to protect Power system apparatus from transients

Course Description:

Introduction to Transients, Transients in Lumped Circuits, Modeling of Transmission Lines and Cables for Transient Studies, Transients of Shunt Capacitor Banks, Switching Transients and Temporary Over-voltages, Transient Behavior of Synchronous Generators, Transient Behavior of Induction and Synchronous Motors, Transient Behavior of Transformers, Gas-Insulated Substations—Very Fast Transient Over-voltages [VFTO], Transients in Grounding Systems, IEC and IEEE standards.

References:

1. J.C. Das, Transients in Electrical Systems- Analysis, Recognition and Mitigation, The McGraw-Hill companies, 2010
2. Allan Greenwood, "Electrical Transients in Power System", Wiley India Pvt. Ltd. 2nd Edition, India, 2012
3. Pritindra Chowdhari, "Electromagnetic Transients in Power Systems", PHI Ltd. 2nd Edition, New Delhi, 2012
4. Akihiro Ametani, Naoto Nagaoka, Yoshihiro Baba, Teruo Ohno, Power System Transients: Theory and Applications, CRC Press 2013
5. Juan A. Martinez-Velasco, Transient Analysis of Power Systems: Solution Techniques, Tools and Applications, John Wiley & sons Ltd, 2015

14EE3028 POWER SYSTEM PLANNING AND RELIABILITY

Credits: 3:0:0 **(Version 1.1)**

Course Objectives:
- To learn the fundamentals of load forecasting and its types
- To know the generation and transmission system reliability
- To study the expansion planning in power systems.

Course Outcomes:

At the end of the course the students will be able to
- Apply the load forecasting methods in case studies.
- Analyze the generation and transmission system reliability
- Design expansion planning in power systems.

Course Description:

Objectives of forecasting, Load growth patterns and their importance in planning, Multiple regression technique, Weather sensitive load forecasting, Annual forecasting, Use of AI in load forecasting, Probabilistic generation and load models, Determination of LOLP and reliability of ISO and interconnected generation systems, Deterministic contingency analysis-probabilistic load flow-Fuzzy load flow probabilistic transmission system reliability analysis, Determination of reliability indices like LOLP ,LOLE and expected value of demand not served. Expansion planning procedures followed for integrated transmission system planning, Capacitor placing problem in transmission system and radial distributions system. Sub transmission lines and distribution substations-Design primary and secondary systems-distribution system protection and coordination of protective devices.

References:

1. Marko cepin, "Assessment of power system reliability" wiley publishers,2011
2. Fawwaz Elkarm and Nazith Abushikah, "Power system planning technologies and applications",Engineering science and reference,2012
3. James Mamoh, "Smart Grid : Fundamentals of Design and Analysis", IEEE press, second edition, 2007
4. Janaka Ekanyake, " Smart Grid Technology and application", John Wiley,2012
5. Kothari D.P., Nagrath I.J., "Modern Power System Analysis, Tata Mc graw Hill education, 2003.

14EE3029 ELECTRIC AND HYBRID VEHICLES

Credits: 3:0:0 **(Version 1.1)**

Course Objectives:
- To understand the concept of Electric Vehicle Technology.
- To understand various components of EV and HEV
- To understand various energy recovery schemes used in EV and HEV.

Course Outcomes:

At the end of the course, the student will be able to
- Discriminate and design different configurations of EV and HEV.
- Setup different motor drive controllers
- Chose different technology to use the energy on-board optimally.

Course Description:

Environmental Impact and History of Modern Transportation – Configuration of EV – Need and advantages over fuelled vehicle – Performance of Electric Vehicles –Types of Electric Vehicle - Configuration and Types of HEV and its merits and demerits - Fuel Cell Vehicles – Battery –principle and Chemical reaction of Lead acid and Lithium Batteries –Electric Propulsion Systems - DC Motor Drives Principle and Performance - Induction Motor Drives - Principles –Steady state Performance - Permanent Magnetic Brush-Less DC Motor Drives - Basic Principles of BLDC Motor Drive – SRM - Principles – Steady state Performance –Fundamentals of Regenerative Braking - Ultra capacitors – Fly Wheels.

References:

1. Mehrdad Ehsani, YiminGao, Sebatien Gay and Ali Emadi, "Modern Electric, Hybrid Electric and Fuel cell vehicles: Fundamentals, Theory and Design", CRC press, 2004.
2. James Larminie and John Loury, "Electric Vehicle Technology – Explained", John Wiley & Sons Ltd, 2003.
3. Sandeep Dhameja, "Electric Vehicle Battery Systems", Butterworth – Heinemann, 2002.
4. Ronald K Jurgen, "Electric and Hybrid – Electric Vehicles", SAE, 2002.
5. Ron Hodkinson and John Fenton, "Light Weight Electric/Hybrid Vehicle Design", Butterworth – Heinemann, 2001.

14EE3030 MODELLING AND DESIGN OF ELECTRIC AND HYBRID VEHICLE

Credits: 3:0:0 **(Version 1.1)**

Prerequisite: 14EE3029 Electric and Hybrid Vehicles

Course Objectives:

- To understand structural modelling of EHV.
- To understand various vehicle propulsion mechanisms for EHV.
- To understand the factors those influence the performance of EHV.

Course Outcomes:

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

- Suggest a suitable aerodynamic design for improving the vehicle performance.
- Analyse the performance of EHV using the mathematical model.
- Describe the use of drives and controllers for EHV.

Course Description:

Vehicle Architecture - Tractive Effort - Aerodynamic Considerations - Consideration of Rolling Resistance - Transmission Efficiency- Consideration of Vehicle Mass - Electric Vehicle Chassis and Body Design – Vehicle Linear, Dynamic Model and reference Model - Modelling Vehicle Acceleration - Modelling Electric Vehicle Range – IC Engine for Hybrid Vehicle Modelling -Battery Modelling – Modelling DC Motor drive and Controller - Induction Motor drive and controller - SRM drive and controller drive – PMSM drive and Controller.

References:

1. Seref Soylu, "Electric Vehicles – Modelling and Simulations", InTech, Croatia, 2011.
2. Mehrdd Ehsani, Yimin Gao, Sebatien Gay, Ali Emadi, "Modern Electric, Hybrid Electric and Fuel cell vehicles: Fundamentals, Theory and Design", CRC press, 2004.
3. James Larminie, John Loury, "Electric Vehicle Technology – Explained", John Wiley & Sons Ltd, U.K., 2003.
4. Haitham Abu-Rub, Atif Iqbal, JaroslawGuzinski , "High Performance Control of AC Drives with Matlab / Simulink Models", John Wiley, U.K., 2012.
5. Thipse S. S., "Internal Combustion Engines", Jaico Publishing House, New Delhi, 2010.

14EE3031 POWER MANAGEMENT FOR HEV

Credits: 3:0:0 **(Version 1.1)**

Course Objectives:
- To study the need for vehicle power management.
- To gain a knowledge about the controllers for vehicle power management.
- To learn about component design and fuel economy for HEV.

Course Outcomes:
At the end of the course, the student will be able to
- Know various approaches for vehicle power management.
- Design a suitable controller for HEV.
- Manage energy storage systems for electric vehicle.

Course Description:
Vehicle Configuration – Vehicle Fuel Consumption and Performance – Power demand in drive cycles – objective of Vehicle Power Management (VPM) – VPM in conventional and HEV – Analytical approach for VPM – Wavelet Technology – Dynamic and quadratic programming – Intelligent System approach for VPM – Application of Fuzzy Logic and Neural Network in VPM – Sliding mode and Fuzzy Logic based powertrain controller for Series HEV – Management of Energy Storage Systems in EV, HEV and PHEV – HEV Component design and optimization for fuel economy – Future trends

References:

1. Xi Zhang, Chris Mi, "Vehicle Power Management: Modeling, Control and Optimization" Springer – Verlag, London, 2011.
2. Wei Liu, "Introduction to Hybrid Vehicle System Modeling and Control", Wiley Publication, 2013.
3. Danil Prokhorov, "Computational Intelligence in Automotive Applications", Springer, 2008.
4. Sheldon S. Williamson, "Energy Management Strategies for Electric and Plug-in Hybrid Electric Vehicles", Springer, 2013.

14EE3032 HYBRID ELECTRIC VEHICLE POWERTRAINS

Credits: 3:0:0 **(Version 1.1)**
Prerequisite: 14EE3029 Electric and Hybrid Vehicles

Course Objectives:
- To learn various Hybrid powertrains, power train modeling and hybrid electric system design.
- To gain knowledge about the operation and characteristics of various electric machines and converters/controllers used in HEV.
- To understand the energy requirements of hybrid vehicle using IC engine, battery and Fuel cell, their management system and selection of hybrid system.

Course Outcomes:
At the end of the course, the student will be able to
- Analyze the various hybrid powertrain architecture and model power trains for HEV.
- Select and use various electric motors and suitable power electronic converters for driving motors in EHV so as to deliver maximum efficiency and energy regeneration.
- Describe the energy requirements for hybrid electric vehicles and selection of hybrid system with suitable energy sources.

Course Description:
Hybrid Powertrains for Commercial Vehicles-Classification-Hybrid Powertrain Architecture Evolution - Energy Power Requirements for HEV Power Train Modeling and Control- IC Engines for commercial

vehicles-Clutches and transmission for commercial vehicles – Electric Machines in Hybrid Powertrain- Electric Machines and their Controllers for EV- DC and AC Electric Machines-Operation, characteristics, Efficiency- Converters for Electric vehicle- DC–DC Converters Applied in Hybrid Vehicle Systems, DC–AC Inverter-Design Requirements of an Energy Storage Unit Equipped with Battery-BMS design, Battery and Ultra capacitor in hybrid power train, voltage equalization- Basic Hybrid Powertrains Modeling- Hybrid-electric Power Conversion Systems-Hybrid-electric System Design and Optimization- Characteristics of Hybrid-electric Powertrains -Hybrid System Selection- Fuel Cell Hybrid Powertrain Systems-operation-PEM vehicles, SOFC vehicles- Future Powertrain Technologies.

References:

1. Antoni Szumanowski, “Hybrid Electric Power Train Engineering and Technology: Modeling, Control, and Simulation”, Warsaw University of Technology, Idea Group,U.S.; 1st edition, May, 2013
2. Haoran Hu, Simon Baseley and Rudolf M. Smaling, “Advanced Hybrid Powertrains for Commercial Vehicles”, SAE International, Warrendale, Pennsylvania, USA, 2012
3. Iqbal Husain, “Electric and Hybrid Vehicles: Design Fundamentals”, Second Edition, CRC Press, 2003
4. Gianfranco Pistoia, “Electric and Hybrid Vehicles: Power Sources, Models, Sustainability, Infrastructure and the Market”, Elsevier Publication, 1st Edition, 2010.
5. James Larminie and John Loury, “Electric Vehicle Technology – Explained”, John Wiley & Sons Ltd, 2003.
6. Wei Liu, “Introduction to Hybrid Vehicle System Modeling and Control”, Wiley Publication, 2013.

14EE3033 VEHICLE ENERGY STORAGE SYSTEMS

Credits: 3:0:0 **(Version 1.1)**

Course Objectives:

- To understand the operation of various storage devices, their characteristics and maintenance in electric vehicles.
- To learn the factors affecting the performance and management of the battery.
- To study the multiple energy sources hybridization.

Course Outcomes:

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

- Know the usage of various storage devices that can be particularly used in electric vehicles.
- Select a suitable storage device and interpret their characteristics.
- Manage the energy requirement when multiple sources are used for storing and/or generation.

Course Description:

Essential of energy storage in Electric vehicles- Energy storage, conversion and power systems from the perspective of HEV propulsion systems -Types of energy sources for EV- Electrochemical storage systems- Batteries- Principle-Battery Parameters- Lead Acid Batteries, Nickel-Based Batteries, Lithium Batteries, Metal–Air Batteries- Battery Modeling- Constant Current Discharge Approach- Standard Driving Cycles- Power Density Approach- Fuel Cells- Characteristics- Types -Fuel cell EV- Supercapacitors- Flywheels -Energy management-Methods of determining storage charge- Energy storage systems requirements-Service life in partial-state-of-charge (PSOC) Operation-Dynamic charge acceptance- Multiple Energy Sources Hybridization-Maintenance-Introduction to Charging stations- Future trends of Hybrid Vehicle Storage Technology.

References:
1. James Larminie and John Loury, “Electric Vehicle Technology – Explained”, John Wiley & Sons Ltd, 2003.
2. Christopher D. Rahnand Chao-Yang Wang, “Battery Systems Engineering”, Wiley Publication, New Delhi, India, 2013
3. Iqbal Husain, “Electric and Hybrid Vehicles: Design Fundamentals”,2nd Edition, CRC Press, 2003
4. Adam Stienecker ,“Hybrid Energy Storage Systems: An Ultracapacitor-Battery Energy Storage System for Hybrid Electric Vehicles”, VDM Verlag Publication, 2009
5. Rodrigo Garcia-Valle and João A. Peças Lopes “Electric Vehicle Integration into Modern Power Networks (Power Electronics and Power Systems)”, Springer Publication, 2012 Edition.
6. Wei Liu, “Introduction to Hybrid Vehicle System Modeling and Control”, Wiley Publication, 2013
7. Davide Andrea “Battery Management Systems for Large Lithium Battery Packs”, Artech House Publishers, 2010

14EE3034 ELECTRIC VEHICLE BATTERY TECHNOLOGY

Credits: 3:0:0 **(Version 1.1)**

Course Objectives:
- To learn about the various types of batteries for EV, their operation and characteristics.
- To gain knowledge about the equivalent circuit, modeling of battery and balancing of cells.
- To understand about the function of BMS and Battery manufacturing and maintenance.

Course Outcomes:
At the end of the course, the student will be able to
- Categorize various types of batteries for EV and analyze their performance.
- Model a battery based on the parameters of the battery and implement cell balancing.
- Know the functions of energy management system and deploying it in an EV.

Course Description:
Battery Electric Vehicles-Technology details-Vehicle Energy Efficiency Performance-EV Battery Capacity- Battery Parameters-Types of Battery for EV- Technical Characteristics-Battery Modeling- Purpose of Battery Modeling- Battery Equivalent Circuit- EV Battery Charging And Discharging- Battery Performance- Battery Storage System Modeling and Control- Methods of Determining State of Charge - Estimation of Battery Power Availability- Partnership for a New Generation Vehicles PNGV-Hybrid Pulse Power Characterization HPPC, Based on Electrical Circuit Equivalent Model- Battery Life Prediction- Aging Behavior and Mechanisms- State of Life- Cell Balancing- SOC Balancing, Hardware Implementation of Balancing, Cell Balancing Control Algorithms and Evaluation- Estimation of Cell Core Temperature- EV Battery System Efficiency, Battery Management Systems-Functionality, Technology, Topology -Functions-Measurement, Management, Evaluation-Deploying a BMS- Battery Manufacturing Process-Maintenance-Datasheet- Recycling and Disposal.

References:
1. Sandeep Dhameja, “Electric Vehicle Battery Systems”, Newnes Publication, 1st Edition, 2002.
2. Christopher D. Rahn, Chao-Yang Wang, “Battery Systems Engineering”, Wiley Publication 2013.
3. Wei Liu, “Introduction to Hybrid Vehicle System Modeling and Control”, Wiley Publication 2013
4. James Larminie and John Loury, “Electric Vehicle Technology – Explained”, John Wiley & Sons Ltd, 2003.

5. Davide Andrea "Battery Management Systems for Large Lithium Battery Packs", Artech House Publishers 2010.

14EE3035 MODELING OF POWER CONVERTERS

Credits: 3:0:0 **(Version 1.1)**

Prerequisite: 14EE3002 Power Converter Analysis – I
14EE3003 Power Converter Analysis – II

Course Objectives:

- To gain knowledge of latest advances in the field of power electronics.
- To understand the basics of modeling of power converters.
- To introduce the phenomena of non-linearity in power converters.

Course Outcomes:

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

- Describe the effect of power electronic converter in a system using their models and transfer functions
- Able to design filters for converters.
- Explain the impact of non-linear phenomena in power electronic circuits

Course Description:

Basic AC modeling approach – State-space averaging – Circuit averaging and averaged switch modeling – Canonical circuit model .Analysis of converter transfer functions – Graphical construction of impedances and transfer functions – Graphical construction of Converter transfer functions .Effect of an input filter on converter transfer functions – Design of a damped input filter. Border collision bifurcations in the current mode controlled boost converter -Bifurcations and chaos in the latched voltage controlled buck converter - Saddle-node and Neimark bifurcations in PWM DC-DC converters .Non-Linear Phenomena in Power Electronics Circuits and Analysis of stability and bifurcation in power electronic induction motor drive systems.

References:

1. Erickson R.W., Maksimovic D., "Fundamentals of Power Electronics", Kluwer Academic Publishers, USA, 2nd Edition, 2004.
2. Banerjee S., Varghese G. C., "Non-linear phenomena in Power Electronics: Attractors, Bifurcations, Chaos and Non-linear control", IEEE press, New York, 2001.
3. Chi Kong Tse, "Complex Behaviour of Switching Power Converters", CRC Press, New York, 2004.
4. Ned Mohan, T. M. Undeland, W. P. Robbins, "Power Electronics: Converters, Applications and Design", John Wiley & Sons, USA, 3rd Edition, 2003.
5. Hua Bai, Chris Mi, "Transients of Modern Power Electronics", John Wiley & Sons, UK, 2011.

14EE3036 POWER ELECTRONICS IN WIND AND SOLAR POWER CONVERSION

Credits: 3:0:0 **(Version 1.1)**

Course Objectives:

- To understand the role of power electronics in various photovoltaic energy conversion and wind energy conversion systems
- To gain knowledge in examining the performance of various converters and inverters.
- To learn the methods of Investigation and the integration of renewable energy conversion system with the grid.

Course Outcomes:
At the end of the course, the student will be able to
- Describe various factors which affect the wind energy conversion system.
- Distinguish Grid connector concepts and Identify Grid related problems.
- Design PV systems to meet the requirement of Energy needs

Course Description:
Photovoltaic Energy Conversion: Solar radiation and measurement and availability - solar cells and their characteristics - influence of insulation and temperature - Electrical storage with batteries–Switching devices-DC Power conditioning converters – MPPT- AC and DC power conditioners -Line commutated inverters – synchronized operation with grid supply- Harmonic problem–Applications - Wind energy conversion(WEC):Principle, classification, components-Power in the wind- Performance of induction generators for WECS - Self excited induction generator for isolated power generators - Theory of self-excitation - Capacitance requirements – Power conditioning schemes - Controllable DC Power from Self excited induction generators (SEIGs) -system performance. Grid Connected WECS: Grid connectors concepts - wind farm and its accessories - Grid related problems - Generator control- Performance improvements – Different schemes - AC voltage controllers - Harmonics and PF improvement - Wind/solar PV integrated systems -Optimization of system components - storage – Reliability evaluation.

References:

1. S.Chakrabarthy,M.G Simoes, William F Kramer, "Power Electronics for Renewable & Distributed Energy Systems",Springer, Verilog London 2013.
2. Rai, G.D., "Solar Energy Utilization", Khanna Publishers Limited, New Delhi, 2000.
3. Mukund R Patel, "Wind and Solar Power Systems", Taylor & Francis Group, United Kingdom, 2nd Edition, 2005.
4. Thomas Markvart and Luis Castaser, "Practical Handbook of Photo-Voltaics", Elsevier Science & Technology, New Delhi, 2003.
5. Hermann-josef Wagner, JyotirmayMathur, "Introduction To Wind Energy Systems: Basics, Technology and Operation", Springer International, United Kingdom, 2009.
6. Rai, G.D., "Non-conventional Energy Sources", Khanna Publishers Limited, New Delhi, 1stEdition, 2004.

14EE3037 DSP BASED CONTROL OF POWER ELECTRONICS AND DRIVES

Credits: 3:0:0 **(Version 1.1)**

Course Objectives:
- To gain knowledge on the basics of motion control Digital Signal Processor.
- To learn about the transformation technique involved for drive application.
- To study about the open loop/closed loop control of drive using a DSP

Course Outcomes:
At the end of the course, the student will be able to
- Configure the DSP for the selected drive control.
- Programme the DSP to generate control signals for the selected drive control.
- Implement the Open loop/closed loop control of DSP based Control for the selected drive.

Course Description:
TMS320C28XX architecture overview – Memory – Central Processing Unit – General Purpose I/O functionality – Interrupts – Event Managers – General Purpose Timers – Compare Units – Capture Units – Quadrature Encoded Pulse Circuitry – Analog to Digital Converters – Programming - Clarke's &

Parke's Transformation – Space Vector PWM Technique – control of DC buck –boost converter, Multilevel & Matrix DC Motor - Induction Motor control –Converter - Stepper Motor Control – Control of Permanent Magnet Synchronous Motor – Switched Reluctance Motor control – BLDC Motor Control.

References:

1. TMS320F28X DSP System Control and Interrupts Reference Guide.
2. TMS320C28X CPU and Instruction Set Reference Guide.
3. Hamid A. Toliyat, Steven G.Campbell, "DSP based Electromechanical Motion Control", CRC Press 2004.
4. Bimal K. Bose, "Power Electronics and Variable Frequency Drives – Technology and Applications", IEEE Press, 1997.
5. Peter Vas, "Vector Control of AC Machines", Oxford University Press, 1990.
6. Ned Mohan, "Advanced Electric Drives: Analysis, Control and Modeling using SIMULINK"John Wiley & Sons Ltd., 2001.

14EE3038 POWER QUALITY

Credits: 3:0:0 **(Version 1.1)**

Course Objectives:

- To learn the power quality problems in grid connected and isolated systems.
- To understand power electronic devices can be used to mitigate power quality problems
- To learn a PQ monitoring methodology and PQ standards.

Course Outcomes:

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

- Solve problems on harmonics distortion on electrical power systems.
- Carryout the research work on power quality issues.
- Design systems to mitigate PQ problems.

Course Description:

Power quality – Voltage quality - Power quality issues - Electro Magnetic Compatibility (EMC) Standards - CBEMA & ITIC curves - Short interruptions - End user issues - Long Interruptions - Voltage Sag - Mitigation methods – Transients and over-voltage protection - Utility capacitor switching transients - Utility lightning protection – Waveform Distortion - Definition and terms in Harmonics - Principles of controlling harmonics - Mitigation and control techniques - Introduction - Power quality monitoring - Deregulation effect on power quality monitoring - Brief introduction to power quality -measurement equipments and power conditioning equipments - Planning, Conducting and Analyzing power quality survey.

References:

1. Barry W. Kennedy, "Power Quality Primer", McGraw-Hill, New York, 2000.
2. Sankaran C., "Power Quality", Washington, CRC Press, 2001.
3. Math H.J. Bollen, "Understanding Power Quality Problems: Voltage Sags and Interruptions", New York, IEEE Press, 1999.
4. Bhim Singh, Ambrish Chandra, Kamal Al-Haddad "Power Quality: Problems and Mitigation Techniques" John Wiley & Sons, 2014
5. Dugan, Mark F. Mc Granaghan and H. Wayne Beaty, "Electrical Power Systems Quality", McGraw-Hill, NewYork, 2002.

14EE3039 TIDAL ENERGY

Credits: 3:0:0 **(Version 1.1)**

Course Objectives:

- To acquire knowledge about the basics, design and analysis of tidal energy.
- To study the structure of tidal current and tidal dynamics.
- To understand the operation of tidal power plants.

Course Outcomes:

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

- Analyze the tides and tidal current and thereby able to find the possibilities of power generation from it.
- Suggest new mechanisms to harvest energy from tides based on tidal currents and tidal dynamics.
- Design efficient tidal power plants.

Course Description:

Tides – Generating Forces – Enumerate and discuss all forces and periodicities related to tides – Analysis and prediction of tides and tidal current – methods to analyze sea level and current by classic harmonic analysis and by selected modern tools related to energy spectra. Structure of tidal currents – effects of intense turbulence generated by tides which erases vertical stratification and forms the tidal fronts in shallow water domains – Tidal dynamics – Using Kelvin and Sverdrup Waves to explain primary features of the observed tides – Introduction to numerical solution of the tidal equation – Tidal Power plant – Electrical generators in tidal energy converters - power quality issues - control schemes for electrical system design in tidal energy converters - energy system economics and cost of electricity.

References:

1. Oceanography Course Team, "Waves, tides and shallow-water processes". Pergamon Press, 2nd Edition, Reprint 2006.
2. Pugh D.T., "Tides, Surges and Mean Sea-Level: A Handbook for Engineers and Scientists", Wiley, Chichester, 2004.
3. Massel S. R. "Fluid mechanics for Marine Ecologists", Springer Verlag Berlin Heidelberg, 1st Edition, 1999.
4. Mann, K. H., J. R. N. Lazier, "Dynamics of Marine Ecosystems", Blackwell Scientific Publication, 3rd Edition 2006.
5. Raymond Alcorn and Dara O'Sullivan, "Electrical Design for Ocean Wave and Tidal Energy Systems", The Institution of Engineering and Technology, 2013.

14EE3040 SIMULATION OF POWER ELECTRONIC SYSTEMS

Credits: 3:0:0 **(Version 1.1)**

Prerequisite: 14EE3012 Power Electronic Circuits / 14EE3002 Power Converter Analysis – I & 14EE3003 Power Converter Analysis – II

Course Objectives:

- To study the basics of static and dynamic models of power electronic switches.
- To learn the usage of the software tools like MATLAB, PSIM and PSPICE.
- To understand the operation of different types of power electronic converters using the above mentioned tools.

Course Outcomes:

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

- Do the mathematical modeling of power devices under steady state and dynamic conditions.

- Use the various functional blocks available in the simulation packages for the problems specified.
- Design and simulate any power electronic circuits and compare the performance with other simulation tools.

Course Description:
Need for simulation - Challenges in simulation, Mathematical modeling of power electronic systems - MATLAB PROGRAMMING:Basic Operations, Plotting. MATLAB Programs to analyze power electronic circuits - Model analysis using SIMULINK – Simpower systems- Simulating Induction Motor Drive- Performing Harmonic Analysis - PSIM: Power circuit components – Control circuit & other components Simulation of PWM inverters- Simulation of BLDC and SRM - PSPICE:File formats– Dot commands - SPICE models of Power Electronic Devices -Simulation of inverters.

References:

1. Shailendra Jain, “Modelling & Simulation using MATLAB & Simulink”,Wiley-India,2011
2. Rashid .M.H., “SPICE for Power Electronics and Electric Power”, CRC Press, New Delhi, 3rdEdition, 2012.
3. Rashid, M.H., “Power Electronics Handbook”, Academic Press, USA, 2011.
4. SimPowersystems User Guide, 2011.
5. PSIM User’s Guide”, Powersim Inc., 2011.

14EE3041 POWER ELECTRONICS APPLICATIONS TO POWER SYSTEMS

Credits: 3:0:0 **(Version 1.1)**

Course Objectives:
- To understand the stable operation of power system components.
- To learn the possibilities to extend power system operation and control.
- To understand the types of power electronic devices used in power transmission systems. .

Course Outcomes:
At the end of the course, the student will be able to
- Find the solutions for eliminating harmonics and EMI present in the output due to fast switching devices.
- Apply power system fundamentals to the design power electronic system that meet specific needs.
- Design various power electronic circuits used in power transmission systems.

Course Description:
High power devices - Characteristics - Single and three phase converters - Harmonics – Effects of source and load impedance - Gate control - Basic means of control - Control characteristics - Stability of control - Reactive power control - Power flow analysis - Static VAR control - Sources of reactive power - Harmonics and filters - Static VAR compensators - Thyristor Controlled Reactor – Thyristor Switched Capacitor - Static Condenser - Controllable Series Compensation.

References:

1. Padiyar. K.R., “HVDC Power Transmission System”, New Age International Private Limited, New Delhi, Reprint 2010.
2. Erich Uhlmann, “Power Transmission by Direct Current”, Springer International Edition, New Delhi, 1st Indian Reprint, 2004.
3. Rai, G.D., “Solar Energy Utilization”, Khanna Publishers Limited, New Delhi, 2000.
4. Kimbark, E.X., “Direct Current Transmission”, Wiley Inderscience, New York, 1971.

5. Rao S., "EHV-AC, HVDC Transmission and Distribution Engineering (Theory, Practice and Solved Problems)", Khanna Publishers, New Delhi, 2006.

14EE3042 NEURO-FUZZY CONTROLLERS FOR ELECTRIC DRIVES

Credits: 3:0:0 **(Version 1.1)**

Course Objectives:

- To gain knowledge on the fundamental concept of neurons and their artificial models
- To understand the structure of fuzzy logic controller and its application to electric drives.
- To gain comprehensive knowledge of adaptive and hybrid neuro fuzzy controllers for Drives.

Course Outcomes:

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

- Apply the concept of neural network for control of electric drives.
- Use the concept of fuzzy controller for electric drives
- Adapt appropriate neuro fuzzy controller for electric drives

Course Description:

Introduction to Neural Networks - Biological neurons and their artificial models - Learning, adaptation and neural network's learning rules - Types of neural networks, Neural network for non-linear systems - Schemes of Neuro control – Introduction to Fuzzy Logic - Fuzzy sets- Fuzzy operation -Fuzzy arithmetic - Fuzzy relations, Fuzzy measure –Approximate reasoning -Fuzzy propositions - Fuzzy quantifiers , Structure of fuzzy logic controller - Fuzzification models, defuzzification module - Non-linear fuzzy control - Neuro controllers & Fuzzy Controllers for AC Drives – Hybrid Neuro- Fuzzy Controllers & Adaptive Neuro – Fuzzy Controllers for Motor Drives.

References:

1. Jang Jyh-shing Roger, Sun Chuen-tsai, MizutaniEiji," Neuro-Fuzzy And Soft Computing: A Computational Approach To Learning And Machine Intelligence" PHI Learning Private limited,2009
2. Timothy Ross, "Fuzzy Logic with Engineering Applications", Wiley India Private Ltd, New Delhi, 2011
3. Jacek M Zurada, "Introduction to Artificial Neural Systems", Jaico Publishing House, New Delhi, 2001
4. Laurene Fausett, "Fundamentals of Neural Networks: Architectures, Algorithms and Applications", Pearson Education India, New Delhi, 2009.
5. Driankov, Hellendroon, "Introduction to Fuzzy Control", Narosa Publishers Limited, New Delhi, 2001.
6. K.VinothKumar, R, Saravana Kumar., "Neural Network and Fuzzy Logic ", Kataria and sons Publisher, New Delhi, 2014.
7. S.N.Sivanandam, S.N.Deepa, "Principles of soft computing ", John Wiley & Sons, 2007

14EE3043 ADVANCED CONTROL TECHNIQUES FOR INDUCTION GENERATORS

Credits: 3:0:0 **(Version 1.1)**

Prerequisite: 14EE3014 Wind Energy

Course Objectives:

- To understand the transient and steady state modeling of induction generators.
- To gain an in-depth knowledge about the different control techniques of induction generators.

- To acquire knowledge on optimized control of induction generators.

Course Outcomes:

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

- Analyze the complex control concepts
- Design control techniques for grid integration
- Apply the maximum power searching techniques

Course Description:

Steady State Model, Performance Characteristics, Modified Equivalent Circuits – Effect of Rotor-Injected EMF – Dynamic d-q Axis Model, Induction Machine in Transient State, State Space Based Induction Generator Modeling, DFIG, Partition of the SEIG State Matrix with an RLC load, Problems - Constant–voltage, Constant–frequency Generation, Reactive Power Compensation ,Variable-voltage, Variable-frequency Generation, Scalar Control Schemes, Direct Vector Control, Indirect Vector Control, HCC based Maximum Power Search, Fuzzy Logic Controller based Maximum Power Search.

References:

1. Godoy Simões M., Farret F. A., "Alternative Energy Systems: Design and Analysis with Induction Generators," 2ndEdition, CRC Press, Boca Raton, 2007.
2. Bhadra S. N., Kastha D., Banerjee S., "Wind Electrical Systems", Oxford University Press, New Delhi, 2013.
3. Vladislav Akhmatov, "Induction Generators for Wind Power", Multi-Science Publishing Company, UK, 2007.
4. Ion Boldea, "Variable Speed Generators", CRC Press, Boca Raton, 2nd Edition 2015.
5. Loi Lei Lai, Tze Fun Chan, "Distributed Generation: Induction and Permanent Magnet Generators", John Wiley & Sons, England, 2008
6. Abad G., Lopez J., Rodriguez M., Marroyo L., Iwanski G. "Doubly Fed Induction Machine, Modeling and Control for Wind Energy Generation", Wiley - IEEE Press, England, 2011.
7. Haitham Abu Rub, Atif Iqbal, Jaroslaw Guzinski, "High Performance Control of AC Drives" Wiley Publisher 2012.

14EE3044 OPTIMAL CONTROL OF WIND ENERGY SYSTEMS

Credits: 3:0:0 **(Version 1.1)**

Prerequisite: 14EE3014 Wind Energy

Course Objectives:

- To understand the importance of optimal control in wind energy systems
- To understand the basics of modeling in wind energy conversion system
- To understand the various parameters that need to be controlled in wind energy systems

Course Outcomes:

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

- Know the efficient control of wind energy systems
- Analyse the various techniques that can be used to obtain optimal control
- Suggest suitable control techniques for an efficient wind energy conversion system

Course Description:

Electrical Generator Modeling - Drive Train Modeling Power Electronics Converters & Grid Modeling – Linearization & Eigen value analysis – Case study – Control of generators in WECS – Control System for Grid connected operation and Energy Quality Assessment - MPPT strategies – PI , ON/OFF & Sliding mode control – Feedback Linearization & QFT Robust Control. LQ control of WECS – 2LFSP applied to

WECS with Rigidly-coupled generator and flexibly- coupled generator - Voltage and Reactive Power Control

References:

1. Iulian Munteanu, Antoneta Iuliana Bratcu, Nicolaos-Antonio Cutululis, Emil Ceang, "Optimal Control of Wind Energy Systems - Towards a Global Approach", Springer- Verlag, London, 2008.
2. Thomas Ackermann, "Wind Power in Power Systems", John Wiley & Sons Ltd., England, 2005.
3. Fernando D. Bianchi, Hernan De Battista, Ricardo J. Mantz, "Wind Turbine Control Systems: Principles, Modelling and Gain Scheduling Design", Springer-Verlag, London, 2008.
4. Olimpo Anaya-Lara, Nick Jenkins, JanakaEkanayake, Phill Cartwright, Mike Hughes, "Wind Energy Generation- Modelling and Control", John Wiley & Sons Ltd., UK, 2009.
5. Siegfried Heier, "Grid Integration of Wind Energy Conversion System", 2nd Edition, John Wiley & Sons Ltd., England, 2006.

14EE3045 WIND RESOURCE ASSESSMENT AND FORECASTING METHODS

Credits: 3:0:0 **(Version 1.1)**

Prerequisite: 14EE3014 Wind Energy

Course Objectives:

- To gain the basic knowledge of assessing potential sites for wind farms
- To learn the statistical basics involved in forecasting of data
- To be equipped with the latest forecasting techniques

Course Outcomes:

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

- Analyze the forecasting models for wind speed
- Develop accurate forecasting models
- Asses the economical benefit of wind resource assessment

Course Description:

Forecasting Techniques –Time Series and Cross-sectional Data- Measuring Forecast Accuracy - Principles of Decomposition – Moving Averages– Local Regression Smoothing – Census Bureau Method - Forecasting Scenario - Averaging Methods – Smoothing Methods - Regression Methods and Forecasting – ARIMA Models: Time Series Data – Forecasting with ARIMA Models -Intervention analysis – State space models – Non-linear models – Neural network forecasting- Wind Power Assessment of a particular geographical area- Economical Analysis

References:

1. Makridakis S., S. C. Wheelwright, R.J. Hyndman, "Forecasting – Methods and Applications", 3rd Edition, Wiley-India Edition, New Delhi, 2011
2. Wind Resource Assessment Handbook, AWS Scientific Inc., New York 1997.
3. Michael Brower, Daniel W. Bernadett, Kurt V.Elsholz, Matthew V. Filippelli, Michael J. Markus, Mark A. Taylor, Jeremy Tensen, "Wind Resource Assessment: A Practical Guide to Developing a Wind Project", John Wiley & Sons, London, 2012.
4. J. Scott Armstrong, "Principles of Forecasting: A Handbook for Researchers and Practitioners", Springer Science + Business Media Inc., USA, 2001.
5. Douglas C. Montgomery, Cheryl L. Jennings, Murat Kulahci, "Introduction to Time Series Analysis and Forecasting", John Wiley & Sons, New Jersey, 2008.

14EE3046 TURBINES FOR RENEWABLE ENERGY SYSTEMS

Credits: 3:0:0 **(Version 1.1)**

Course Objectives:

- To understand different turbines used for renewable energy systems
- To learn about turbines for different power generation schemes
- To identify any flaws and faults related to turbines and its design

Course Outcomes:

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

- Describe about the turbines, its operation under various conditions.
- Design and develop turbines for different power generation systems
- Propose efficient designs for turbines

Course Description:

Energy Conversion – Types of Turbines – General Turbine Design Aspects- Solar Based Power Generation Types – Turbine Models for Solar Applications - Horizontal and Vertical Axis Wind Turbines – Design - Problems Softwares for Turbine Design - Overview – Turbine Design for Solar Based Power Generation - Conventional, Pumped Storage - Hydro Turbine Designs- Francis, Pelton, Kaplan turbines - Turbine Design for Tidal Power- Turbines for Geothermal Plant, Ocean Thermal Energy Conversion Systems. Design Issues- Problems

References:

1. David M. Eggleston., “Wind Turbine Engineering Design”, Amazon publications, 1st Edition, 1987.
2. Peter Jamieson, “Innovation in Wind turbine design”, Wiley, 1st Edition, 2011.
3. Jeremy Thake., “The Micro-Hydro Pelton Turbine Manual: Design, Manufacture and Installation for Small-Scale Hydro-Power” Amazon, 2001.
4. Shylakhin., “Steam Turbines: Theory and Design” Amazon, 2005.
5. Martin O. L. Hansen**,** *“*Aerodynamics of Wind Turbines” Routledge 3 edition, New York, 2015

14EE3047 DATA MINING FOR RENEWABLE ENERGY TECHNOLOGY

Credits: 3:0:0 **(Version 1.1)**

Course Objectives:

- To know basic concepts of data mining.
- To earn competency in the algorithms and learning schemes of data mining.
- To learn about data mining techniques for research in renewable energy.

Course Outcomes:

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

- Describe various data mining techniques applied to solar and wind energy
- Operate on vast data base available in renewable energy sector and to develop useful conclusions
- Apply various data mining techniques for wind and solar resource estimation

Course Description:

Data Mining, Functionalities, Classification, Primitives, Data Preprocessing, Data Warehousing, Multidimensional Data Model, Data Warehouse Architecture & Implementation, Mining Frequent Patterns, Associations, Mining Multilevel Association Rules - Decision tree Induction, Bayesian Classification, Lazy Learners, Other Classification Methods, Prediction, Accuracy and Error Measures, Categorization of Major Clustering Methods, Partitioning Methods, Hierarchical Methods, Mining Stream, Time-Series and Sequence Data - Application of Data Mining in Wind Power System, Wind

Power Prediction, Modeling and Forecasting of Solar Radiation Data, Analyzing Solar Power Plant Performance.

References:

1. Jiawei Han, MichelineKamber, "Data Mining : Concepts and Techniques", II Edition, Morgan Kaufmann Publishers, San Francisco, 2012
2. Ian Witten, Eibe Frank, "Data Mining: Practical Machine Learning Tools and Techniques", III Edition, Morgan Kaufmann Publishers, San Francisco 2011.
3. Sumathi S., S. N. Sivanandam, "Introduction to Data Mining and its Applications", Springer-Verlag Berlin Heidelberg 2006.
4. David Hand, HeikkiMannila, Padhraic Smyth, "Principles of Data Mining", A Bradford Book, The MIT Press, Cambridge, Massachusetts London, England, 2001.
5. Michael J A Berry, Gordon S Linoff, "Data Mining Techniques", II Edition, Wiley India, 2011.

14EE3048 GRID CONVERTERS FOR WIND POWER SYSTEMS

Credits: 3:0:0 **(Version 1.1)**

Prerequisite: 14EE3012 Power Electronic Circuits
14EE3014 Wind Energy

Course Objectives:

- To know key concepts about converter structures and grid requirements
- To study about the latest power conversion and control technology in wind power systems
- To gain in-depth understanding about grid synchronization

Course Outcomes:

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

- Identify the stringent grid requirements to be satisfied for high penetration of wind energy systems
- Describe the topologies, modulation and controllers of grid connecting converters for wind power interfacing
- Design controllers and filters used for effective interfacing of wind power generators to the grid

Course Description:

Introduction – Grid Converter Structures for Wind Turbine System – Grid Requirements for Wind Turbine System – Grid Synchronization in Three-Phase Power Converters – Grid Converter Control for Wind Turbine System - Control of Grid Converters under Grid Faults – Grid Filter Design – Grid Current Control

References:

1. Teodorescu R., Liserre M., Rodriguez P., "Grid Converters for Photovoltaic and Wind Power System", John Wiley & Sons Ltd., UK, 2011.
2. Wu B., Lang Y., Zargari N., Kouro S., "Power Conversion and Control of Wind Energy", John Wiley & Sons, New Jersey, 2011.
3. Zhong Q.C., Hornik T., "Control of Power Inverters in Renewable Energy and Smart Grid Integration", John Wiley & Sons, UK, 2013.
4. Gevorkian P., "Large-Scale Solar Power System Design – An Engineering Guide for Grid-Connected Solar Power Generation", Mc-Graw Hill, New York, 2011.
5. Vittal V., Ayyanar R., "Grid Integration and Dynamic Impact of Wind Energy", Springer, New York, 2013.

14EE3049 OFFSHORE WIND POWER

Credits: 3:0:0 **(Version 1.1)**

Course Objectives:

- To understand the overview of complete offshore wind issues.
- To understand the fundamental and electrical aspects of offshore wind turbines, regulatory framework, grid integration and market incentives
- To gain knowledge on advantages and ecological impacts of offshore wind

Course Outcomes:

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

- know the design optimization of offshore wind energy
- illustrate the latest technology in offshore wind energy, foundation design and turbine materials
- know the intricacies of successful installation

Course Description:

Introduction – Offshore Wind Energy System Components – Leasing and Stages of Offshore Development – Cost Factors - Offshore Wind Energy Technology – New Concepts and Components – Analysis and Design Tools for Wind Turbines – Offshore Floating Turbines – Foundation Design in Deep Waters – Turbine Materials - Transport, Installation and Logistics – Evaluation of Harmonic Risk in Offshore Wind Farms – Upkeep of Offshore Wind Farms – Grid Integration of Offshore Wind Power – Ecological Impacts of Offshore Wind Energy.

References:

1. Twidell J., Gaudiosi G., "Offshore Wind Power", Multiscience Publishing Co. Ltd., UK, 2009
2. Jos Beurskens, "Converting Offshore Wind into Electricity", Eburon Academic Publishers, The Netherlands, 2011.
3. Kurt Thomsen., "Offshore Wind: A Comprehensive Guide to Successful Offshore Wind Farm Installation", Elsevier, US, 2012.
4. Koller J., Koppel J., Peters W., "Offshore Wind Energy – Research on Environmental Impacts", Springer, New York, 2006
5. Zubiaga M., et al., "Energy Transmission and Grid Integration of AC Offshore Wind Farms", InTech Publishers, Croatia, 2012
6. Paul A. Lynn , "Onshore and Offshore Wind Energy: An Introduction" Wiley-Blackwell ,UK, 2011

14EE3050 WIND POWER IN POWER SYSTEMS

Credits: 3:0:0 **(Version 1.1)**

Course Objectives:

- To understand the power system impacts of wind power, technical regulations and interconnections.
- To understand the basic concepts of power quality standards for wind turbines
- To gain knowledge about modelling and control of smart grid renewable energy systems

Course Outcomes:

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

- Analyse the technical, economic and safety issues inherent in the integration of wind power in the power system
- Know the basic interconnection issues, electrical design of wind power plant and importance of power system stability, modelling and control
- Identify the necessity of dynamic modelling of wind turbines and smart grid technology.

Course Description:
Introduction – Power System Impacts of Wind Power – Power Quality Standards for Wind Turbines – Measurement of Electrical Characteristics – Technical Regulations for Interconnection of Wind Power Plants to Power Systems - Electrical Design of Wind Power Plant – Transmission Systems for Offshore Wind Power Plants – Wind Power and Storage - Dynamic Modeling of Wind Turbines for Power System Studies – Generic Wind Power Plant Model – High-Order Models of Doubly Fed Induction Generators – Impacts of Wind Power on Power System Stability - Wind Power and Smart Grid – Active Management of Distribution Systems – Reactive Power Capability and Voltage Control with Wind Turbines.

References:

1. Ackermann T., "Wind Power in Power System", Wiley Publications, Germany, 2nd Edition,2012
2. Wu B., Lang Y., Zargari N., Kouro S., "Power Conversion and Control of Wind Energy", John Wiley & Sons, New Jersey, 2011.
3. Bollen M., Hassan F., "Integration of Distributed Generation in the Power System", John Wiley & Sons, New Jersey, 2011.
4. Keyhani A., "Design of Smart Power Grid Renewable Energy Systems", John Wiley & Sons, New Jersey, 2011.
5. Vittal V., Ayyanar R., "Grid Integration and Dynamic Impact of Wind Energy", Springer, New York, 2013.

14EE3051 SOLAR CELL AND MODULE TECHNOLOGY

Credits: 3:0:0 **(Version 1.1)**

Course Objectives:
- To understand the properties of semiconductors and different types of solar cell
- To gain knowledge about the need for purity and minimization of crystal imperfections for making high performance solar cells
- To learn the different quality check procedures

Course Outcomes:
At the end of the course, the student will be able to
- Describe the different solar cells and its semiconductor physics
- Identify the suitable solar cell based on the application and cost
- Explain the manufacturing and testing procedures of different solar cells

Course Description:
The physics of solar cell-properties of semiconductors-PN Junction diode electrostatics-Solar cell fundamentals- Efficiency and band gap-spectral response-parasitic resistance effects-production of metallurgical grade silicon-production of semiconductor grade silicon-requirements of silicon for crystalline solar cells-routs to solar grade silicon-Bulk crystal growth and wafering for PV-Crystalline silicon solar cells -manufacturing process-crystalline silicon photovoltaic modules-Thin film silicon solar cells-Amorphous silicon solar cells-Dye sensitized and Organic solar cells-Organic Electronic Materials-fabrication-Rating PV Performance-Current versus voltage measurements- Primary reference cell calibration methods-spectral responsibility measurements-Module qualification and certification.

References:

1. Antonio Luque, Steven Hegedus, "Hand book of Photovoltaic Science and Engineering", John Wiley& Sons Ltd, England, 2011.
2. Larry D. Partain, "Solar Cells and Their Applications", John Wiley & Sons Ltd, England, 2010.
3. Tom Markvart, "Solar Cells: Materials, Manufacture and Operation", Elsevier, USA, 2nd Edition, 2013.

4. JefPoortmans, Vladimir Arkhipov, “Thin Film Solar Cells: Fabrication, Characterization and Applications”, John Wiley & Sons, 2006
5. Solanki Chetan Singh, “Solar Photovoltaics: Fundamentals, Technologies and Applications”, PHI Learning Pvt. Ltd. 2011.

14EE3052 PV SYSTEM DESIGN AND INSTALLATION

Credits: 3:0:0 **(Version 1.1)**

Prerequisite: 14EE3011 Photovoltaic Systems

Course Objectives:

- To learn the different configurations of photovoltaic Energy systems.
- To gain knowledge in the PV System design procedures.
- To enhance the skills in the sizing, maintenance and trouble shooting of different components used in the PV System.

Course Outcomes:

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

- Perform a basic load analysis and photovoltaic system sizing.
- Design and install a new PV system for the required demand.
- Identify and troubleshoot the faults and suggest safety measures to avoid those faults.

Course Description:

An overview of Photovoltaic- Photovoltaic Electric Principles- The solar resource-Photovoltaics and weather- Calculating the solar Energy-Site survey- Electrical Load Analysis-Photovoltaic Modules-Module Performance-Mounting Photovoltaic Modules- Batteries- Battery Sizing exercise- Battery wiring configuration- PV Controllers- Controller sizing exercise- Inverters-The four configurations for solar power system selection-Planning, Regulations and Approvals-Grid Interconnection requirements-Residential Design, Commercial Design, Utility Design- Photovoltaic Installation- PV Components maintenance- Appliances Maintenance-Troubleshooting-Hazards- Safety.

References:

1. “Photovoltaics: Design and Installation Manual”, Solar Energy International, Canada, 2004.
2. Steven Magee, “Solar photovoltaic Design for residential, commercial and Utility Systems”, Createspace, 1st edition, 2010.
3. Michael Boxwell, “Solar Electricity Handbook: A simple practical guide to solar Energy-Designing and Installing Photovoltaic Solar Electric Systems”, Greenstream Publishing, UK, 2012.
4. Geoff Stapleton, Susan Neill, “Grid-connected Solar Electric Systems: The Earthscan Expert Handbook for Planning, Design and Installation”, Earthscan, Oxon, 2012.
5. John R. Balfour, Michael Shaw,” Advanced Photovoltaic System Design”, Jones and Bartlett Learning, 2011.
6. Deutsche Gesellschaft für Sonnenenergie “Planning and Installing Photovoltaic Systems”, Earthscan, USA, 2008.

14EE3053 MATERIALS FOR SOLAR POWER

Credits: 3:0:0 **(Version 1.1)**

Course Objectives:

- To learn the characteristics of different solar cell materials
- To understand the technology of silicon extraction

- To gain knowledge on design and PV cell manufacturing process

Course Outcomes:

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

- Describe the properties and characteristics of materials used in energy applications
- Design the solar cells and explain the manufacturing technology
- Efficiently exhibit the various cell fabrication techniques

Course Description:

Materials: Glazing materials, Properties and Characteristics of Materials, Reflection from surfaces, Selective Surfaces: Ideal coating characteristics, Types and applications, Anti-reflective coating, Preparation and characterization, Reflecting Surfaces and transparent materials, Insulation and properties. Physics of Solar Cells, Electrical conductivity, Density of electrons and holes, Carrier transport: Drift, diffusion, Absorption of light, Recombination process, Materials for Photovoltaic Conversion. Technology for Si Extraction, Cell fabrication and metallization techniques: Preparation of metallurgical, electronic and solar grade Silicon, Production of single crystal Silicon: Procedure of masking, photolithography and etching, Design of complete silicon, GaAs, InP solar cell – Nanomaterials.

References:

1. William D. Callister, Jr, “Materials Science and Engineering: An Introduction”, John Wiley, New York, 2010.
2. Srinivasan, “Engg Materials and Metallurgy”, Tata McGraw-Hill Education Limited, 2nd Edition 2010.
3. Jenny Nelson, “The Physics of Solar Cells**”** Imperial College Press, 2003.
4. Arthur Willoughby, “Solar Cell Materials: Developing Technologies”, John Wiley and Sons, 2010.
5. Tom Markvart, “Solar Cells: Materials, Manufacture and Operation” Elsevier, USA, 2nd Edition, 2013.

14EE3054 PASSIVE SOLAR ARCHITECTURE

Credits: 3:0:0 **(Version 1.1)**

Course Objectives:

- To learn the art of building design with energy perspective
- To understand the role of the site selection in designing a passive building with an emphasis on the climate and other environmental conditions.
- To understand passive solar applications for heating ,cooling, ventilation and day lighting to create a comfortable thermal environment

Course Outcomes:

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

- Analyze the site and its context in preparation for designing a building, particularly with respect to climate and other environmental conditions
- Design cost-effective and efficient passive solar buildings.
- Design and build environments that are both thermally comfortable and delightful by utilizing the combined site-specific potentials of sun light, wind and rain.

Course Description:

Art of Building Design- Energy Management-Thermal comfort- solar temperature and its significance - heat gain through building envelope; solar radiation on buildings; building orientation - shading devices - Overhangs; Ventilation- Air-conditioning systems with Energy conservation. Passive cooling and Heating-Types - Heat transfer Parameters- Solar temperature - Decrement factor - Phase lag. Design of day lighting; Estimation of building loads: method, correlations - Computer packages for carrying out thermal design of buildings -Bioclimatic classification of India - Passive concepts appropriate for the various climatic zones in India - Typical design of selected buildings in various climatic zones - Thumb rules for design of buildings and building codes.

References:

1. Daniel D. Chiras, "The Natural House", Chelsea Green Publishing Company, Vermont, 2001.
2. Daniel D. Chiras, "The New Ecological Home", Chelsea Green Publishing Company, Vermont, 2004.
3. Colin Porteous, Kerr Macgregor, "Solar architecture in cool climates", Earthscan Publications Ltd., UK, 2005.
4. Daniel D. Chiras," The Solar House: Passive Heating and Cooling", Chelsea Green Publising Company, Vermont, 2002.
5. James Kachadorian, "Passive Solar House" Chelsea Green Publising Company, Vermont, 2009
6. MiliMajumdar,"Energy-efficient buildings in India" Tata Energy Research Institute, TERI-,2009.

14EE3055 OCEANIC ENERGY

Credits: 3:0:0 **(Version 1.1)**

Course Objectives:

- To get good understanding about the basics, design and analysis of two important oceanic energy components i.e., tidal and wave.
- To understand the operation of tidal power plants and wave power plants.
- To know about integration of tidal and wave power plants with grid.

Course Outcomes:

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

- Identify the possibilities of power generation from ocean.
- Model estuaries and suggest new methods to harvest oceanic energy.
- Design efficient tidal and wave power plants.

Course Description:

Historical Development - Tidal phenomenon - Propagation of tides in estuaries -Coriolis effect -Barrage effects Tidal Schemes - Basin Schemes - Retiming of tidal energy - physiography of the estuary - Geology - Tides Waves currents - Ecosystem characteristics - Hydraulic and numerical models - Hybrid models - Barrier Modeling and effects - Utility system planning and simulation - Civil works - Design parameters - Dikes Construction schedules - Electromechanical equipment generating equipment turbines -Transmission Integration of output with electric utility systems considerations - Wave structure - Global wave energy potential technologies concentration effects - Tapered channel - Oscillating water column - Mighty whale design Turbines for wave energy - Ocean wave conversion system power distribution - Grid connection - Environmental impacts.

References:

1. Robert H. Clark, "Elements of Tidal-Electric Engineering", Wiley-IEEE Press, USA, 2007.
2. Jack Hardisty, "The Analysis of Tidal Stream Power", Wiley, UK, 2009
3. Michael E. McCormick, "Ocean Wave Energy Conversion" Dover Publications, USA, 2009
4. Joao Cruz, "Ocean Wave Energy: Current Status and Future Perspectives", Springer, Berlin, 2010.
5. Raymond Alcorn and Dara O'Sullivan, "Electrical Design for Ocean Wave and Tidal Energy Systems", the Institution of Engineering and Technology, 2013.

14EE3056 GEOTHERMAL ENERGY

Credits: 3:0:0 **(Version 1.1)**

Course Objectives:

- To gain an in-depth understanding of the issues associated with the development of geothermal energy.
- To get to know the geothermal energy conversion methods.
- To acquire knowledge of energy analysis applicable to geothermal systems.

Course Outcomes:

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

- Predict and identify the possibilities of geothermal energy resources.
- Analyze geothermal energy resources based on construction and thereby design power plants.
- Perform energy analysis related to geothermal power plants.

Course Description:

Model of a hydrothermal geothermal resource, Hot dry rock, HDR-Geo pressure Magma energy Phases of an exploration program Synthesis interpretation Geothermal well drilling reservoir well flow testing Calcite scaling in well casings modeling and simulation - Single-Flash Steam power plants Gathering system design considerations Energy conversion system flash plants conversion system Scale potential in waste brine Equipment list flash plants Origins and nature of dry-steam resources Equipment list for dry-steam plants Binary cycle power plants Working fluid selection Hybrid flash systems binary systems Total-flow systems Hybrid fossil Combined heat and power plants Hot dry rock (enhanced geothermal systems) Power plants for hypersaline brines - First law for open, steady systems - Second law for open, steady systems -Exergy -Exergy accounting for open, steady systems -Exergy efficiencies and applications to geothermal plants.

References:

1. Ronald DiPippo, "Geothermal Power Plants: Principles, Applications and Case Studies and environmental impact, 2nd Edition, Elsevier Science, USA, 2012.
2. Boyle, "Renewable Energy", Oxford University Press, 2nd Edition, UK, 2012.
3. Ernst Huenges, Patrick Ledru, "Geothermal Energy Systems: Exploration, Development and Utilization", Wiley, 1st Edition, Weinhim, 2010.
4. Harsh K. Gupta, Sukanta Roy, "Geothermal Energy: An Alternative Resource for the 21st Century" Elsevier Science; 1st Edition, Netherlands, 2006.
5. Ernst Huenges, Patrick Ledru, "Geothermal Energy Systems: Exploration, Development, and Utilization", Wiley VCH, 2010.

14EE3057 POLICY AND REGULATORY ASPECTS OF RENEWABLE POWER GENERATION

Credits: 3:0:0 **(Version 1.1)**

Course Objectives:

- To study the policy and regulatory framework to make renewable power generation economically viable.
- To acquire knowledge on tariff determination issue and decentralized power generation.
- To get aware of recent off grid programs started by Govt. of India.

Course Outcomes:

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

- Evaluate the economical and technical viability of renewable power generation.
- Explain the policy frameworks for various renewable energy sources.
- Identify the possibilities of electrification in remote villages through various DDG schemes.

Course Description:
Renewable energy credit schemes, Statuary requirements and activities of various states in this regards - Tariff determination issue - National Solar Mission - Regulations regarding grid interconnections of renewable energy systems - Need and advantage of Decentralized energy solutions - Emergence of policy and regulatory framework for decentralized electricity (Gokak Committee report) -Status of grid connected and off grid distributed generation (National and International) - Electrification and off grid status/scenario in India - Scope and challenges in implementing off grid solutions - Policy & regulatory Framework for rural electrification - Relevant policies and frameworks in other countries - Recent off grid programs started by Govt. of India for enhancing the rural electrification through off-grid solutions - DDG scheme under Rajiv Gandhi Grameen Vidyutikaran Yojana (RGGVY) - Remote Village Electrification Program - Village Energy Security Program (VESP) - Off grid Program under JNNSM.

References:

1. H. Lee Willis, Walter G. Scott, “Distributed Power Generation Planning and Evaluation”, IET Power Marcel Dekker, Inc. (2000).
2. Alexandra Niez, “Comparative Study on Rural Electrification Policies in Emerging Economies: Keys to Successful Policies”, International Energy Agency, Information Paper, March 2010.
3. Marcus Wiemann, Elena María Cantos Gómez, Luis-Carlos Miró Baz, “Best practices of the Alliance for Rural Electrification: what renewable energy can achieve in developing countries; Alliance for Rural Electrification”, Third edition, September 2013.
4. “Gokak Committee Report on DDG & Report on the Working Group on Power for Twelfth Plan (2007-12)”, Government of India, Ministry of Power, New Delhi.
5. P. Garg, “Energy Scenario and Vision 2020 in India”, Ministry of Environment and Forests, CGO Complex, Lodi Road, Delhi, India Journal of Sustainable Energy & Environment 3 (2012), 7-17.

14EE3058 NUCLEAR ENGINEERING

Credits: 3:0:0 **(Version 1.1)**

Course Objectives:
- To gain knowledge on Nuclear reaction materials and various reprocessing techniques
- To understand the nuclear waste disposal techniques and radiation protection aspects
- To learn future nuclear reactor systems with respect to generation of energy, fuel breeding, incineration of nuclear material and safety

Course Outcomes:
At the end of the course, the student will be able to
- Explain the fundamentals of nuclear reactions.
- Describe the nuclear fuel cycles, characteristics and fundamental principles governing nuclear fission chain reaction, fusion and kinetics.
- Select the appropriate type of nuclear materials and reprocessing methods for power generation.

Course Description:
Nuclear reactions - Mechanism of nuclear fission - Nuclides - Radioactivity – Decay chains - Neutron reactions - Fission process - Reactors – types, design and construction of nuclear reactors - Heat transfer techniques in nuclear reactors - Reactor materials- Nuclear Fuel Cycles - Characteristics of nuclear fuels - Uranium –Production and purification of Uranium - conversion to UF4 and UF6 - other fuels like Zirconium, Thorium, Berylium - Reprocessing - Nuclear fuel cycles - Role of solvent extraction in

reprocessing - Solvent extraction equipment - Separation of reactor products - Processes to be considered - 'Fuel Element' dissolution - Precipitation process – ion exchange - Redox - Purex- TTA - chelation - U235 - Hexone - TBP and thorax Processes - Oxidative slaging and electro - Refining - Isotopes - Principles of Isotope separation - Types of nuclear wastes - Safety control and pollution control and abatement - International convention on safety aspects - Radiation hazards prevention.

References:

1. Raymond LeRoy Murray, "Nuclear energy: an introduction to the concepts, systems, and applications of nuclear processes", 6th Edition, Butterworth-Heinemann, 2009.
2. John R. Lamarsh, "Introduction to Nuclear Reactor Theory",3rd Edition ,Pearson India, 2014.
3. Glasstone, S. and Sesonske, A, "Nuclear Reactor Engineering", 4th Edition, Springer, 2014.
4. Winterton, R.H.S., "Thermal Design of Nuclear Reactors", Elsevier, 23-Apr-2014 –Technology & Engineering
5. James Duderstadt, Nuclear Reactor analysis, Scholarly Publishing Office, University of Michigan Library, 2007

14EE3059 HYDRO POWER TECHNOLOGY

Credits: 3:0:0 **(Version 1.1)**

Course Objectives:

- To learn the basic concepts of hydro system components and design
- To understand the economical and electrical aspects of Small, mini and micro hydro turbines
- To study the selection, testing and governing of turbines.

Course Outcomes:

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

- Prepare an estimate, layout and plan for the construction of hydro power plant.
- Perform theoretical calculations in developing a prototype hydro systems
- Select and analyze the particular turbine for specific need

Course Description:

Overview of Hydropower systems - Rainfall and Run of measurements - Hydrographs- Determination of site selection- Types of hydroelectric power plants- General arrangements and Layouts- Preparation of Reports, estimates, project feasibility and load prediction - Design and Construction of Hydroelectric Power Stations-Trends in Development of Generating Plant and Machinery-Plant Equipment for pumped Storage Schemes - Measurement of pressure head, Velocity- Selection of turbines based on Specific quantities- Performance characteristics – Testing &Governingof hydraulic turbines -Functions of Turbine Governor - Condition for Governor Stability - Surge Tank Oscillation and Speed Regulative Problem of Turbine Governing - Remaining Lifecycle Analysis - Analysis of Small, mini and micro hydro turbines – Economical and Electrical Aspects of Small, mini and micro hydro turbines-Potential developments – Design and reliability of Small, mini and micro hydro turbines.

References:

1. P.K Nag, "Power plant Engineering", Fourth edition, Tata McGraw-Hill Education, 2014
2. JyotirmayMathu "Introduction to Hydro Energy Systems", Springer, 2011.
3. A.K.Raja, AmitPrakashSrivastava, "Power Plant Engineering", New Age International, 2013.
4. Finn R. Forsund , "Hydropower economics", Springer, 2015
5. Scott Davis," Microhydro: Clean power from water", New Society Publishers, 2005.

14EE3060 DESIGN AND DEVELOPMENT OF WIND TURBINES

Credits: 3:0:0 **(Version 1.1)**

Course Objectives:
- To learn the concepts of structural dynamics and acoustics of wind turbines
- To gain knowledge about the latest technologies for turbine design
- To understand the challenges in wind power generation

Course Outcomes:

At the end of the course, the student will be able to
- Demonstrate the aerodynamic and structural aspect of wind turbines.
- Design wind turbines of different rating
- Explore recent technological advancements in wind turbine design

Course Description:

Aerodynamics and aero elastics of wind turbines – Structural dynamics of wind turbines – Wind turbine acoustics – Design and development of megawatt wind turbines – Design and development of small wind turbines – Development and analysis of vertical-axis wind turbines – Direct drive superconducting wind generators – Intelligent wind power unit with tandem wind rotors – New small turbine technologies - Implementation of 'smart' rotor concepts - Wind turbine power curve – Wind turbine cooling techniques – Wind turbine noise measurements and abatement.

References:

1. Tong W., "Wind Power Generation and Wind Turbine Design", WIT Press, UK, 2010
2. Jamieson P., "Innovation in Wind Turbine Design", John Wiley & Sons Ltd., UK, 2011.
3. Rivkin D. A., Toomey K., Silk L., "Wind Turbine Technology and Design", Jones &Barlett Learning, USA, 2013
4. Wood D., "Small Wind Turbines: Analysis, Design and Application", Springer, Hong Kong, 2011.
5. Burton T., Jenkins N., Sharpe D., Bossanyi E., "Wind Energy Handbook", Second Edition, John Wiley &Sons, 2011.

LIST OF SUBJECTS

S.No	Sub. Code	Subject Name	Credits
1	15EE2001	Transmission and Distribution Management Systems	3:0:0
2	15EE2002	Smart Metering and Demand Side Integration	3:0:0
3	15EE2003	Operation and Planning of Electricity Grids	3:0:0
4	15EE2004	Power Quality Issues and Mitigation Techniques	3:0:0
5	15EE2005	Testing and Installation of Power System Apparatus	3:0:0
6	15EE2006	Digital Signal Processing Techniques in Power System Protection	3:0:0
7	15EE2007	Power Electronics for Renewable Energy	3:0:0
8	15EE2008	Battery Technology for Renewable Energy	3:0:0
9	15EE2009	Energy Economics	3:0:0
10	15EE2010	Industrial Electronics	3:0:0
11	15EE2011	Electronics in Agricultural Automation	3:0:0
12	15EE2012	Consumer Electronics	3:0:0
13	15EE2013	Micromotors and its Applications	3:0:0
15	15EE2014	Permanent Magnet Motors	3:0:0
15	15EE2015	Advances in Electrical Engineering Applied to Hospital Engineering	3:0:0
16	15EE2016	Industrial Mechatronics	3:0:0
17	15EE2017	Condition Monitoring of Electrical Machines	3:0:0
18	15EE2018	Green Electronics	3:0:0
19	15EE2019	Energy Storage in Power Systems	3:0:0
20	15EE2020	Microgrids	3:0:0
21	15EE2021	Graph Theory Applications to Electrical Engineering	3:0:0
22	15EE2022	Power System Optimization	3:0:0
23	15EE2023	Substation Design	3:0:0
24	15EE2024	Distribution System Planning and Automation	3:0:0
25	15EE2025	Testing and Commissioning of Electrical Equipment	3:0:0
26	15EE2026	Electrical Estimation and Costing	3:0:0
27	15EE2027	Electromagnetics Lab	0:0:2
28	15EE2028	FEM Analysis Lab	0:0:2
29	15EE2029	Alternate Energy Sources for Hospitals	3:0:0
30	15EE3001	Advanced Control of Electric Drives	3:0:0
31	15EE3002	Switched Mode Power Converters	3:0:0
32	15EE3003	Advanced Soft Computing Techniques	3:0:0
33	15EE3004	Predictive Control of Power Converters and Electrical Drives	3:0:0
34	15EE3005	Advanced Power Converters for Renewable Energy Systems	3:0:0
35	15EE3006	Smart Grid Technologies	3:0:0
36	15EE3007	Solar Energy Forecasting Techniques	3:0:0

15EE2001 TRANSMISSION AND DISTRIBUTION MANAGEMENT SYSTEMS

Credits: 3:0:0

Course Objectives

- To study concept of Transmission and Distribution Management system
- To emphasize the importance of distribution management system topology
- To illustrate the significance of monitoring and operation system

Course Outcomes

- To implement the management system in a smaller level
- To understand the Outage Management System
- To design proto type transmission and distributed system

Description

Introduction-Data Sources and Associated External systems: SCADA-Customer Information System-Energy Management System (EMS)-RTU-Modelling and analysis tools: Distribution system modelling-topology analysis-load forecasting-state estimation-Applications: System Monitoring- system Operation-system management-outage management system (OMS)-Transmission system introduction- IEDs and SCADA-PMU-Wide Area applications-Visualization Techniques

Reference Books

1. Janaka Ekanayake, Nick Jenkins, KithsiriLiyanage, Jianzhong Wu, Akihiko Yokoyama, "Smart Grid: Technology and Applications", John Wiley & Sons, Sussex, 2012.
2. James Momoh, "Smart Grid: Fundamentals of Design and Analysis", Wiley, IEEE Press, New Jersey, 2012.
3. Jenkins, N., Ekanayake, J.B., Strbac, G. "Distributed Generation", Institution of Engineering and Technology, Stevenage, United Kingdom, 2010.
4. Weedy, B. and Cory, B.J., "Electric Power Systems", John Wiley and Sons, New York, 2004.
5. Bernd M. Buchholz , Zbigniew Styczynsk, "Smart Grids - Fundamentals and Technologies in Electricity Networks", Springer, Berlin, 2014.

15EE2002 SMART METERING AND DEMAND SIDE INTEGRATION

Credits: 3:0:0

Course Objectives

- To Study about Smart Grid technologies, different smart meters and advanced metering infrastructure.
- To familiarize the communication protocols in Smart Grid network.
- To understand the concept of high performance computing for Smart Grid applications

Course Outcomes

- To know the function and operation of smart meter
- To design communication network topology for smart grid
- To integrate home area network

Description

Introduction-Evolution of electricity metering-key components of smart metering-An overview of hardware used: signal acquistion, signal conditioning, Computation, Communication-Protocols for smart metering: Home area network-Neighbourhood area network-Data Concentrator-Meter data management system-Protocols for communications- Demand side Integration: Service provided by DSI-Implementation of DSI-Hardware support to DSI implementation-Demand Side Response(DSR)

Reference Books

1. Janaka Ekanayake, Nick Jenkins, KithsiriLiyanage, Jianzhong Wu, Akihiko Yokoyama, “Smart Grid: Technology and Applications”, John Wiley & Sons, Sussex, 2012.
2. Clark W Gellings, “The Smart Grid, Enabling Energy Efficiency and Demand Side Response”, CRC Press, Florida, 2009.
3. Kreith F., Goswami, D.Y., “Handbook of Energy Efficiency and Renewable Energy”, CRC Press, Florida, 2007.
4. Vehbi C. Güngör, DilanSahin, TaskinKocak, Salih Ergüt, Concettina Buccella, Carlo Cecati, Gerhard P. Hancke, “Smart Grid Technologies: Communication Technologies and Standards”, IEEE Transactions on Industrial Informatics, Vol. 7, No. 4, November 2011.
5. James Momoh, “Smart Grid: Fundamentals of Design and Analysis”, Wiley, IEEE Press, New Jersey, 2012.

15EE2003 OPERATION AND PLANNING OF ELECTRICITY GRIDS

Credits: 3:0:0

Course Objectives

- To introduce the grid integration
- To have the wider knowledge on planning and design of a distribution infrastructure.
- To gain the knowledge on polices and standards in Electricity Grids

Course Outcomes

- To identify the faults in grid integration
- To predict and predefine the preventive measures in the grid
- To follow the policies and standards

Description

Introduction-Requirements for grid interconnection- limits on operational parameters: voltage, frequency, response to grid abnormal operating conditions- islanding issues- Challenges, approaches and Impact of grid integration with Renewable Energy sources on existing power system: reliability, stability and power quality issues- Policies and standards-Expands of grid

Reference Books

1. Narayan S. Rau, "Optimization Principles: Practical Applications to the Operation and Markets of the Electric Power Industry", Wiley-Interscience Publisher Limited, New York, 2003.
2. F. I. Denny and D. E. Dismukes , "Power System Operations and Electricity Markets" , Wiley-Interscience Publisher Limited, New York, 2002.
3. M. Shahidehpour, H. Yamin, Zuyi Li, "Market Operations in Electric Power Systems: Forecasting, Scheduling, and Risk Management", Wiley-Interscience Publisher Limited, New York, 2002.
4. Arthur Mazer, "Electric Power Planning for Regulated and Deregulated Markets", Wiley-IEEE Press, New Jersey, 2007
5. Xiao-Ping Zhang, "Restructured Electric Power Systems: Analysis of Electricity Markets with Equilibrium Models", Wiley-IEEE Press, Cambridge, 1st Edition, 2010.

15EE2004 POWER QUALITY ISSUES AND MITIGATION TECHNIQUES

Credits: 3:0:0

Course Objectives

- To study the different cause of power quality issues.
- To realize the concept of power and power factor in single phase and three phase systems supplying non linear loads
- To understand the conventional and active compensation techniques used for power factor correction and load voltage regulation.

Course Outcomes

- To devise suitable harmonic elimination technique to improve the quality of power.
- To assess the quality of Power.
- Follow the International standards of quality of power.

Description

Introduction – Characterization of Electric Power Quality-IEC and IEEE standards- Single phase linear and non linear loads- three phase balanced and unbalanced with distorted supply- Principle of load compensation and voltage regulation – harmonic reduction and voltage sag reduction-Passive (Tuned and Detuned Filters) and Active Filters-Realization and control of DSTATCOM-voltage Restoration- Realization and control of DVR – Unified Power Quality Conditioner-power factor correction Techniques

Reference Books

1. Roger C. Dugan, Mark F. McGranaghan, Surya Santoso , H. Wayne Beaty, " Electrical Power Systems Quality", McGraw Hill, New York, 3rd Edition, 2012.
2. Arrillaga J., Watson N.R., Chen S., "Power System Quality Assessment", Wiley Publications Limited, New York, 2000.
3. Bollens M.H.J., "Understanding Power Quality Problems: Voltage Sags and Interruptions", IEEE Press, New York, 2000.
4. Heydt G.T., "Electric Power Quality, Stars in a Circle Publications, Indiana, 2nd Edition, 1994.
5. Sankaran C., "Power Quality", C.R.C Press, New York, 2001.

15EE2005 TESTING AND INSTALLATION OF POWER SYSTEM APPARATUS

Credits: 3:0:0

Course Objectives

- To study the different testing of plants and equipments.
- To study the different causes of power quality issues.
- To study the installation and commissioning of rotating machine
- To study the installation and commissioning of transmission line

.

Course Outcomes

- To analyze the testing of equipments
- To analyze the commissioning of machine and transmission line
- To assess the quality of Power.

Description

Safety management during operation and maintenance-clearance and creepages- electric shock-Testing of Plants and Equipments- Temperature Rise test, insulation and HV test, dielectric absorption, switching impulse test, oscillographic test-Power quality- Power quality specifications, IEEE Recommended Practice for Monitoring Electric Power Quality-Testing of Rotating Machine- installation and commissioning of induction motor and rotating electric machine, care-commissioning of synchronous generator, protection and automation of synchronous generator, synchronous motor, D.C. generator and motor with reference to Indian Standard (IS). Transmission line-Commissioning of A.C transmission line and HVDC transmission- substation equipment, bus bar system, power transformer, distribution transformer and special transformer with reference to Indian Standard (IS).

Reference Books

1. Rao, S., “Testing , commissioning, operation and maintenance of electrical equipment”, Khanna Technical Publication, New Delhi, 6th Edition, 2013
2. Paul Gill, “Electrical power equipment maintenance and testing”, CRC Press, Boca Raton, 2nd Edition, 2008.
3. Philip Kiameh, “Electrical equipment handbook: Troubleshooting and Maintenance”, McGraw-Hill Limited, New York, 2003.
4. Charles I. Huber “Operating, Testing, and Preventive Maintenance of Electrical Power Apparatus ”, Prentice Hall; 1st edition, 2002
5. Relevant IEEE Standards and Indian Standards.

15EE2006 DIGITAL SIGNAL PROCESSING TECHNIQUES IN POWER SYSTEM PROTECTION

Credits: 3:0:0

Course Objectives

- To understand the basic concepts and recent trends in power system protection.
- To study the protection systems used for electric machines, transformers, bus bars, overhead and underground feeders.
- To study the different artificial technique used in power system protection.

Course Outcomes:

- To work with various type of relaying schemes used for different apparatus protection.
- To design and work with the concepts of digital and numerical relaying.
- To demonstrate and ability to design the relevant protection systems for the main elements of a power system.

Description

Evolution in protection systems-software tools for digital simulation of relaying signals-Fundamentals of system and signal analysis- Relaying algorithms, software considerations-Digital protection schemes for transmission lines, generators, and transformers, adaptive relaying, integrated substation protection and control- Digital methods for fault detection and fault location, Playback simulators for testing of protective relays

Reference Books

1. Lewis Blackburn, J., "Protective Relaying – Principles and Applications", Marcel Dekar, Incorporation, New York, 2006.
2. Waldemar Rebizant, Janusz Szafran, "Digital Signal Processing in Power System Protection and Control"**,** Springer Verlag, London, 2011.
3. The Electricity Training Association, 'Power System Protection Vol1-4', IEE, U.K., 2005.
4. Arun G Padkye, James S Thorp, "Computer Relaying for Power Systems", John Wiley & Sons Limited, 2nd Edition, 2009.
5. Hassan Khorashadi Zadeh, " Artificial Intelligence Based Power System Protection to mitigate Wide Area Disturbance", Proquest, Michigan, 2008.

15EE2007 POWER ELECTRONICS FOR RENEWABLE ENERGY SYSTEMS

Credits: 3:0:0

Course Objectives

- To understand the Impact of Power Electronics on Energy Systems
- To understand the Challenges of the Current Energy Scenario
- To learn about New Class of Power Converters for Renewable Energy

Course Outcomes

- Knowledge about new power electronic converters, such as FACTS and HVDC systems
- The configurations and roles of power electronics in various wind turbine concepts
- The mainstream solutions available in the PV industry

Description

Energy, Global Warming and Impact of Power Electronics in the Present Century, Challenges of the Current Energy Scenario: The Power Electronics Contribution , Recent Advances in Power Semiconductor technology, AC-Link Universal Power Converters: A New Class of Power Converters for Renewable Energy , High Power Electronics: Key Technology for Wind Turbines, Photovoltaic Energy Conversion Systems, Grid-Connected PV System Configurations, Control of Grid-Connected PV Systems, Recent Developments in Multilevel Inverter-Based PV Systems

Reference Books

1. Haitham Abu-Rub, Mariusz Malinowski, Kamal Al-Haddad, "Power electronics for Renewable Energy Systems, Transportation and Industrial Applications, John Wiley & Sons Limited, Sussex, 2014.
2. Sudipta Chakraborty, Marcelo G. Simões, William E. Kramer, "Power Electronics for Renewable and Distributed Energy Systems: A Sourcebook", Springer – Verlog, London 2013.
3. Fang Lin Luo, Ye Hong, "Renewable Energy Systems: Advanced Conversion Technologies and Applications", CRC Press, New York, 2013.
4. Qing-Chang Zhong, Tomas Hornik, "Control of Power Inverters in Renewable Energy and Smart Grid Integration", John Wiley & Sons, Ltd, United Kingdom, 2013
5. Ewald F. Fuchs, Mohammad A.S. Masoum, "Power Conversion of Renewable Energy Systems", Springer Science & Business Media, LLC, London, 2011.

15EE2008 BATTERY TECHNOLOGY FOR RENEWABLE ENERGY

Credits: 3:0:0

Course Objectives

- To understand the basic concepts of batteries and their uses.
- To develop an efficient energy storage system for the renewable energy systems.
- To solve the different kinds of storage problems that occurs in renewable energy systems.

Course Outcomes

- Selecting the type of battery to be used for the specific renewable energy system
- Characterizing the batteries
- Improving the lifetime of batteries through proper usage.

Description

Principles of operation- classification- electrical specifications-factors affecting battery performance-battery standardization-battery design-general characteristics-selection of batteries. Primary batteries-Classification-Cell components-Cell design-Performance -Characteristics-Types-Button configuration- Solid electrolyte batteries- Reserve batteries- Classification-characteristics of reserve batteries- battery design and application. Secondary batteries-characterization and application of secondary batteries-types. Metal-air batteries, Flow batteries & portable fuel cells -Introduction- General Characteristics and Operation of the fuel cell-designs for low wattage fuel cells -System requirements-Fuel processing & storage technologies-Hardware & performance

Reference Books

1. Brodd Ralph J., "Batteries for Sustainability: Selected Entries from the Encyclopedia of Sustainability Science and Technology", Springer Science & Business Media, New York, 2012.
2. Thomas B. Reddy, "Linden's Handbook of Batteries", McGraw Hill Professional, USA, 4th Edition, 2011.
3. Ogumi Z, "Battery/Energy technology (General)", The Electrochemical Society, New Jersey, 2010.
4. Dudney N, "Metal/Air and Metal/Water Batteries", The Electrochemical Society, New Jersey, 2010.
5. Ronald M. Dell, David A. J. Rand, Paul Connor, Robert (Bob) D Bailey, "Understanding Batteries", Royal Society of Chemistry, Cambridge, 2001.

15EE2009 ENERGY ECONOMICS

Credits: 3:0:0

Course Objectives

- To provide a variety of theoretical and empirical topics related to energy demand, energy supply, energy prices, environmental consequences of energy consumption and production.
- To understand the various public policies affecting energy demand, supply, prices, and environmental effects.

Course Outcomes

- Predicting the economics of various energy systems.
- Identifying the economics of electricity
- Understanding the economics of environmental protection.

Description

Introduction to Energy Economics - Energy Data and Energy Balance - Understanding the Energy Demand - Energy Demand Analysis, forecasting and management - Economic Analysis of Energy Investments – functioning of Energy Exchangers - Economics of fossil fuel supply - Economics of Non-renewable, Renewable and Electricity Energy supply - Economics of Environmental protection

Reference Books

1. Subhes C. Bhattacharyya, “Energy Economics-Concepts, Issues, Markets and Goverence”, Springer Science & Business Media, New York, 2011.
2. Ferdinand E. Banks, “Energy Economics: A Modern Introduction”, Springer Science & Business Media, New York, 2003.
3. http://www.iaee.org/en/publications/book.aspx
4. http://www.ieefa.org/

15EE2010 INDUSTRIAL ELECTRONICS

Credits: 3:0:0

Course Objectives

- To learn electronics in applied manner with perspective of industry.
- To understand the design philosophy for mechanical processes control based on analog and digital electronics and electrical machines.
- To know troubleshooting

Course Outcomes

- Able to design the logic controllers according to the industrial need
- Able to troubleshoot the electrical apparatus
- Able to analyze the control both in open loop and closed loop

Description

Industrial logic circuits – Industrial Timers- Programmable Controllers- Photo-electronics- Lasers- Fiber Optics- Industrial Power Supplies- Inverters and Converters – Open loop and closed loop feedback systems – Input Devices- Output Devices- Troubleshooting of Electrical Motors – Data Sheet and Name Plate Details Interpretation – Industrial Wiring Standard - Troubleshooting of Wiring System –Industrial Heating – Case Studies of Industrial Applications

Reference Books

1. Thomas E.Kissel, "Industrial Electronics", Prentice Hall of India, New Delhi, 3rd Edition, 2003.
2. Dale R. Patrick, Stephen W. Fardo, "Industrial Electronics: Devices and Systems", Fairmont Press, Georgia, 2000.
3. Bogdan M. Wilamowski, J. David Irwin, "Industrial Electronics Hand Book", CRC Press, London, 2nd Edition, 2011
4. Paul, A. B., "Industrial Electronics and Control", Prentice Hall of India Limited, 2nd Edition, 2009.
5. Skvarenina, Timothy L., "The Power Electronics handbook", CRC press, New York, 2001.

15EE2011 ELECTRONICS IN AGRICULTURAL AUTOMATION

Credits: 3:0:0

Course Objectives

- To understand the fundamentals of electronics in agriculture.
- To understand the use of computers in agriculture automation.

Course Outcomes

- Understanding of basics of agriculture.
- Application of electronics to agriculture automation
- Understanding of signal processing and image processing concepts for agriculture problems

Description

Basics of Agriculture -Introduction to Soil Science & Crop Science, Agriculture equipments and Automation: Operating principles of sensors and actuators for Agriculture, Measurement of temperature, pH, conductivity and soil moisture. Soil analysis and soil testing. Agro Meteorological instruments: Use of optoelectronic devices, PLDs, Microprocessors and Microcontroller, Data converters, Display devices in agricultural automation, Automatic drip irrigation. Computers & Special Information technology for ground water modeling, crop forecasting & estimate, soil erosion etc, Simulators used for study of crop growth. Data logger, Computer based automatic weather station. Green House Instrumentation

Reference Books

1. Sahi, V.N., “Fundamentals of Soil”, Kalyani Publication, Delhi, 2004.

2. Michale, A.M., “Principles of Agricultural Engineering “, Jain Brothers, New Delhi, 2009.
3. George Joseph , “Fundamentals of remote sensing”, Universities Press, Hyderabad,2003.
4. Muralikrishna ,I.V., “Spatial information technology, Vol I & II”, BS Publications Private Limited, Hyderabad.
5. Acharya, G.N., Hapse, D.G., “Treaties on Agro-Physics & Agri electronics”.

15EE2012 CONSUMER ELECTRONICS

Credits: 3:0:0

Course Objectives

- To gain knowledge in various consumer electronics circuits in home appliances and application.
- To understand the operation of audio, video systems.
- To learn the operation of various memory devices.
- To understand the performance of various switching systems.

Course Outcomes

- Knowledge in various consumer electronics circuits in home appliances and other applications
- Will be sufficiently acquainted with latest developments in daily use electronics.

Description

Audio systems - Hi-Fi systems, stereophonic sound system, public address systems, Acoustics, Quadraphonic sound systems, Graphics Equalizer, Electronic tuning, Digital sound recording on tape and disc. Video systems - B & W TV, color TV and HD TV systems, Electric cameras, VCR, VCP, Block diagram and principles of working of cable TV and DTH, cable TV using internet. Memory devices -CD systems, Memory diskettes, Discs and drums vide monitoring audio, video recording media & Systems. Switching systems -Dolby noise reduction digital and analog recording. Switching Systems: Switching systems for telephone exchange, PAB EPRABX, modular telephones, Telephone message recording concepts, remix controlled systems. Home appliances - Electronic toys, Microwave oven, Refrigerators, washing machines, calculator, Smart Phones, data organizers

Reference Books

1. Bali, S. P., "Consumer Electronics", Pearson Education India, New Delhi, 2007.
2. Gulati, R. R., "Monochrome and Colour Television", New Age International Private Limited, New Delhi, 2007.
3. Gulati, R. R., "Composite Satellite and Cable Television", New Age International Private Limited, New Delhi, 2005.
4. Handbook of Electronics & Communication Engineering, Ramesh Publishing House, Mumbai, 2014.
5. Veera Lakshmi, A., Srivel, R., "Television and Video Engineering", Ane Books Private Limited, 2010.

15EE2013 MICRO MOTORS AND ITS APPLICATIONS

Credits: 3:0:0

Course Objectives

- To be familiarized with small electric machines and micro drives.
- To explain the operating theory and practical design approaches for the most commonly used types of micro motors
- To understand the characteristics of small motors

Course Outcomes

- able to provide the latest information about small electric motors, supply electronic unit, control circuits ,encoders etc
- able to use mentioned types of motors for different applications.
- can apply the knowledge acquired in developing new products

Description

Micromotors: dc micromotors: PCB motors, voice coil motors, ultrasonic wave motors, coreless motors, PM motors, disc motors, servo motors, brushless motors, step motors, ac servo motors, synchronous motors, induction motors, universal motors and axial field motors. Operating Principle, Characteristics and Control- Latest Micromotors – Nano scale motors-Applications to information technology equipments, Computers: FDD, HDD, printers and plotters, instruments, Consumers products such as cameras, camcorders, timers, clock, CD players Wipers, FAX machines, copiers etc.

Reference Books

1. Jacek F. Gieras, “Permanent Magnet Motor Technology: Design and Applications”, CRC Press, USA, 2010.
2. Sergey Edward Lyshevski, “MEMS and NEMS: Systems, Devices, and Structures”, CRC Press,USA, 2005.
3. Azfal Suleman, “Smart Structures: Applications and Related Technologies”, Springer Wien, New York, 2001.
4. Kenji Uchino, “Entrepreneurship for Engineers, CRC Press, Boca Raton,2010.

15EE2014 PERMANENT MAGNET MOTORS

Credits: 3:0:0

Course Objectives

- To gain the knowledge of permanent magnet materials and circuits
- To get the details on design, analysis , control and applications of various PM motors
- To understand the different applications of PM Motors

Course Outcomes

- able to relate the characteristics of PM motor with the proper application.
- able to design power electronic converters for PM motors .
- able to apply PM motors for appropriate applications

Description

Permanent magnet materials and circuits; Characteristics, parameters, properties, classification and calculations, Permanent magnet motors, D.C. brushed motors, design analysis and control and applications, PM synchronous motors, rotor construction such as surface mounted PM, buried PM, inset type PM and interior type PM rotor and cage less rotor motors, line start and inverter fed control and applications. PM brushless dc motor, theory, operation, control and applications, axial field disc construction, PM step motors, hybrid step motors, sensor less control, reduction of torque pulsations; Case studies such electric vehicles, marine propulsion, spindle drives, commercial and industrial drives, PV fed water pumping

Reference Books

1. Jacek F. Gieras, "Permanent Magnet Motor Technology, Design and Application", CRC Press, USA, 3rd Edition, 2011.
2. Ramu Krishnan, " Permanent Magnet Synchronous and Brushless DC Motor Drives", CRC Press, Boca Raton, 2009.
3. Duane C. Hanselman, "Brushless Permanent Magnet Motor Design", Magna Physics Publication, Madison, 2006.
4. Chang-Liang Xia, "Permanent magnet Brushless DC Motor drives and control", Wiley, 2012.
5. Gieras**,** Jacek F.,Wang, Rong-Jie, Kamper, Maarten J, "Axial Flux Permanent Magnet Brushless Machines " 2nd edition , Springer , 2008.

15EE2015 ADVANCES IN ELECTRICAL ENGINEERING APPLIED TO HOSPITAL ENGINEERING

Credits: 3:0:0

Course Objectives

- To study about the aspects of clinical engineering.
- To study about the various aspects of electrical engineering issues involved in hospitals.

Course Outcomes

- Know the role and importance of clinical engineer in the management of the hospital.
- Ability to specify the type of networking facility to be provided in the hospital.
- Capability to identify the electromagnetic effects on medical devices and to make the devices electromagnetically compatible.

Course description:

Definition of Bio-Engineering, Biomedical Engineering, Clinical engineering & Hospital engineering Modern Hospital Architecture. Computerized preventive maintenance planning. Importance of ISO certification, Electrical power systems in hospitals - Design of sub stations, wiring in hospitals, protective systems – over voltage and over current protectors, circuit breakers, Surge protectors, EMI filters, Stabilized and uninterrupted power supply systems, generator sets and uninterrupted power supply for ICU and computerized monitoring units. Specification & estimation for hospital wiring - small case study-Power quality issues in hospital electrical systems, Electromagnetic noise stability, Battery used in hospital devices, Electromagnetic Compatibility (EMC), power quality meter, isolation transformers, power transformers, Hospital power quality audits, telemedicine. Basics of air conditioning and refrigeration systems, Design of operation theatres, theatre lighting, OT tables, power supply systems, Hospital gas supply systems, Electric powered wheel chairs & stretches. Hospital information systems. Computerization in pharmacy & billing. Automated clinical laboratory systems & radiology information systems

Reference Books

1. Syed Amin Tabish, “Hospital and Health services Administration Principles and Practices”, Oxford Press, New Delhi, 2001.
2. Kline, Jacob, ed. Handbook of biomedical engineering. Elsevier, 2012.
3. Eric Udd, “Fibre Optic Sensors and introduction for Engineers and Scientists”, Wiley; 2 edition, October 2011.
4. Patrick Regan “Local Area Networks”, Prentice Hall; 1 edition, 2003
5. Goyal, R.C., “Hospital Administration and Human Resource Management”, Prentice Hall of India, New Delhi, 4th Edition, 2006.

15EE2016 INDUSTRIAL MECHATRONICS

Credits: 3:0:0

Course Objectives

- Exposed to concepts of mechatronics.
- gain knowledge in elements of mechatronics systems
- exposed to different interfacing used in industry

Course Outcomes

- The students will be able to design, use and maintain various mechatronics elements.
- The students will obtain the working skills for carrying out (understanding, planning, and executing) innovation projects, developing mechatronics industrial products.

Description

Introduction to mechatronics, role of mechatronics in automation, manufacturing and product development; Sensors and Feedback Devices, Control Elements and Actuators : On/off push buttons, control relays, thermal over load relays, contactors, selector switches, solid state switches. Mechanical actuators, Computational Elements and Controllers, block and functional diagrams controllers for robotics and CNC, linear and rotary encoders, timers, counters, microprocessors and microcontrollers: introduction, programming and applications, introduction to PLC, simple programs for process control application based on relay ladder logic-Supervisory Control and Data Acquisition Systems (SCADA) and Human Machine Interface (HMI); Interfacing Systems, TCP/IP, MAP/TOP; Application of Mechatronic Systems : Introduction to factory automation and integration, design of simple Mechatronics systems, Case studies based on the application of mechatronics in manufacturing, autotronics, bionics and avionics

Reference Books

1. Cetinkunt, S., "Mechatronics", John wiley, 2007.
2. J Stenersons, "Fundamentals of Programmable Logic Controllers Sensors and Communications", Prentice Hall, 2004.
3. Kuttan K K, "Introduction to Mechatronics", Oxford University Press, 2007.
4. D. G. Alciatore and M. B. Histand, "Introduction to Mechatronics and Measurement Systems", McGraw Hill, NY, 2007.
5. Bolton W, "Mechatronics", Pearson Education Asia, New Delhi, 2004.

14EE2017 CONDITION MONITORING OF ELECTRICAL MACHINES

Credits: 3:0:0

Course Objectives

- Study about the Condition monitoring of engineering plant has increased in importance as more engineering processes become automated and the manpower needed to operate and supervise plant is reduced.
- Study about the dynamic behavior of electrical machines, particularly associated with the control now available with modern power electronics,
- Study about the electromagnetic behavior of electrical machines,
- Study about the behavior of electrical machine insulation systems.

Course Outcomes

- The students will understand the advantages of Condition monitoring and its applications
- The understanding of signal processing tools to measure parameters of electrical machines will be obtained.
- Understanding of the concepts of fault diagnosis in AC and DC Machines will be obtained.

Description

Introduction to condition monitoring- Need for monitoring - Construction of electrical machines - Structure of electrical machines and their types - Machine specification and failure modes - Insulation ageing mechanisms - Insulation failure modes - Other failure modes – Failure sequence and effect on monitoring - Typical root causes and failure modes - Reliability analysis - Machinery structure - Typical failure rates - Instrumentation requirements - Temperature, vibration, force and Torque - Spectral analysis - High-order spectral analysis - Wavelet analysis - Correlation analysis - Vibration monitoring of motor and generator - Electrical techniques: current, flux and power monitoring - Condition-based maintenance and asset management - Life-cycle costing

Reference Books

1. Tavner P, Penman J, “Condition monitoring of electrical machines”, Research Studies Ltd. Wiley, London, 2011.
2. Peter vas, “Parameter estimation, condition monitoring & diagnosis of electrical machines”., Oxford University Press,1995.
3. Hamid A. Toliyat, Subhasis Nandi, Seungdeog Choi, Homayoun Meshgin-kelk, “Electrical Machines, Modeling, Condition Monitoring and Fault diagnosis”, CRC Press, Taylor and Francis Group, First Edition, 2013.
4. Rao, B.K.N., Penman J, “Handbook of Condition Monitoring”, Elsevier Science Ltd, London, 2001.
5. Tang, W.H., Q.H.Wu, “Condition monitoring and Assessment of Power Transformers using Computation Intelligence”, Springer Verilog Ltd, London, 2011.

15EE2018 GREEN ELECTRONICS

Credits: 3:0:0

Course Objectives

- To impart knowledge in the area of Green electronics
- To understand the challenges in executing green electronics based projects
- To explore the scope of nanotechnology in green electronics.

Course Outcomes

- To understand green electronics concepts
- To use green materials in new products
- To assemble Lead-Free assembly

Description

Environmental Progress in Electronics Products. Reliability of Green Electronic Systems. Environmental Compliance Strategy and Integration. Management of the Global Design Team in Compliance with Green Design and Manufacturing. Successful Conversion to Lead-Free Assembly-Establishing a Master Plan for Implementing the Use of Green Materials and Processes in New Products. Fabrication of Green Printed Wiring Boards. Green Finishes for IC Components. Designing energy-efficient PCs using integrated power management, Battery selection and application—environmental considerations, Implementing green printed wiring board manufacturing, Design for Disassembly, Reuse, and Recycling- Defining Electronics Recycling. Ultra light hybrid vehicles, Nanotechnology Opportunities in Green Electronics

Reference Books

1. Shina, Sammy, "Green Electronics Design and Manufacturing", McGraw-Hill Incorporation, New York, 2008.
2. Goldberg, Lee H., "Green Electronics/green bottom line: environmentally responsible engineering", Newnes, 1999.
3. John X. Wang, "Green Electronics Manufacturing: Creating Environmental Sensible Products", CRC Press, Florida, 2012.
4. Paul Scherz, Simon Monk, "Practical Electronics for Inventors", McGraw-Hill/TAB Electronics, New York, 3rd Edition, 2013.
5. David Findley, "Do-It-Yourself Home Energy Audits: 101 Simple Solutions to Lower Energy Costs, Increase Your Home's Efficiency, and Save the Environment", TAB Electronics, 2010.

15EE2019 ENERGY STORAGE IN POWER SYSTEMS

Credits: 3:0:0

Course Objectives

- To understand the importance of energy storage
- To understand different energy storage options
- To gain the knowledge on the selection of energy storage systems

Course Outcomes

- Describe specific characteristics of different energy sources.
- Select the energy storage options for different operating conditions
- Explain the difficulties in solution methods integrating the energy storage systems to the grid

Description

Introduction-General Concepts- Importance of Energy Storage-Thermal Energy Storage-Mechanical Energy Storage-Electromagnetic Energy Storage-Hydrogen Storage – Pumped Hydro Storage-Energy Storage for Medium-to-Large Scale Applications –Choice of Energy Storage Systems- Energy Storage for Wind and Solar PV Systems-Power System Integration.

Reference Books

1. Marc A.Rosen , "Energy Storage ", Nova Science Publishers, 2012 .
2. Jonathan M. Bowen, "Energy Storage: Issues and Applications", Nova Science Publishers, 2011.
3. Ter-Gazarian, A., "Energy Storage for Power Systems", Peter Peregrinus Limited, London, 2011.
4. Robert A. Huggins, "Energy Storage", Springer, Germany, 2010.
5. Richard Baxter, "Energy Storage: A Nontechnical Guide", Pennwell Corporation, Oklahama, 2006.

15EE2020 MICROGRIDS

Credits: 3:0:0

Course Objectives

- To study the concept of microgrid and its configuration
- To gain the knowledge on microgrid controllers.
- To understand the benefits of microgrids.

Course Outcomes

- explain the operational methods of microgrids
- design the controllers for microgrids
- perform assessment on the different benefits of microgrids.

Description

Microgrids Concept- Control Architecture - Intelligent Local Controllers - Control Issues- Microgrid Protection-Operation of multi-microgrids- Micro-grid standards - micro Energy Management Systems - Pilot Sites: Success Stories and Learnt- Quantification of Technical, Economic, Environmental and Social Benefits of Microgrid Operation – DC Microgrid Control Architectures – Microgrid Communication

Reference Books

1. Nikos Hatziargyriou, "Microgrids: Architectures and Control", Wiley-IEEE Press, USA, Press, 2013.
2. Shin'ya Obara, "Optimum Design of Renewable Energy Systems: Microgrid and Nature Grid Methods", Engineering Science Reference Series, USA, 2014.
3. Carlos Moreira ., " Microgrids ", LAP Lambert Academic Publishing, 2012
4. Ritwik Majumder, "Microgrid: Stability Analysis and Control", VDM Publishing, Germany, 2010.
5. Robert Galvin, Kurt Yeager, "Perfect Power", McGraw Hill Incorporation, USA, 2009.

15EE2021 GRAPH THEORY APPLICATIONS TO ELECTRICAL ENGINEERING

Credits: 3:0:0

Course Objectives

- To understand the concept of graphs
- To gain the knowledge on the application of graph theory to the analysis and design of electrical networks.
- To use graph theory for optimizing the design of electrical network.

Course Outcomes

- model engineering systems using graph theory
- apply graph theory for control system applications
- apply graph algorithm in solving electrical engineering problems .

Description

Basic of graph theory: trees, f-circuits, f-cutsets, connected and seperable graphs etc. Matrices of a graph and relations between them, Generation of network functions of one and two-port networks using spanning tree and directed tree algorithms, Graph searches like BFS and DFS, Path problems like shortest paths, all paths between a pair of nodes etc. Generation of directed graphs and their use in the determination of transfer functions of networks. Applications in Electrical Engineering, Applications of graph algorithms in routing, assignment and other problems in circuit design

Reference Books

1. Narsingh Deo, “Graph Theory with Applications to Engineering and Computer Science”, Prentice Hall of India, New Delhi, 2004.
2. Balakrishnan, R., Ranganathan, K., “A Text Book of Graph Theory”, Springer, New York, 2012.
3. Bondy, J.A., Murty, U. S. R., “Graph Theory”, Springer, Germany, New York, 2008.
4. Bella Bollobas, “Modern Graph Theory”, Springer-Verilog, Germany, 2013.
5. Yagang Zhang, “New Frontiers in Graph Theory”, InTech, China, 2012.

15EE2022 POWER SYSTEM OPTIMIZATION

Credits: 3:0:0

Course Objectives

- To know the importance of power system optimization
- To acquire a comprehensive idea on various aspects of power system optimization problems and their formulations.
- To understand various optimization techniques.

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Course Outcomes

- Formulate different power system optimization problems
- apply evolutionary optimization techniques in power system applications.
- know about the power system security states.

Description

Characteristics of generation units, economic dispatch of thermal plants, unit commitment-hydro thermal coordination – hydro-thermal scheduling- maintenance scheduling, emission minimization, Combined heat and power dispatch- optimal planning optimal power flow, security constrained optimization- state estimation-optimal siting of DGs and Wind Turbines. Traditional and Modern Optimization Techniques

Reference Books

1. Kothari D. P., Dhillon, J. S., "Power System Optimization", Prentice Hall of India Learning Private Limited, New Delhi, 2012.
2. Soliman Abdel-Hady Soliman, Abdel-Aal Hassan Mantawy, "Modern Optimization Techniques with Applications in Electric Power Systems", Springer Science & Business Media, U.S.A., 2011.
3. Jizhong Zhu, "Optimization of Power System Operation", John Wiley & Sons, USA, 2009.
4. James A. Momoh, "Electric Power System Applications of Optimization", Taylor & Francis, U.S.A., 2nd Edition, 2008.
5. James A. Momoh, "Electric Power System Applications of Optimization", CRC Press, U.S.A., 2000.

15EE2023 SUBSTATION DESIGN

Credits: 3:0:0

Course Objectives

- To acquire knowledge of basic substation components
- To understand on the constructional features and design of substations
- To gain basic concepts of substation automation and control

Course Outcomes

- able to draw the substation lay out
- able to design and analyze a sub station
- able to perform substation control according to the standard operating procedure

Description

Types of substations layout and bus bar arrangements – Earthing – Types of Earthing - Grounding; design and Practices, Lightening Arrestors - substation auxiliaries – Transformer design – Circuit Breaker design – Current Transformer and Power Transformer design – Bus bar design - Cable routing, data acquisition, substation Control, load shedding, implementation. SCADA-Communication – Substation operation – substation maintenance

Reference Books

1. Gupta P.V., Satnam P.S., "Substation Design and Equipment", Dhanpat Rai Publications Private Limited, New Delhi, 2013.
2. John D. McDonald, "Electric Power Substations Engineering", CRC Press, USA, 3rd Edition, 2012.
3. Dominik Pieniazek P.E., "HV Substation Design: Applications and Considerations", IEEE CED, USA, 2012.
4. Leon Kempner, "Substation Structure Design Guide", ASCE Publications, USA, 2008.
5. Praneesh Prasad, "Substation Design", California State University, Sacramento, 2006.

15EE2024 DISTRIBUTION SYSTEM PLANNING AND AUTOMATION

Credits: 3:0:0

Course Objectives

- To understand different configurations of distribution systems
- To have a knowledge on distribution systems load patterns
- To learn the importance of distribution automation

Course Outcomes

- able to examine the load characteristics of distribution systems
- able to design the distribution substation
- able to recognize the need for voltage regulation and distribution automation

Description

Configuration of distribution systems - load characteristics, distribution transformers, distribution substation design, feeder design, voltage regulation, protection in distribution systems, SCADA, distribution automation. Fault Identification in distribution systems

Reference Books

1. Ganen Turan, "Electric Power Distribution System Engineering", CRC Press, USA, 2nd Edition, 2007.
2. Pabla, A.S., "Electric Power Distribution", Tata Mc-Graw Hill Private Limited, New Delhi, 5th Edition, 2005.
3. William Kersting, "Distribution Modelling & Analysis", CRC Press, USA, 3rd Edition, 2002.
4. Juergen Schlabbach, Karl-Heinz Rofalski, "Power System Engineering: Planning, Design, and Operation of Power Systems and Equipment ", John Wiley & Sons, New York, 2008.
5. Khedkar, M.K., Dhole G.M., "A Textbook of Electric Power Distribution Automation", Laxmi Publications Limited, New Delhi, 2010.

15EE2025 TESTING AND COMMISSIONING OF ELECTRICAL EQUIPMENT

Credits: 3:0:0

Course Objectives

- To understand the testing procedure of various electrical equipments.
- To get exposure to the commissioning of various electrical equipments.
- To acquire the knowledge on testing standards.

Course Outcomes

- able to demonstrate testing of electrical machines.
- able to commission various electrical equipment .
- able to gain knowledge on testing standards.

Description

Testing of Transformers, DC machines, Induction machines synchronous machines and other Electric apparatus. Study of testing standard (BIS and EMC) etc. on electrical equipment - Type tests and routine tests. Tests before commissioning and after commissioning of electrical equipments. Various testing standards.

Reference Books

1. Rao S, “Testing, Commissioning, Operation and Maintenance of Electrical Equipment”, Khanna Publishers, New Delhi, 2014.
2. Paul Gill, “Electrical Power Equipment Maintenance and Testing”, CRC Press, USA, 2nd Edition, 2008.
3. Hemant Joshi, “Residential, Commercial and Industrial Electrical Systems: Protection, testing and commissioning”, Tata McGraw-Hill Education, New Delhi,2008
4. Keith Harker, “Power System Commissioning and Maintenance Practice” IEE Press, UK, 1998.
5. Singh R.P., “Electrical Workshop: Safety, Commissioning, Maintenance & Testing of Electrical Equipment”, I.K. International Publishing House Private Limited, New Delhi, 2012.

15EE2026 ELECTRICAL ESTIMATION AND COSTING

Credits: 3:0:0

Course Objectives

- To understand electrical engineering drawing, IE rules, NEC, different types of electrical installation and their design considerations
- To understand the methods and procedure of estimating the material required; develop the skill of preparing schedule of material; detailed estimates; costing of different types of Installation
- To know the preparation of the tender documents, procedure for tendering, evaluation and billing of executed work of different types of electrical Installation Project.

Course Outcomes

- able to define different types of Electrical Installation and interpret the Electrical Engineering Drawing
- able to state IE rules, NEC related to Electrical Installation and testing.
- able to state and describe the basic terms, general rules, circuit design procedure, wiring design and design considerations of Electrical Installations.
- able to understand the concept of contracts, contractors, tender and tender document and its related procedures.

Description

Drawing and IE rules-Service Connection-Preparing the schedule of Material- Costing of Material, Labour, Overhead, Contingencies- Residential Building Electrification- Electrification of commercial Installation - Electrification of factory unit Installation - Testing of Installation - Contracts, Tenders and Execution.

Reference Books

1. Raina, K.B., Bhattacharya, S.K., “Electrical Design, Estimating and Costing”, New Age International Private Limited, New Delhi, 2005.
2. Gupta, J.B., “Electrical Installation Estimating & Costing”, S. K. Kataria & Sons, New Delhi 2009.
3. Arora, B.D., “Handbook of Electrical Wiring Estimating & Costing”, R.B. Publication, New Delhi, 2011.
4. AdamDing, “Electrical Estimating Professional Reference”, Cengage Learning, Kentucky 2008.
5. Uppal, S.L., Carg, G.C., “Electrical Wiring Estimation and Costing, Oscar Publications”, New Delhi, 2011.

15EE2027 ELECTROMAGNETICS LAB

Credits: 0:0:2

Course Objectives

- Analyze various electric field configurations
- Analyze various magnetic field configurations
- Analyze the Propagation of Electromagnetic Waves

Course Outcomes

- Able to design small electromagnetic applications.
- Able to understand the industrial applications of Electromagnetic Fields.

Description

This laboratory demonstrates the students the sources of electromagnetic fields, configuration and their applications.

Experiments

The faculty conducting the laboratory will prepare a list of 12 experiments and get the approval of HOD/Director and notify it at the beginning of each semester.

15EE2028 FEM ANALYSIS LAB

Credits: 0:0:2

Course Objectives

- Demonstrate an awareness of the potential areas of applications of CAE tools.
- Demonstrate an ability to formulate, implement and document solutions to solve simple engineering problems using the Finite Element Method.

Course Outcomes

- able to evaluate the performance parameters of an electrical apparatus.
- able to evaluate the validity of the FEM model and solution in relation to the original problem specification.

Description

This laboratory will demonstrate the students about the application of Finite Element Methods for analysis of Electrical apparatus.

Experiments

The faculty conducting the laboratory will prepare a list of 12 experiments and get the approval of HOD/Director and notify it at the beginning of each semester.

15EE2029 ALTERNATE ENERGY SOURCES FOR HOSPITALS

Credits: 3:0:0

Objectives:
- To identify alternate sources of electric power to hospitals
- To analyse the feasibility of biomass and solar energy
- To understand the optimize energy generation through control techniques

Outcomes:
- To learn the sources of electric power to hospitals
- To apply various optimization techniques to improve efficiency
- To design the systems for power generation

Description

Power Station layout – Need for alternate energy – Gasifier, Biomass storage, Fermentation, Biomass conversion processes, reactor design-gas engines, combustion efficiency, O_2, CO_2 measurements, Cogeneration of Biogas with Combined Heat and Power - gas storage, gas regulator, control valve, fuel cell- Solar Thermal Systems - Ground & Roof Mounted PV modules, storage, inverter, Power Electronic in Photovoltaic Systems –Stand-alone photovoltaic Systems – Grid connected photovoltaic systems- Maximum Power Point Tracking- Solar Tree – Solar Powered lighting scheme for Operation Theater – Solar Powered Autoclave - Solar Powered Air Conditioning Unit – Solar Powered Hospital – Green Ambulance

References:

1. Khan B.H., "Non-Conventional Energy Resources", Tata Mc-Graw Hill Publishing Company Ltd, New Delhi 2006.
2. Rai G. D., "Non conventional Energy Sources", Khanna Publishers, New Delhi, 2007.
3. Thomas .b. Johansson, Henry Kelly, Amulya K.N .Reddy, Robert .H. Williams, "Renewable Energy Sources for Fuels and Electricity", Island Press, Washington DC, 2009.
4. Sukhatme, S.P., "Solar Energy", Tata McGrawHill Education India Private Limited, New Delhi, 2006.
5. John Twidell, Tony Wier, "Renewable Energy Sources", Taylor & Francis Publishers, NewYork, 2005.

15EE3001 ADVANCED CONTROL OF ELECTRIC DRIVES

Credits: 3:0:0

Course Objectives

- To impart the basic knowledge about various AC and DC drives.
- To understand the working of Reluctance and BLDC drives.
- To know about various DSP based and AI based Drives.

Course Outcomes

- To understand the concept of modern power electronic drives.
- To design, test and analyze Torque and Vector controlled drives.
- To apply the DSP and AI based drives for applications.

Description

Modulation of Power Electronic Converters – Current Control of Generalized Load – Drive Principles – Modeling and Control of DC Machines, Synchronous Machines, Induction Machines and Switched Reluctance Drive Systems – Types of Torque-Controlled Drive Schemes – Direct and Vector Controlled Drives – DSP Controlled Drives – Cogging Torque Minimization Techniques in Drives – AI-based Techniques: Fuzzy Logic and Neural-Network based Drives – Drives for Renewable Energy Systems: Micro-Hydro Systems - PMDD Generator: Principle and Design – Application in Zephyros Wind Turbine – Archimedes Wave Swing (AWS) Direct Drive

Reference Books

1. Hamid A Toliyat and Steven G. Campbell, "DSP Based Electromechanical Motion Control", CRC Press, UK, 2004.
2. Maurizio Cirrincione, Marcello Pucci and Gianpaolo Vitale, "Power Converters and AC Electrical Drives", CRC Press, Boca Raton, 2012.
3. Ned Mohan, "Advanced Electric Drives: Analysis, Control and Modeling using Simulink", John Wiley and Sons Limited, New Jersey, 2014.
4. Rik De Doncker, Duco W. J. Pulle and Andre Veltman, "Advanced Electrical Drives: Analysis, Modeling and Control" , Springer, London, 2011
5. Markus Mueller and Henk Polinder, "Electrical Drives for Direct Drive Renewable Energy Systems", Woodhead Publishing Limited, Cambridge, 2013.

15EE3002 SWITCHED MODE POWER CONVERTERS

Credits: 3:0:0

Course Objectives

- To impart the basic knowledge about the power electronic converters.
- To understand the steady state and dynamic modeling of various converters.
- To know about closed loop performance of various converters for applications.

Course Outcomes

- To understand the concept of modern power converters.
- To design, Model and Analyze power converters.
- To apply the switched mode converters in applications.

Description

Switching Devices Ideal and Real Characteristics – Reactive Elements in Converters – Design of Inductor, Transformer, Capacitors for Power Electronic Applications – Switched Mode Power Converters – Primitive DC to DC Power Converter – Non-Isolated DC to DC Power Converter – Cuk, Sepic and Quadratic Converters – Isolated DC to DC Power Converter – Forward, Flyback, Half/Full Bridge Converters – Steady-State and Dynamic Model, Analysis, Modeling and Performance Functions of Switching Power Converters – Load Resonant Converters – Resonant Switch Converters – Zero Voltage and Current Switching – Closed Loop Control of Switching Converters – Steady State Error, Control Bandwidth and Compensator Design – Closed Loop Dynamic Performance Functions –Design of Feed- Back Compensators – Unity Power Factor Rectifiers, Resistor Emulation Principle – Applications

Reference Books

1. Keng C. Wu, “Switch-Mode Power Converters: Design and Analysis”, Academic Press, California, 2005.
2. Robert W. Erickson, Dragan Maksimovic “Fundamentals of Power Electronics,” Springer, Massachusetts, 2005.
3. Ramanarayanan V., “Course Material on Switched Mode Power Conversion”, Department of Electrical Engineering, Indian Institute of Science, Bangalore, 2007.
4. Issa Batarseh, “Power Electronic Circuits”, John Wiley, USA, 2004.
5. Philip T Krein, “Elements of Power Electronics”, Oxford Press, UK, 1998.

15EE3003 ADVANCED SOFT COMPUTING TECHNIQUES

Credits: 3:0:0

Course Objectives

- To develop an in-depth understanding of various soft computing techniques.
- To analyze the mechanisms of different AI techniques and modern heuristics algorithms.
- To develop skills to apply the soft computing techniques for various practical optimization problems.

Course Outcomes

- State the mechanisms of various soft computing techniques.
- Understand the techniques of various modern heuristic optimization algorithms.
- Apply the soft computing techniques for practical applications

Description

Introduction to Genetic Algorithm, Particle Swarm Optimization and ABC Algorithm – Optimization applied to Fuzzy Logic and Artificial Neural Network - Ant Colony Optimization: Real to Artificial Ants, Colony Optimization Metaheuristic, ACO Algorithm, ACO Theory and Applications – Cuckoo Search and Firefly Algorithm: Introduction, Algorithm, Binary Approach and Applications, Hybridization of cuckoo and firefly algorithm and Intelligent Firefly Algorithm for Global Optimization – Differential Evolution: Introduction and Types, Advances in DE, Single-Objective Optimization, DE Strategies, Intrinsic and Non-Intrinsic Control Parameters and Applications

Reference Books

1. Anyong Qing, "Differential Evolution: Fundamentals and Applications in Electrical Engineering, John Wiley and Sons, IEEE Press, Singapore, 2009.
2. Marco Dorigo and Thomas Stutzle, "Ant Colony Optimization", A Bradford Book, The MIT Press, London, 2004.
3. Xin-She Yang, "Cuckoo Search and Firefly Algorithm: Theory and Applications", Springer, Switzerland 2014.
4. Sivanandam. S. N. and Deepa. S. N, "Principles of Soft Computing", Wiley, New Delhi, 2011.
5. Devendra K. Chaturvedi, "Soft Computing: Techniques and its Applications in Electrical Engineering", Springer, India, 2008.

15EE3004 PREDICTIVE CONTROL OF POWER CONVERTERS AND ELECTRICAL DRIVES

Credits: 3:0:0

Course Objectives

- To provide a comprehensive and technical understanding on Predictive Control.
- To impart understanding on the performance improvement with the Predictive Controllers.
- To able to tune the Predictive Controller to obtain a good response.

Course Outcomes

- To formulate the Predictive Control as a fixed term feedback controller for a power electronic and drive controllers.
- To ensure the robustness of the system to bounded disturbances.
- To determine the stability properties of a Predictive Controller.
- To design a system with constraint checking horizon.

Description

Classical control methods – Basics of Predictive Control – Predictive Control of a Three Phase Inverter, Three Phase Neutral Point Clamped Inverter, Active Front End Rectifier and Matrix Converter – Predictive control of Induction Motor, Permanent Magnet Synchronous Motor (PMSM) – Design and implementation issues of model predictive control – Delay Compensation – Effect of Model Parameter Errors – EMI/EMC Issues of Power Converters

Reference Books

1. Jose Rodriguez, Patricio Cortes, “Predictive Control of Power Converters and Electrical Drives”, John Wiley & Sons, United Kingdom, 2012.
2. Patricio Cortés, et.al, “Predictive Control in Power Electronics and Drives”, IEEE Transactions on Industrial Electronics, Vol.55, No.12, December 2008.
3. Jiaying Wang, “Model Predictive Control of Power Electronics Converter”, M.S Thesis, Norwegian University of Science and Technology, Norway, 2012.
4. Lars Grune, Jurgen Pannek, “Nonlinear Model Predictive Control: Theory and Algorithm”, Springer-Verlag, London, 2011.
5. Liuping Wang, “Model Predictive Control System Design and Implementation using MATLAB”, Advances in Industrial Control, Springer – Verlag, London, 2009.

15EE3005 ADVANCED POWER CONVERTERS FOR RENEWABLE ENERGY SYSTEMS

Credits: 3:0:0

Course Objectives

- To describe the advanced conversion technologies for renewable energy systems.
- To understand the cutting edge techniques for the determination of switching angles for modern AC, DC Converters.
- To know about the importance of converters in improving energy saving and power supply quality.

Course Outcomes

- To describe appropriate methods to determine accurate solutions for power converters.
- To design converters for industrial applications.
- T0 test and analyze the applications of modern converters in wind turbine and solar panel energy systems.

Description

New Energy Sources: Nuclear Fusion, Capture of Neutrino by Solar, Supernovae and Big Bang – Voltage Lift Converters: Luo Converters, Cuk Converters, SEPIC Converters and Switched Capacitorized Converters – Super Lift and Ultra Lift Converters: P/O and N/O Luo Converters – Multilevel Inverters Introduction – Quasi-Linear MLI and Soft Switching MLI – Laddered MLI for Solar Panel (Simulation and Analysis) – Trinary Hybrid MLI for Solar Panel (Simulation and Analysis) – DC Modulated Multiphase AC / AC Converters – Sub Envelope Modulation Method of AC / AC Matrix Converters – AC/DC/AC Converters for Wind Turbine Systems

References Books

1. Fang Lin Luo and Hong Ye, “Renewable Energy System: Advanced Conversion Technologies and Applications”, CRC Press, Taylor and Francis Group, Boca Raton 2013.
2. Fang Lin Luo and Hong Ye, “Advanced DC / AC Inverters: Applications in Renewable Energy”, CRC Press, Taylor and Francis Group, Boca Raton, 2013.
3. Andrezej M. Trzynadlowski, “Introduction to Modern Power Electronics”, Wiley-Blackwell, 2nd Edition, Switzerland, 2010. .
4. Euzeil dos Santos and Edison R. da Silva, “Advanced Power Electronics Converters: PWM Converters Processing AC Voltages”, Wiley-IEEE Press, Canada, 2015.
5. Adrian Ioinovici, “Power Electronics and Energy Conversion Systems”, John Wiley and Sons Limited., United Kingdom, 2013.

15EE3006 SMART GRID TECHNOLOGIES

Credits 3:0:0

Course Objectives

- To understand the structure of a smart grid and smart energy resources.
- To understand transmission, distribution and communication systems.
- To understand the impacts of smart grids in Cyber and data security.

Course Outcomes

- To construct the smart grid network.
- To apply various communication technologies for smart grid network.
- To implement the various computing and security modules in the network.

Description

Introduction to Smart Grid – Smart Energy Resources – Integration of Smart Energy Resources – Protection Techniques - Smart Substations – Transmission, Distribution and Communication Systems – Monitoring and Diagnosis – Geospatial Technologies – Asset Management – Smart Meters and Advanced Metering Infrastructure – Consumer Demand Management – High Performance Computing – Cyber Security – Smart Grid Standardization – Data Privacy and Benefits – Smart Grid Initiatives

References Books

1. Stuart Borlase, "Smart Grids: Infrastructure, Technology and Solutions", CRC Press, Taylor and Francis Group, Boca Raton, 2012.
2. JanakaEkanayake, Nick Jenkins "Smart Grid Technology and applications", John Wiley & Sons Limited, UK, 2012.
3. Stephen F. Bush, "Smart Grid: Communication-Enabled Intelligence for the Electric Power Grid, Wiley – Blackwell, USA, 2014.
4. Ali Keyhani , "Design of Smart Power Grid Renewable Energy Systems", John Wiley & Sons, New Jersey, 2011
5. Nouredine Hadjsaid, Jean-Claude Sabonnadiere, "Smart Grids", John Wiley & Sons Limited, New Jersey, 2012.

15EE3007 SOLAR ENERGY FORECASTING TECHNIQUES

Credits: 3:0:0

Course Objectives

- To understand the basics of assessing solar energy using satellite forecasts
- To learn the mathematical basics involved in forecasting of data
- To equip the student with the latest forecasting techniques

Course Outcomes

- Ability to understand the basics of available forecasting models
- Ability to understand the technical aspects of solar resource assessment
- Ability to develop accurate forecasting models

Description

Weather Monitoring - Solar-Radiation Datasets, Solar Resource Variability, Quantifying and Simulating Solar-Plant Variability Using Irradiance Data. Classification of Solar Forecasting Methods - Deterministic and Stochastic Forecasting Approaches. A Critical Appraisal of Physically-Based Forecasting Approaches. Satellite Forecasts, Sky-Imager Forecasts, Data Inputs to Stochastic-Learning Approaches, Metrics for Evaluation of Solar-Forecasting Models - Solar Resource Variability, Conventional Metrics Model Evaluation, A Time Horizon Invariant (THI) Metric- Applying the THI Metric to evaluate Persistence and Nonlinear Autoregressive Forecast Models - NAR and NARX Forecasting Models, Comparison of Forecasting Models and Persistence. Comparison with a Satellite Cloud- Motion Forecast Model, Numerical Weather Prediction (NWP)

Reference Books

1. Kleissl J., "Solar Energy Forecasting and Resource Assessment", Academic Press, 1st Edition, 2013.
2. Richard Headen Inman, Jr., "Solar Forecasting Review", M.S Thesis, University of California, San Diego, 2012.
3. Sophie Pelland, George Galanis, George Kallos, "Solar and photovoltaic forecasting through post-processing of the Global Environmental Multiscale Numerical Weather Prediction Model", progressing in Photovoltaics: Research and Applications, 2011.
4. Yang Dazhi, "Solar Modeling and Forecast", Report, National University of Singapore, Singapore, 2012.
5. Md Rahat Hossain, Amanullah Maung Than Oo, Shawkat Ali, A.B.M., "Hybrid Prediction Method for Solar Power Using Different Computational Intelligence Algorithms", Smart Grid and Renewable Energy, Vol. 4, 2013, pp.76-87.

LIST OF SUBJECTS

Sub. Code	Subject Name	Credits
14EE1001	Basic Electrical Engineering	3:0:0
14EE2001	Electric Circuits and Networks	3:1:0
14EE2002	Electric Circuit Analysis	3:1:0
14EE2003	Network Analysis and Synthesis	3:1:0
14EE2004	Electromagnetic Fields	3:1:0
14EE2005	DC Machines and Transformers	3:1:0
14EE2006	DC Machines and Transformers Laboratory	0:0:2
14EE2007	Induction and Synchronous Machines	3:1:0
14EE2008	AC Machines and Controls Laboratory	0:0:2
14EE2009	Electrical Machine Design	3:1:0
14EE2010	Power Electronics	3:0:0
14EE2011	Power Electronics Laboratory	0:0:2
14EE2012	Electric Drives and Control	3:0:0
14EE2013	Transmission and Distribution	3:1:0
14EE2014	Power System Analysis	3:1:0
14EE2015	Computer Aided Power System Analysis Laboratory	0:0:2
14EE2016	Power System Protection and Switchgear	3:0:0
14EE2017	Linear, Digital IC and Measurements Laboratory	0:0:2
14EE2018	Energy Systems	3:0:0
14EE2019	Special Electrical Machines	3:0:0
14EE2020	Automotive Electronics	3:0:0
14EE2021	Illumination Engineering	3:0:0
14EE2022	Power System Stability	3:0:0
14EE2023	Power System Operation and Control	3:0:0
14EE2024	Basics of Electric and Hybrid Vehicle	3:0:0
14EE2025	Fundamentals of Electrical Safety	3:0:0
14EE2026	High Voltage Engineering	3:0:0
14EE2027	HVDC and FACTS	3:0:0
14EE2028	Building Automation	3:0:0
14EE2029	Design Laboratory	0:0:1
14EE2030	Power System Simulation Laboratory	0:0:2
14EE2031	Renewable Energy – I	3:0:0
14EE2032	Renewable Energy – II	3:0:0
14EE2033	Harmonics and Power Quality	3:0:0
14EE2034	Power System Reliability	3:0:0
14EE2035	Switched Mode Power Supplies	3:0:0
14EE2036	Smart Grid	3:0:0
14EE2037	Computer Aided Graphics for Electrical Engineers	0:0:2
14EE2038	Advanced Topics in Power Electronics	3:0:0
14EE3001	Power Semiconductor Devices	3:0:0
14EE3002	Power Converter Analysis – I	3:0:0
14EE3003	Power Converter Analysis – II	3:0:0
14EE3004	Solid State DC Drives	3:0:0
14EE3005	Solid State AC Drives	3:0:0
14EE3006	Waste To Energy Conversion	3:0:0
14EE3007	Generalized Theory of Electrical Machines	3:0:0
14EE3008	Special Machines and Controllers	3:0:0

14EE3009	Power Electronics Laboratory	0:0:1
14EE3010	Electric Drives and Control Laboratory	0:0:1
14EE3011	Photovoltaic Systems	3:0:0
14EE3012	Power Electronic Circuits	3:0:0
14EE3013	Energy Engineering	3:0:0
14EE3014	Wind Energy	3:0:0
14EE3015	Hydrogen and Fuel Cells	3:0:0
14EE3016	Energy Management and Audit	3:0:0
14EE3017	Energy Modeling, Economics and Project Management	3:0:0
14EE3018	Solar Energy Laboratory	0:0:1
14EE3019	Wind Energy Laboratory	0:0:1
14EE3020	Power Engineering Simulation Laboratory	0:0:1
14EE3021	Flexible AC Transmission Systems	3:0:0
14EE3022	HVDC Transmission	3:0:0
14EE3023	Industrial Power System Analysis and Design	3:0:0
14EE3024	Distributed Generation	3:0:0
14EE3025	Communications And Control in Smart Grid	3:0:0
14EE3026	Electrical Transients in Power Systems	3:0:0
14EE3027	EHV Power Transmission	3:0:0
14EE3028	Power System Planning And Reliability	3:0:0
14EE3029	Electric and Hybrid Vehicles	3:0:0
14EE3030	Modelling and Design of Electric and Hybrid Vehicle	3:0:0
14EE3031	Power Management For HEV	3:0:0
14EE3032	Hybrid-Electric Vehicle Powertrains	3:0:0
14EE3033	Vehicle Energy Storage Systems	3:0:0
14EE3034	Electric Vehicle Battery Technology	3:0:0
14EE3035	Modeling of Power Converters	3:0:0
14EE3036	Power Electronics in Wind and Solar Power Conversion	3:0:0
14EE3037	DSP Based Control of Power Electronics and Drives	3:0:0
14EE3038	Power Quality	3:0:0
14EE3039	Tidal Energy	3:0:0
14EE3040	Simulation of Power Electronic Systems	3:0:0
14EE3041	Power Electronics Applications to Power System	3:0:0
14EE3042	Neuro-Fuzzy Controller for Electric Drives	3:0:0
14EE3043	Advanced Control Techniques for Induction Generators	3:0:0
14EE3044	Optimal Control of Wind Energy Systems	3:0:0
14EE3045	Wind Resource Assessment and Forecasting Methods	3:0:0
14EE3046	Turbines for Renewable Energy System	3:0:0
14EE3047	Data Mining for Renewable Energy Technologies	3:0:0
14EE3048	Grid Converters for Wind Power Systems	3:0:0
14EE3049	Offshore Wind Power	3:0:0
14EE3050	Wind Power in Power Systems	3:0:0
14EE3051	Solar Cell and Module Technology	3:0:0
14EE3052	PV System Design and Installation	3:0:0
14EE3053	Materials for Solar Power	3:0:0

14EE3054	Passive Solar Architecture	3:0:0
14EE3055	Oceanic Energy	3:0:0
14EE3056	Geothermal Energy	3:0:0
14EE3057	Policy and Regulatory Aspects of Renewable Power Generation	3:0:0
14EE3058	Nuclear Engineering	3:0:0
14EE3059	Hydro Power Technology	3:0:0
14EE3060	Design and Development of Wind Turbines	3:0:0
14EE3061	Control and Drives for Solar Systems	3:0:0
14EE3062	Logic Controller for Automation	3:0:0
14EE3063	HMI Systems	3:0:0
14EE3064	PLC Applications & Industrial Communication	3:0:0
14EE3065	Industrial DC Drives	3:0:0
14EE3066	Industrial AC Drives	3:0:0
14EE3067	Data logging and Visualization	3:0:0
14EE3068	Advanced SCADA Applications	3:0:0
14EE3069	Low Voltage Switchgear	3:0:0
14EE3070	Distributed Control System	3:0:0
14EE3071	Automation Laboratory-I	0:0:2
14EE3072	Automation Laboratory-II	0:0:2
14EE3073	Modeling and Simulation of Dynamic Systems	3:0:0
14EE3074	Distribution Automation	3:0:0

14EE1001 BASIC ELECTRICAL ENGINEERING

Credits: 3:0:0

Course Objective

- To impart the basic knowledge about the Electric and Magnetic circuits.
- To understand the working of various Electrical Machines.
- To know about various measuring instruments and house wiring.

Course Outcome

- Predicting the behavior of any electrical and magnetic circuits.
- Identifying the type of electrical machine used for a particular application.
- Wiring any circuit depending upon the requirement.

Description

Electrical Quantities –Circuit Elements and sources – Ohm's Law and Kirchhoff's laws – Basics of Electric Circuits – Basics of Magnetic Circuits – Introduction to Alternating Quantities – Sources of Electrical Energy – Transmission and Distribution – Introduction to Three phase system – Working principle, operation and application of DC & AC Generator and Motor, Transformer - Classification of Instruments – Principle of Analog instrument – Moving Coil instrument – Moving Iron Instrument – Induction type Energymeter – Earthing &Wiring.

Reference Books

1. Muraleedharan K. A, Muthusubramanian R &Salivahanan S, "Basic Electrical, Electronics & Computer Engineering", Tata McGraw- Hill Limited, New Delhi, 2010.
2. Jegathesan .V, VinothKumar.K, Saravanakumar.R, "Basic Electrical & Electronics Engineering", Wiley India Private Limited, New Delhi, 2011.
3. Surajit Chattopadhyay, Samarjit Sengupta, "Basic Electrical Engineering", Narosa Publishing House Private Ltd, New Delhi, 1st Edition, 2010.
4. Mehta,V.K, Rohit Mehta, "Principles of Electrical Engineering", S. Chand Group, 1st Edition, 2007.

14EE2001 ELECTRIC CIRCUITS AND NETWORKS

Credits 3:1:0

Corequisite: 14MA2003 Mathematical Transforms
14MA2004 Laplace Transforms, Fourier series and Transforms

Course Objective

- To develop the ability to apply the basic laws and theorems to analyze a DC and AC electric circuit.
- To use mathematical methods such as Laplace transform and some linear algebra techniques and differential equations to solve circuits problems.
- To analyze three phase circuits

Course Outcome

The student will be able to

- Analyze simple circuits applying Ohm's and Kirchhoff's laws
- Analyze first-order response of RL, RC and RLC circuits.
- Design any non linear network, filters and attenuators for an application

Description

Basic Circuit Laws – Network reduction – Source transformation – Mesh and Nodal analysis - Star Delta Conversion – Network Theorems – Series and Parallel Resonance – Frequency Response – Analysis of coupled circuits – Tuned Circuits – Analysis of Three phase balanced and unbalanced circuits with star and delta connected loads – Power Measurement – Time domain and S domain analysis of networks – Poles and Zeroes of Network Function – Transient Response of RL, RC and RLC Circuits for DC input and AC with Sinusoidal Input – Z, Y, H, ABCD and image parameters of two port networks.

Reference Books

1. William H. Hayt Jr, Jack E. Kemmerly and Steven M. Durbin, "Engineering Circuits Analysis", Tata McGraw Hill Publishing Company Limited, 6th Edition, New Delhi, 2003.
2. Joseph A. Edminister, Mahmood Nahri, "Electric Circuits", Schaum's series, Tata McGraw-Hill Publishing Company Limited, New Delhi, 2001.
3. Sudhakar A., Shyam Mohan S.P., "Circuits and Network Analysis and Synthesis", Tata McGraw Hill Publishing Company Limited, New Delhi, 2007.
4. Kuo F.F., "Network Analysis and Synthesis", Wiley India Private Limited, New Delhi, 2nd Edition, 2006.
5. Chakrabati A, "Circuits Theory (Analysis and synthesis), DhanpathRai & Sons, New Delhi, 1999.

14EE2002 ELECTRIC CIRCUIT ANALYSIS

Credits 3:1:0

Corequisite: 14MA2003 Mathematical Transforms
14MA2004 Laplace Transforms, Fourier series and Transforms

Course objective

- To develop the ability to apply the basic laws and theorems to analyze a DC and AC electric circuit.
- To use mathematical methods such as Laplace transform, linear algebra techniques and differential equations to solve circuits problems.

Course outcome

The student will be able to

- Apply techniques for the analysis and simulation of linear electric circuits.
- Understand resistive and energy storage elements, controlled sources and transforms
- Analyze the transient and steady state behavior of a circuit using the S-plane representation.

Description

Circuit components: passive and active components, Ohms law - Kirchhoff's Laws - Star delta transformation - voltage and current division rule, Steady State Analysis of DC and AC Circuits - Network Topology - Formation of matrix equations and analysis of complex circuits using mesh and node analysis – Network Theorems and its applications - Phasor - sinusoidal steady state response - power and power factor – resonace..

Reference Books

1. Sudhakar, A., Shyam Mohan S.P., "Circuits and Network Analysis and Synthesis", Tata McGraw Hill Publishing Company Limited, 3rd Edition, 2007.
2. Chakrabarti. A "Circuit Theory (Analysis and Synthesis)", DhanpatRai and Company, 6th Edition, 2010.
3. William H. Hayt Jr, Jack E. Kemmerly, Steven M. Durbin, "Engineering Circuits Analysis", Tata McGraw Hill Publishing Company Limited, 6th Edition, New Delhi, 2003.
4. John Bird, 'Electrical Circuit Theory and Technology' Newnes an imprint of Elsevier, 4th Edition, 2010.
5. Joseph A. Edminister, Mahmood Nahri, "Electric Circuits", Schaum's series, Tata McGraw-Hill Publishing Company Limited, New Delhi, 2001.

14EE2003 NETWORK ANALYSIS AND SYNTHESIS

Credits 3:1:0

Pre requisite: 14MA2003 Mathematical Transforms
14MA2004 Laplace Transforms Fourier series and Transforms

Course objective

- To make the students capable of analyzing any given electrical network.
- To make the students learn how to synthesize an electrical network from a given impedance/admittance function.
- To make the students to learn the concept of filters.

Course outcome

The student will be able to

- Analyze the various electrical and electronic networks using the techniques they learn.
- Analyze three phase circuits.
- Construct a circuit to suit their application

Description

S Domain Analysis-Poles and Zeros of network functions-Time domain response from pole zero plots. Three phase balanced and unbalanced circuits – Mutual Inductance – ideal transformer. Transient Analysis of RL, RC, RLC circuits for DC and sinusoidal excitation using Laplace Transform. Two Port networks and Filters-Z,Y,h,g,T and inverse T parameters-Design of constant K,m derived and composite filters -.Network Synthesis-Hurwitz polynomials--Synthesis of RL,RC,LC and one port networks

Reference Books

1. Sudhakar A. Shyammohan, "Circuits and Networks Analysis and Synthesis" Tata McGraw Hill Publishing company limited, New Delhi, 3rd Edition, 2007.
2. Umesh Sinha, "Network Analysis and Synthesis," SathyaPrakasan Publishers Limited, New Delhi, 2012.
3. W.H Hayt, JE Kemmerly, SM Durbin, "Engineering Circuit Analysis", Tata McGraw Hill Publishing Company Limited, New Delhi, 6th Edition, 2006.
4. Allan H. Robbins, Wilheln C Miller, "Circuit Analysis, Principles of Applications", 1st Indian reprint 2008.
5. William D. Stanley, "Network Analysis with Applications", Dorling Kindersley India Private Limited, New Delhi, 4th Edition, 2nd Reprint, 2009.

14EE2004 ELECTROMAGNETIC FIELDS

Credits: 3:1:0

Corequisite: 14MA2001 Vector Calculus and Complex Analysis

Course Objective

- To understand the concept of charge, current and fields
- To calculate electromagnetic field distribution for various configurations
- To impart knowledge on electrostatic, magnetostatic, electromagnetic fields

Course Outcome

The student will be able to

- gain knowledge on vector fields
- solve the advanced EMF problems
- gain knowledge on EM waves and their propagation through various medium

Description

Vector Algebra – Coordinate Systems – Vector Calculus -Coulomb's Law, Electric Field Intensity, Electric Field due to various charge configurations-Electric Potential, Electric Flux, Electric Flux Density, Electrostatic Energy, Capacitance - Current Density, Magnetic Flux, Magnetic Flux Density, Magnetic Field Intensity, Magnetic Field due to various current loop configurations- Ampere's Law, Force and Torque – Inductance -Displacement Current, Eddy Current - Faraday's Law – Lenz's Law , Transformer and Motional emfs - Maxwell's Equations - Generation, Propagation of Waves in Dielectrics, Conductors and Transmission lines, Power and the Poynting Vector

Reference Books

1. Joseph. A.Edminister, "Theory and Problems of Electro Magnetics", Schaum's Outline Series, Tata Mc Graw- Hill Publishing Company Limited, New Delhi, 2nd Edition, 2005.
2. UdayA.Bakshi, Ajay V.Bakshi, "Electromagnetic Fields", Technical Publications, Pune, 1st Edition, 2006
3. Clayton R.Paul, Keith W.Whites, Syed A. Nasar, "Introduction to Electromagnetic Fields", Tata McGraw-Hill Publishing Company Ltd., New Delhi, 2008
4. Bhag Singh Guru, Huseyin R. Hiziroglu, "Electromagnetic Field Theory Fundamentals", Cambridge University Press, UK, 2004.
5. William H.Hayt Jr., John A.Buck, "Engineering Electro Magnetics", Tata McGraw- Hill Education India Private Limited, New Delhi, 3rd Edition, 2007.

14EE2005 DC MACHINES AND TRANSFORMERS

Credits: 3:1:0

Prerequisite: 14EE2001 Electric Circuits and Networks

Course Objective

- To introduce the concept of rotating machines and the principle of electromechanical energy conversion in single and multiple excited systems.
- To understand the generation of D.C. voltages by using different type of generators and study their performance.
- To study the working principles of D.C. motors and their load characteristics, starting and methods of speed control.

Course Outcome

The student will be able to

- gain knowledge on constructional details of different type of transformers, working principle and its performance

- estimate the various losses taking place in D.C. machines and transformers.
- analyze the different testing methods of electrical machines to arrive at its performance.

Description

Electro-mechanical energy conversion-energy and coenergy – singly and doubly excited systems - Principle of operation, Construction, No load characteristic, Load characteristics of various types of DC Generators - Principle of operation, Electrical and Mechanical characteristics, Speed control, Losses, efficiency and predetermination of efficiency of DC Motor - Principle of operation, EMF equation, Phasor diagrams -Equivalent circuit - Voltage regulation, Regulation curve, Losses, Efficiency of a transformer - Tests on transformer-Auto transformer – Principle of operation –comparison with two winding transformer.

Reference Books

1. Kothari D.P., Nagrath I.J., "Electric Machines", Tata McGraw- Hill Education India Private Limited, New Delhi, 4th Edition, 2010.
2. Arthur Eugene Fitzgerald, Charles Kingsley Jr, Stephen D. Umans , " Electric Machinery", Mc Graw – Hill Professional Series , New York, 6th Edition, 2002.
3. Murugesh Kumar, K., "DC Machines and Transformers", Vikas Publishing House Private Limited., New Delhi, 2nd Edition, 2004.
4. Cotton, H., "Advanced Electrical Technology", A.H Wheeler and Company Publications, London, 1990.
5. Rajput R.K., "Direct Current Machines", Lakshmi Publications, New Delhi, 4th Edition, 2007.

14EE2006 DC MACHINES AND TRANSFORMERS LABORATORY

Credits 0:0:2

Corequisite: 14EE2005 DC Machines and Transformers

Course Objective

- Examine the relationship between the electrical and mechanical parameters of a DC electric machine and Transformer.
- Able to determine/predetermine the performance of the selected machine.

Course Outcome

- Based on the load demand, the student will be able to select suitable machine for an application.

Description

The laboratory will demonstrate the student to

- Explore all the possible configurations of a DC machine and Transformers.
- The performance and control characteristics of these configurations and Transformers.
- The method of testing to derive the equivalent circuit of a given design.

Experiments:

The faculty conducting the laboratory will prepare a list of 12 experiments and get the approval of HOD/Director and notify it at the beginning of each semester.

14EE2007 INDUCTION AND SYNCHRONOUS MACHINES

Credit: 3:1:0

Prerequisite: 14EE2005 DC Machines and Transformers

Course Objective

- To learn the concepts of Synchronous and Asynchronous Machines.
- To understand the effect of performance indicators of the machines.
- To understand the operation of machine on standalone/Infinite bus bar.

Course Outcome

The student will be able to

- Have knowledge of selecting the suitable motor for an application.
- Identify the various operating condition of selected machine.
- Interpret the condition of machine under standalone/Infinite bus bar operations.

Description

Alternating Current Machine Windings, Construction of A.C Machines, Three Phase Induction Motor, Equivalent Circuit, Performance characteristics, Speed Control and Starting methods, Single Phase Induction Motor and Linear Induction Motor, Stepper Motor - Alternator - Principle of operation, Voltage regulation, Power expression, Parallel operation of Alternator, Operation of alternator on Infinite Bus bar, Two Reaction Theory - Synchronous Motor – Principle of Operation, Starting methods, Effect of field excitation- Hunting.

Reference Books

1. Murugesh Kumar, K, "Induction and Synchronous Machines", Vikas Publishing House Limited, New Delhi, 4th Reprint, 2009.
2. Arthur Eugene Fitzgerald, Charles Kingsley, Stephen D. Umans, "Electric Machinery", McGraw Hill Professional Series, New York, 6th Edition, 2002.
3. Alexander, S. Langsdorf, "Theory of Alternating Current Machinery", Tata McGraw Hill Education India Private Limited, New Delhi, 2nd Edition, 2009.
4. Kothari D.P., Nagrath I.J., "Electrical Machines", Tata McGraw Hill Education India Private Limited, New Delhi, 3rd Edition, 2004.
5. Gupta, B.R., Vandana, Singhal, "Fundamentals of Electric Machines", New Age International Publishers Limited, New Delhi, 2nd Edition, 2002.

14EE2008 AC MACHINES AND CONTROLS LABORATORY

Credits 0:0:2

Corequisite: 14EE2007 Induction and Synchronous Machines

Course Objective

- Able to understand the characteristics of the AC Machine.
- Study the transfer function of a electromechanical system.

Course Outcome

The student will be able to

- Select suitable AC machine for application.
- Determine/predetermine the performance of the selected machine.
- Determine the transfer function of any system.

Description

The laboratory will demonstrate the student about the operation and performance analysis of a AC Machines and derive the transfer function for an electromechanical system.

Experiments:

The faculty conducting the laboratory will prepare a list of 12 experiments and get the approval of HOD/Director and notify it at the beginning of each semester.

14EE2009 ELECTRICAL MACHINE DESIGN

Prerequisites: 14EE2005 DC Machines and Transformers
14EE2007 Induction and Synchronous Machines

Credits 3:1:0

Course Objective

- To impart knowledge on the design aspects of Electrical Machines.
- Good understanding on the design and application of DC and AC machine.
- Knowledge of basic design concepts and cooling arrangement of transformer.

Course Outcome

The student will be able to

- demonstrate the magnetic circuit and electric circuit's aspects of any machine.
- design the DC and AC machine for any specification given.
- design the transformer and its cooling tubes for the speciation given.

Description

Major Consideration – Main Dimensions – Choice of Specific Electric and Magnetic Loading – Output Equation – Selection of number of Poles – Design of Armature, Field Winding, Field Pole, Commutator and Brushes of DC Machines – Design of Yoke, Core and Winding for Core and Shell type Transformer – Design of Tank and Cooling tube of Transformers – Main dimensions of Induction Motors - Design of Length of Air gap – Design of Squirrel cage and Wound Rotor – Design of Salient Pole Machines – Armature and Rotor Design – Estimation of Air gap length – Design of Damper winding – Design of Turbo Alternators – Design of Field Winding and Rotor.

Reference Books

1. Sawhney, A.K., "A Course in Electrical Machine Design", DhanpatRai& Sons, New Delhi, 2011.
2. Sen, S.K., "Principles of Electrical Machine Designs with Computer Programs", Oxford and IBH Publishing Company Private Ltd., New Delhi, Second Edition, 2009.
3. A.Shanmugasundaram, G.Gangadharan, R.Palani "Electrical Machine Design Data Book", New Age International Pvt. Ltd., New Delhi, Reprint 2007.
4. Deshpande M.V., "Design and Testing of Electrical Machines", Prentice Hall India, New Delhi, 3rd Edition, 2009.
5. Balbir Singh, "Electrical Machine Design", Vikas Publishing House Private Limited, New Delhi, 1981.

14EE2010 POWER ELECTRONICS

Credits: 3:0:0

Course Objective

- Study the Static and Dynamic characteristics of Power Semiconductor Devices.
- Understand the operation of power electronic converters and its control strategies of various power converters.
- Study the design parameters for control circuitry requirement of various converters.

Course Outcome

The student will be able to

- know the usage of electronics and solid-state power devices for the control, conversion, and protection of electrical energy.
- Design power electronics circuits based on criteria (power, efficiency, ripple voltage and current, harmonic distortions, power factor).
- Select components; interpret terminal characteristics of the components for designing the circuitry for power converters.

Description

Power Diodes – Power Transistors – Power MOSFET – IGBT - SCR – TRIACS - GTOs - IGCT - MCT – AC to DC Converter – Single and Three phase-uncontrolled and controlled – Full wave and Half wave - Dual converters - AC Voltage controller – Cycloconverter – Chopper - Inverter Circuits – series inverter - Control circuits – requirements, control signal generation methods– PWM techniques for DC to AC converters –Control using Microprocessors, Microcontrollers and DSP – Applications: Motor drive applications: DC Motor Drives– AC voltage controller and inverter fed induction motor drives – UPS –HVDC systems – Tap changing of Transformers.

Reference Books

1. Rashid, M.H., "Power Electronics – Circuits, Devices and Applications", Pearson Education India Series Private Limited, New Delhi, 3rd Edition, 2003.
2. Mohan, Ned. et.al, "Power Electronics Converters, Applications and Design", Wiley India Private Limited, New Delhi, 3rd Edition 2007.
3. Philip T. Krein, "Elements of Power Electronics", Oxford University Press Incorporation, New York, 2008.
4. Joseph Vithayathil, "Power Electronics: Principles and Applications", McGraw Hill Education India, New Delhi, 2010.
5. JayantBaliga B., "Fundamentals of Power Semiconductor Devices", Springer-Verlag Publication, New Delhi, 1st Edition, 2008.

14EE2011 POWER ELECTRONICS LABORATORY

Credits 0:0:2

Corequisite: 14EE2010 Power Electronics

Course Objective

- Will enable the students to understand the characteristics of Power Electronic Devices and circuits.

Course Outcome

The student will be able to

- Test and verify the design of Power Converters.
- Use the Data Sheets for the selection of power rating of the device.
- Design suitable power, control and isolation circuits for an application.

Description

This laboratory demonstrates the student to analyze the important operating characteristics of power electronic circuits and power semiconductor devices. Emphasis is on devices, circuits, gating methods and power quality.

Experiments:

The faculty conducting the laboratory will prepare a list of 12 experiments and get the approval of HOD/Director and notify it at the beginning of each semester.

14EE2012 ELECTRIC DRIVES AND CONTROL

Prerequisite: 14EE2010Power Electronics
14EE2005 DC Machines and Transformers
14EE2007 Induction and Synchronous Machines

Credits: 3:0:0

Course Objective

- Understand the classification and characteristics of Drives.
- Analyze the various types and operations of DC & AC Drives.
- Analyze the operation of Special Machine Drives.

Course Outcome

The students will be able to

- Explain the dynamics of Electrical drive systems.

- Select suitable motor depending upon the loading.
- Select suitable converters and their controls for drive applications.

Description

Electric Drives and its types - Choice of Electric drive - Fundamental torque equation - Speed & Torque Characteristics - Modes of operation, Closed loop control of drives - PLL control - Thermal model - Motor rating – DC motors and its performance – Control Strategies - Single and three phase converter fed DC drives and Chopper fed drives - IM and its performance - Control strategies, VSI and CSI control – Rotor resistance control – Slip power recovery - Synchronous motor and their performance – Control Strategies – PMAC and BLDC motor Drives – Stepper motor.

Reference Books

1. Dubey, G.K., “Fundamentals of Electrical Drives”, Narosa Publishing House, 2nd Edition, New Delhi, 2010.
2. Bose, B.K., “Modern Power Electronics and AC Drives", Prentice Hall of India, Private Limited, 1st Edition, New Delhi, 2009.
3. Ion Boldea, Nasar S. A., “Electric Drives”, C.R.C Press, New York, 2nd Edition, 2005.
4. VedamSubramanyam, “Electric Drives: Concepts and Applications”, Tata McGraw- Hill Education India Private Limited, New Delhi, 2nd Edition, 2010.
5. Mohamed A. El-sharkawi, Mohamed A. El, “Fundamentals of Electric Drives”, Cengage Engineering Publisher, Washington DC, 1st Edition, 2009.

14EE2013 TRANSMISSION AND DISTRIBUTION

Credits 3:1:0

Course Objective

- Learn the usage of passive elements in various Power Transmission Systems.
- Understand the factors affecting Insulators.
- Understand the Distribution System.

Course Outcome

The student will be able to

- Analyze the performance of various units involved in the power plants.
- Design a power system solution based on the problem requirements and realistic Constraints.
- Develop a major design experience in distribution system that prepares them for engineering practice.

Description

Basic structure of power system; demand of electrical system – base load, peak load; controlling power balance between generator and load, advantages of interconnected system - Evaluation of Transmission line parameters- types of conductors, representation of transmission line, inductance calculation of single/three phase lines, concept of GMD and GMR, transposition of lines, bundled conductors, skin effect, proximity effect, capacitance calculation of single/three phase lines, Analysis of transmission lines – representation, short/medium/long transmission lines, nominal T/π network, ABCD parameters, surge impedance, Ferranti effect - Insulators for overhead transmission lines - Insulated cables – capacitance of single/three core cable, dielectric loss; Sag - D.C and A.C. distribution, radial and ring main distribution, medium voltage distribution network, low voltage distribution network, single line diagram, substation layout, substation equipments.

References Books

1. Mehta, V.K., Rohit Mehta, “Principles of Power Systems”, S.Chand& Company Private Limited, New Delhi, 14th Edition, 2005.
2. Singh S.N, “Electric Power Generation, Transmission and Distribution”, PHI Learning Private Limited, New Delhi, 2nd Edition, 2009.
3. Soni, M.L., Gupta, P.V., Bhatnagar U.S. Chakrabarthi A., “A Text Book on Power System Engineering”, DhanpatRai& Sons Company Private Limited, New Delhi, 2008.
4. Uppal, S.L., “Electrical Power”, Khanna Publishers Limited, New Delhi, 13th Edition, 2002.

5. Wadhwa, C.L., "Electrical Power Systems", New Age International Publishers Ltd., New Delhi, 6th Edition, 2010.
6. Weedy B.M., Cory B.J., "Electric Power Systems", John Wiley & Sons Limited, England, 4th Edition, 2009.

14EE2014 POWER SYSTEM ANALYSIS

Prerequisites: 14EE2007 Induction and Synchronous Machines
14EE2013 Transmission and Distribution

Credits 3:1:0

Course Objective

- To know the concept of power system.
- To understand the concept of per unit system and single line diagram.
- Develop understanding of the basic concepts of load flow, fault analysis, and transient stability.
- Apply this knowledge to model and predict power system behavior.

Course Outcome

The student will be able to

- Demonstrate the ability to model power systems.
- Analyze the impact of short-circuit faults on the power network and make design changes to the network to control the fault currents.
- Understand the dynamic behaviour of power systems and generators.

Description

Need for system analysis, overall modeling of Power system-one line diagram-per unit representation. Formation of bus impedance matrix-symmetrical and unsymmetrical fault analysis-Formulation of load flow problem-solution by Gauss seidal, Newton Raphson and FDLF method-Steady state and Transient stability - Swing equation and its solution by Modified Euler and Runge- Kutta methods- Equal area criterion-Definitions and standards of power qualities.

Reference Books

1. HadiSaadat, "Power System Analysis", Tata McGraw-Hill Education India Private Limited, New Delhi, 11th Reprint 2007.
2. D. P. Kothari, I. J. Nagrath, " Modern Power System Analysis", Tata McGraw-Hill Education India Private Limited, New Delhi, 2008
3. Gupta, B.R., "Power System Analysis and Design", S.Chand & Company Limited, New Delhi, 2005.
4. Weedy B.M., Cory B.J., "Electric Power Systems", John Wiley & Sons Limited, England, 4th Edition, November 2001.
5. Wadhwa C. L., "Electrical Power Systems", New Age International Private Limited, New Delhi, 6th Edition, 2010.

14EE2015 COMPUTER AIDED POWER SYSTEMS ANALYSIS LABORATORY

Corequisite: 14EE2014 Power System Analysis

Credits 0:0:2

Course Objective

- To enable the students to understand the load flow in a power system.
- To enable the students to do the computation of bus impedance/admittance.
- To enable the students to understand the fault analysis in a power system.

Course Outcome

The student will be able to

- Understand the analysis techniques of a power system.

Description

This laboratory demonstrates the students the usage of simulation software tool for design and control of a Power System.

Experiments:

The faculty conducting the laboratory will prepare a list of 12 experiments and get the approval of HOD/Director and notify it at the beginning of each semester.

14EE2016 POWER SYSTEM PROTECTION AND SWITCHGEARS

Credits 3:0:0

Prerequisite: 14EE2014 Power System Analysis

Course Objective

- To discuss the causes of abnormal operating conditions (faults, lightning and switching surges) of the apparatus and system.
- To understand the characteristics and functions of relays and protection schemes.
- To understand the problems associated with circuit interruption by a circuit breaker.

Course Outcome

The student will be able to

- Choose the appropriate relay for the application.
- Design Protective schemes for various Electrical apparatus.
- Analyze the testing of circuit breakers.

Description

Principles and need for protective schemes –types of fault –types of relays – Torque equation –Testing of relays – Introduction to static relays - Microprocessor and computer based protective relaying. Alternator, transformer, Busbar and motor protection using relays – Feeder Protection - Elementary principles of arc extinction -Types of Circuit Breakers, Rating - Testing of circuit breakers, Switching surges - Lightning phenomenon, Types of lightening arresters and surge absorber - Solid resistance and reactance Earthing - Arc suppression coil - Earthing transformers –Earth wires - Earthing of appliances- Insulation co-ordination.

Reference Books

1. Bhuvanesh A Oza, Nirmal Kumar C Nair, Rashesh P Mehta and Vijay H Makwana., “Power System Protection and Switchgear”, Tata McGraw- Hill Education India Private Limited, New Delhi. 2010.
2. Badri Ram, Vishwakarma D N., “Power System Protection and Switchgear”, Tata McGraw- Hill Education India Private Limited, New Delhi, 22nd Reprint, 2007.
3. Paithankar Y. G., Bhide S. R., “Fundamentals of Power System Protection”, Prentice Hall of India Limited, New Delhi, 2003.
4. Soni, M.L., Gupta, P.V., Bhatnagar, U.S. and Chakrabarti, A., “A Text Book on Power Systems Engineering”, DhanpatRai& Sons Company Limited, New Delhi, 2003.
5. Sunil, S.Rao, “Switchgear Protection and Power Systems”, Khanna Publishers Limited, New Delhi, 12th Edition, 2008.

14EE2017 LINEAR, DIGITAL IC AND MEASUREMENTS LABORATORY

Credits 0:0:2

Corequisite: 14EC2008 Linear Integrated Circuits

Course Objective

- Analyze and design various applications using Op-amp.
- Design and construct waveform generation circuits.
- Design timer, analog and digital circuits using op-amps.
- Design combinational logic circuits using digital ICs.
- Study of measurement techniques and transducers.

Course Outcome

The student will be able to

- Design any circuit for an application with Linear and Digital ICs.
- Use suitable measurement technique for an application.

Description

This laboratory demonstrates the students the usage of Linear, Digital ICs and measurement of any parameters using suitable instruments.

Experiments:

The faculty conducting the laboratory will prepare a list of 12 experiments and get the approval of HOD/Director and notify it at the beginning of each semester.

14EE2018 ENERGY SYSTEMS

Credits 3:0:0

Course Objective

To impart knowledge on

- Generation of electrical power by conventional and non–conventional methods.
- Electrical energy conservation, energy auditing and power quality.
- Principle and design of illumination systems and methods of heating and welding.
- Electric traction systems and their performance.

Course Outcome

The student will be able to

- understand energy economics and perform basic energy audit.
- Utilize the electrical energy efficiently.

Description

Review of power generation – Effect of distributed generation on power system operation – Economic aspects of power generation – load and load duration curves - Economics of power factor improvement – power capacitors – power quality - Importance of electrical energy conservation – methods – energy efficient equipments – Introduction to energy auditing – Importance of lighting – properties of good lighting scheme – laws of illumination – photometry - lighting calculations – basic design of illumination – lighting schemes – energy efficiency lamps. Role of electric heating for industrial applications – Brief introduction to electric welding – welding generator, welding transformer and the characteristics – Requirement of Electric traction – supply systems – mechanics of train movement – traction motors and control – braking – recent trends in electric traction.

Reference Books

1. Khan B.H., “Non-Conventional Energy Resources”, Tata Mc-Graw Hill Publishing Company Ltd, New Delhi 2006.
2. Open Shaw Taylor E., “Utilization of Electric Energy in SI Units.”, Orient Longman Ltd, New Delhi, 11th Reprint, 2007.

3. Gupta J.B., “Utilization of Electric Power and Electric Traction”, S.K.Kataria and Sons, 2002.
4. Partab H., “Art and Science of Utilization of Electrical Energy”, DhanpatRai and Company, New Delhi, 2004.
5. G.D. Rai, “Non Conventional Energy Sources”, Khanna Publishers, New Delhi 2001.

14EE2019 SPECIAL ELECTRICAL MACHINES

Credits 3:0:0

Prerequisite: 14EE2005 DC Machines and Transformers
14EE2007 Induction and Synchronous Machines

Course Objective

- To impart knowledge on Construction, principle of operation and performance of synchronous reluctance motors.
- To impart knowledge on Construction, principle of operation and performance of Stepping Motors.
- To impart knowledge on Construction, principle of operation, control and performance of permanent magnet brushless D.C. motors.

Course Outcome

The student will be able to

- Select an energy efficient linear or rotary motor based on the characteristics of the load & application.
- Incorporate the correct control technique to the machine for efficient operation.
- Improve the performance of the motor by enhancing the motor suitably.

Description

Constructional features – Types – Axial and Radial flux motors – Operating principles – Variable Reluctance and Hybrid Motors – SYNREL Motors – Voltage and Torque Equations - Phasor diagram – Characteristics - Constructional features of stepper motor – Principle of operation – Variable reluctance motor – Hybrid motor – Single and multi-stack configurations – Torque equations – Modes of excitations – Characteristics – Drive circuits – Microprocessor control of stepping motors – Closed loop control – Switched Reluctance Motor (SRM) – Converter Circuits – control techniques - Principle of operation of Permanent Magnet Brushless DC Motor – Types –EMF and torque equations –Commutation - Power controllers – Motor characteristics and control - Linear Induction Motor (LIM) Classification – Construction – Principle of operation – Concept of Current sheet – Goodness factor – DC Linear Motor (DCLM) types –Circuit equation – DCLM control applications.

Reference Books

1. Venkataratnam K., “Special Electric Machines”, Taylor and Francis, London, 2008.
2. Miller, T.J.E. “Brushless Permanent Magnet and Reluctance Motor Drives”, Clarendon Press, Oxford, 1989.
3. Kenjo, T, “Stepping Motors and their Microprocessor control”, Clarendon Press, Oxford, 1989.
4. Kenjo, T, Naganori, S, “Permanent Magnet and Brushless DC motors”, Clarendon Press,Oxford, 1989.
5. Simmi P. Burman, ‘Special Electrical Machines’, S.K.Kataria& Sons, New Delhi, 2nd Edition, 2013.

14EE2020 AUTOMOTIVE ELECTRONICS

Credits 3:0:0

Course Objective

- Study the concepts of sensors, actuators, drives.
- Study Electronics Fuel Injection System and Lighting system and accessories.
- Study the digital control of starting and braking methods in the automobile system.

Course Outcome

The student will be able to

- Understand the significance of automation in automobile.
- Understand the Digital engine control system.
- Understand the significance of automotive electronics in leveraging the passenger safety.

Description

Basic sensor arrangement – Various sensors in vehicle, Actuators for Vehicle, Control Models, Engine Cranking System, Ignition system - Block diagram of starting system - Condition at Starting, Construction and working of starter motor - Advance driver navigation and information system, Collision Avoidance Radar Warning Systems-ABS - Electronic Steering Control and Electronic Suspension - Low Tire Pressure Warning Systems - Insulated & earth return systems - Head light & Side light, Trafficator, Electrical Fuel Pump, Horn, Wiper system - CAN, FLEXRAY, LIN, MOST.

Reference Books

1. William B.Ribbens, "Understanding Automotive Electronics", Butterworth, Heinemann Woburn, New York, 6th Edition, 2003.
2. James D. Halderman and Chase D. Mitchell, "Diagnosis and Troubleshooting of Automotive Electric, Electronic, and Computer Systems", Prentice Hall, New Jersey, 4th Edition, 2006.
3. James D. Halderman and Chase D. Mitchell, "Automotive Electricity and Electronics", Prentice Hall of India, New Delhi, 2004.
4. P L Kohli, "Automotive Electrical Equipment", Tata McGraw- Hill Education India Private Limited, New Delhi, 2008.
5. Joseph Heitner, "Automotive Mechanics", Affiliated East – West Private Limited, 2nd Edition, 2012.

14EE2021 ILLUMINATION ENGINEERING

Credits: 3:0:0

Course Objective

- To design a lighting system including cost estimate and energy efficiency in residential, commercial and industrial establishments.
- To be familiar with the current guidelines in the design, construction, and management of safe and energy-efficient road lighting systems through actual completed projects.
- To understand the concept of lighting system maintenance, basic lighting energy audit and economic analysis of lighting.

Course Outcome

The student will be able to

- Perform indoor & outdoor lighting design calculations.
- Determine appropriate lighting control techniques and equipment to a sample project.
- Perform basic lighting energy audit to a sample project.

Description

Eye & vision – Light & Lighting – Light & Vision –, Light & Color – Basic Concepts and Units – Photometry – Measurement and Quality of Lighting – Daylight – use of light tubes - Incandescent – Electric Discharge – Fluorescent – Arc lamps – Lasers – Neon signs – LED-LCD displays – Luminaries – Wiring-Calculation and Measurement-Polar curves– Lighting calculations– Illumination from point, line and surface sources – Photometry and Spectrometry-photometry – photocells - Lighting design procedure for Industrial – Residential – Office – Departmental stores – Indoor stadium – Theatres – Hospitals. Environment and glare – Lighting Design procedure for Flood – Street – Aviation and Transport lighting – Lighting for Displays and Signaling. Energy and cost consideration.

Reference Books

1. Leon Gaster, John Stewart Dow, "Modern Illuminants And Illuminating Engineering", Nabu Press, Washington DC, 1st Edition, 2010.

2. Jack L. Lindsey, “Applied Illumination Engineering”, Prentice Hall of India, 3rd Sub Edition, New Delhi, 2008.
3. Cady, “Illuminating Engineering”, General Books, USA, 2010.
4. Kamlesh Roy, “Illuminating Engineering”, Laxmi Publications, 2nd Edition, 2006
5. William Edward Barrows, “Electrical Illuminating Engineering”, Bibliolife Publishers, USA,2010.
6. IES Lighting Handbook, 10th Edition, 2011

14EE2022 POWER SYSTEM STABILITY

Credits 3:0:0

Prerequisite: 14EE2014 Power System Analysis

Course Objective

- Impart knowledge about the concept of stability in a Power System.
- Make the students understand the importance of stability under different conditions like transient and steady state in the power system.
- Learn the methods of improving the stability & use of computations for the analysis of this stability.

Course Outcome

The student will be able to

- Realize the disturbances in the power system under various operating conditions.
- Have knowledge about maintaining and improving the stability of a system.
- Get knowledge on methods to analyze transient and steady state stability of a power system.

Description

Concept of Power system stability - Importance of Stability studies - Steady state and Transient state-Modeling of Synchronous machines for stability studies-two machine system and Clarke diagram –factors influencing stability limit-Single and two machine systems – Swing equation – Solution of swing equation by Modified Euler and Runge-kutta method – Equal area criterion and its application – stability of multi-machine system-Factor affecting transient stability – Methods of improving stability-power system stabilizer and its design-Application of computers for stability studies – Voltage Stability.

Reference Books

1. Kundur P., “Power System Stability and Control”, EPRI Power System Engineering Series, McGraw-Hill Education Series, New York, 1st Edition, 2006.
2. Padiyar K.R., “Power System Dynamics, Stability and Control”, BS Publications, Hyderabad, 2nd Edition, 2008.
3. Peter W., Saucer, Pai M.A., “Power System Dynamics and Stability, Pearson Education (Singapore), 9th Edition, 2007.
4. Kothari D.P., “Modern Power System Analysis”, Tata McGraw-Hill Education India Private Limited, New Delhi, 3rd Edition, 2004.
5. Elgerd O.I., “Electric Energy System Theory: An Introduction”, Tata McGraw-Hill Education India Private Limited, New Delhi, 23rd Reprint, 2004.
6. Arrillaga J, Watson N.R., “Computer Modeling of Electrical Power Systems”, John Wiley & Sons Limited, New Jersey, 2003.

14EE2023 POWER SYSTEM OPERATION AND CONTROL

Credits 3:0:0

Prerequisite: 14EE2014 Power System Analysis

Course Objective

- Understand & model power-frequency dynamics and to design power-frequency Controller.
- Understand & model reactive power-voltage interaction.

- Understand different methods of control for maintaining voltage profile against varying System load.

Course Outcome

The student will be able to

- Realize the importance of maintaining the frequency and voltage within the safe range.
- Have knowledge about modeling of systems under varying conditions
- Get knowledge on SCADA system, its function and state estimation concepts

Description

Need for voltage and frequency regulation in power system - System load characteristics - Basic P-F and Q-V control loops - Load frequency control of single area system-static and dynamic response - Typical excitation system – Modeling of AVR–Static and Dynamic analysis – Real power and Reactive Power improvement methods. Static state estimation of power systems- treatment of bad data-network Observability and pseudo measurements - Energy control center functions – System hardware configuration SCADA system – Security monitoring and control – System states and their transition - Various controls for secure operation – Tariff – Unit Commitment - Economic Dispatch.

Reference Books

1. Olle I. Elgerd, "Electric Energy System Theory - An Introduction", Tata Mc Graw-Hill Education India Private Limited, New Delhi, 2nd Edition, 2012.
2. Kundur P., "Power System Stability and Control", EPRI Power System Engineering Series, Mc Graw- Hill Education India Private Limited, New York, 1st Edition, 2006.
3. Allen J.Wood, Bruce F.Woolenbarg, "Power Generation, Operation and Control", John Wiley & Sons Inc., New Jersey, 3rd Edition, 2013.
4. Jizhong Zhu, "Optimization of Power System Operation" John Wiley & Sons Inc., New Jersey, 2009.
5. Kothari. D.P., Nagrath. I.J., "Modern Power system analysis" Tata Mc Graw-Hill Education India Private Limited, New Delhi, 4th Edition, 2011

14EE2024 BASICS OF ELECTRIC AND HYBRID VEHICLE

Credits: 3:0:0

Course Objective

- To understand the concepts of electric and hybrid vehicle
- To know the necessity of alternative and novel energy sources.
- To study the various machines and controller used in electric and hybrid vehicle.

Course Outcome

The student will be able to

- •Develop a hybrid vehicle with existing renewable system.
- •Design a new controller for hybrid electric vehicle.
- •Apply control techniques to store the energy.

Description

Introduction to Hybrid Electric Vehicles: History of hybrid and electric vehicles,Basics of Conventional Vehicles (performance, power source, transmission characteristics) - Hybrid Electric Drive-trains - various hybrid drive-train topologies - power flow control in hybrid drive-train topologies, fuel efficiency analysis - Electric Drive-trains: Basic concept of electric traction, various electric drive-train topologies, power flow control in electric drive-train topologies - Electric Propulsion unit - Configuration and control of DC Motor and Induction Motor Drives – Configuration and control of Permanent Magnet Motor and SRM drives, Energy Storage: Battery, Fuel Cell, Super Capacitor, Flywheel, Hybridization of different energy storage devices - Sizing the drive system - Energy Management Strategies.

Reference Books

1. Iqbal Husain, "Electric and Hybrid Vehicles Design Fundamentals", CRC Press, New York, USA. 2010.

2. MehrdadEhsani ,Yimin Gao, Sebastien E. Gay, Ali Emadi, “Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals, Theory, and Design”, CRC press, New York, USA, 2008
3. Seth Leitman, Bob Brant, “Build Your Own Electric Vehicle”, Professional Edition: McGraw-Hill, New York, 2008.
4. James Larminie, John Lowry, “Electric Vehicle Technology Explained”, Wiley publications, India, 2007.
5. Austin Hughes, “Electric Motors and Drives: Fundamentals, Types and Applications”, McGraw-Hill, New York, USA, , 2006.
6. Carl Vogel, “Build Your Own Electric Motorcycle”, McGraw-Hill, New York, USA, 2009.
7. David Linden, Thomas B. Reddy, “Handbook of Batteries”, McGraw-Hill, New York, USA, 2008

14EE2025 FUNDAMENTALS OF ELECTRICAL SAFETY

Credits: 3:0:0

Course Objective

- Understand the various reasons for electrical accidents
- Exhibit knowledge of safety rules and regulations, and demonstrate awareness of hazards in the workplace.
- Explain the use of personal protective equipment.

Course Outcome

The student will be able to

- Demonstrate proper safety procedures.
- Demonstrate proper use of hand and power tools.
- Create awareness on electrical safety to others.

Description

Energy radiation and electromagnetic interference – Working principles of electrical equipment-Indian electricity act and rules-statutory requirements from electrical inspectorate-international standards on electrical safety – first aid-cardio pulmonary resuscitation (CPR) - Energy leakage-clearances and insulation-voltage classification-heating effects - electrical causes of fire and explosion-ionization-spark and arc-ignition energy-control-Lightning hazards – Fuse – circuit breakers and overload relays – protection against over voltage and under voltage – safe limits of amperage – voltage –safe distance from lines-capacity - Earth fault protection-earthing standards - FRLS insulation-grounding-equipment grounding earth - leakage circuit breaker (ELCB) - Classification of hazardous zones-intrinsically safe and explosion proof electrical apparatus-increase safe equipment-their selection for different zones-temperature classification-grouping of gases-use of barriers and isolators-equipment certifying agencies.

Reference Books

1. Massimo A. G. Mitolo, “Electrical Safety of Low-Voltage Systems”, McGraw-Hill, USA, 2008.
2. John Cadick, Mary Capelli-Schellpfeffer, Dennis K. Neitzel, ‘Electrical Safety Hand book, McGraw-Hill, New York, USA, 2005.
3. Indian Electricity Act and Rules, Government of India.
4. Power Engineers – Hand book of TNEB, Chennai, 1989.
5. Fordham Cooper, W., “Electrical Safety Engineering” Butterworth and Company, London, 1986.
6. Wayne C. Turner, Steve Doty, “Energy Management hand book”, The Fair Mont press, Georgia, 2006.
7. Albert Thumann, William J.Younger, TerryNiehus, “Handbook of Energy Audits”, CRC Press Newyork, 2009.
8. Palmer Hickman, “Electrical Safety-Related Work Practices”, Jones & Bartlett Publishers, London, 2009.

14EE2026 HIGH VOLTAGE ENGINEERING

Credits: 3: 0:0

Course Objectives

- To understand the various types of over voltages in power system and protection methods.
- To impart knowledge of Breakdown mechanism in solid, liquid and gaseous dielectrics.

- To study the Generation and Measurement techniques of High voltages and Current.

Course Outcomes

The student will be able to

- Understand the causes of over voltages and Insulation Coordination.
- Understand generation and measurement of High Voltages and Currents.
- Testing of Electrical Power Apparatus

Description

Introduction - Transients in Simple Circuits - Insulation Co-ordination and Overvoltage Protection - Ground Wires - Surge Protection of Rotating Machine - Mechanism of Breakdown in various medium – Half Wave Rectifier Circuit - Cockroft-Walton Voltage Multiplier Circuit - Electrostatic Generator -Generation of High A.C. Voltages - Impulse Generator Circuits - Sphere Gap - Uniform Field Spark Gap - Rod Gap - Electrostatic Voltmeter - Generating Voltmeter - The Chubb-Fortescue Method - Impulse Voltage Measurements Using Voltage Dividers - Measurement of High D.C. and Impulse Currents - Testing of Overhead Line Insulators - Testing of Cables - Testing of Bushings - Testing of Power Capacitors - Testing of Power Transformers - Testing of Circuit Breakers - Test Voltage

Reference Book

1. Wadhwa C.L., High Voltage Engineering, New Age International Private Limited, 2nd Edition, New Delhi, 2007
2. Naidu M.S., Kamaraju V., “High Voltage Engineering”, Tata McGraw Hill, 3rd Edition, 2004.
3. Kuffel E., Zaengl W.S., “High Voltage Engineering Fundamentals”, Pergamon press, Oxford, London, 2nd Edition, 2000.
4. Hugh M Ryan, “High Voltage Engineering and Testing”, The Institution of Electrical Engineers, London, United Kingdom, 2nd Edition, 2001
5. Subir Ray, “An Introduction to High Voltage Engineering”, PHI Learning Private Ltd, Delhi. 2nd Edition, 2013.

14EE2027 HVDC AND FACTS

Credits: 3:0:0

Course Objective

- To study the various types of Modern transmission systems
- To impart knowledge on HVDC and FACTS
- To study the effect of FACTS controllers on AC transmission system

Course Outcome

The student will be able to

- Understand the various components of HVDC and FACTS.
- Analyze the different control schemes of HVDC and FACTS systems.
- Derive the optimal operating condition for HVDC and FACTS systems.

Description

Types of HVDC Systems, Scheme of HVDC Transmission , Comparison of HVAC and HVDC Transmission , Principles of Control, Rectifier Control , Power Reversal in a DC Link, VDCOL Characteristics , System Control Hierarchy – Inverter Control , Pulse Phase Control – Starting and Stopping of a DC Link, VSC HVDC Transmission System. Flexible AC Transmission System:FACTS Controllers; Description, VSC based Controllers, , Applications of FACTS Controllers in Transmission System, Applications of FACTS Controllers in Distribution System, Static VAR Compensator(SVC); TCSC, Static Synchronous Compensator (STATCOM), Unified Power Flow Controller (UPFC) – Introduction to latest FACTS controllers.

Reference Books

1. Padiyar K.R., “HVDC Power Transmission System”, New Age International Publishers, 2nd Edition, 2010.
2. Padiyar K.R., “FACTS Controllers in Power Transmission and Distribution”, New Age International Publishers, 2007

3. Kamakshaiah S., Kamaraju V., "HVDC Transmission" Tata McGraw Hill Education Private Ltd., New Delhi, 4th reprint 2013.
4. Narain G. Hingorani, "Understanding FACTS -Concepts and Technology of Flexible AC Transmission Systems", Standard Publishers Distributors, Delhi, 2001.
5. Mohan Mathur.R., Rajiv. K.Varma, "Thyristor – Based Facts Controllers for Electrical Transmission Systems", IEEE press and John Wiley & Sons, Inc, 2000.

14EE2028 BUILDING AUTOMATION

Credits: 3:0:0

Course Objective

- Understand about the building automation and its management system.
- Study about the security and safety systems in smart building.
- Suggest suitable possibilities to integrate system and its managements for intelligent building.

Course Outcome

The student will be able to

- Construct and design structured building system by enabling integrated system connections.
- Apply the building automation system and telecommunication facilities in modern intelligent buildings; and apply networking technologies in building automation.
- Evaluate the comprehensive specifications of the importance of energy conservation components for a modern commercial building.

Description

Introduction – Features – Characteristics and Drawbacks of Building Automation system – Building Management System – Energy Meters Types – Meter Networking – Monitoring Energy Parameters, Analysis of Power Quality – Introduction to safety – Fire Development Stages and various security system – Introduction to video management - CCTV Camera Basics – Digital Video Recording, Video Management System – case study.

Reference Books

1. Shengwei Wang, "Intelligent Buildings and Building Automation", Spons Architecture Price Book, New York, 1st Edition, 2009.
2. Jong-jin Kim, "Intelligent Buildings", Butterworth-Heinemann, Illustrated Edition, London, 2006.
3. Derek Clements - Croome, "Intelligent Buildings: Design Management and Operation", Thomas Telford Ltd., UK, Illustrated Edition, 2004.
4. In Partnership with Nijatc, "Building Automation: Control Devices and Applications", Amer Technical Publishers, New York, 1st Edition, 2008.
5. Reinhold A. Carlson, Robert A. Di Giandomenico, "Understanding Building Automation Systems (Direct Digital Control, Energy Management, Life Safety, Security, Access Control, Lighting, Building Management Programs)", R.S. Means Company Incorporation, 1991.

14EE2029 DESIGN LABORATORY

Credits: 0:0:1

Corequisite: All the departmental core subjects

Course Objective

- To motivate the students to do develop a project with their own ideas.

Course Outcome

- Will enable the students to design, fabricate the circuits for a project.
- Usage of Data Sheets for the selection of Electrical, Electronics and Power Electronics components.

Description
This laboratory demonstrates the students about the stages of developing a project.

Experiments:
The faculty conducting the laboratory will prepare a list of 6 experiments and get the approval of HOD/Director and notify it at the beginning of each semester.

14EE2030 POWER SYSTEM SIMULATION LABORATORY

Corequisite: All the professional core subjects

Credits: 0:0:2

Course Objective
- To expose the students to the usage of Modern Simulation Software for Electrical Engineering.

Course Outcome
- Will enable the students to simulate circuits using MATLAB / SIMULINK and PSIM.
- Able to do harmonic analysis, spectral studies; power quality analysis etc during the simulation.

Description
This laboratory demonstrates the students about the implementation and control of any electrical engineering problems using modern simulation softwares.

Experiments:
The faculty conducting the laboratory will prepare a list of 12 experiments and get the approval of HOD/Director and notify it at the beginning of each semester.

14EE2031 Renewable Energy – I

Credits 3:0:0

Course Objective
- To know the basics of solar energy and photovoltaic technology.
- To know the basics of wind energy.
- To know about hybrid energy systems.

Course Outcome
The student will be able to
- Simulate power generation systems using solar and wind energies.
- Understand the Grid connection of Renewable Energy sources.
- Model wind energy conversion systems.

Description
PV Energy Basics - Electrical Efficiency – Construction of PV Cells and Panel Modules – PV modules and strings – Mismatch losses – Models of PV cells – Output Characteristics of a PV cell – Approximate Determination of the PV Panel Parameters – Determination of the PV Panel Maximum Power – Temperature effects – Parameters of PV cells – Inverters for PV – Energy storage for PV – Power Electronic Topologies in PV Systems – Stand-alone PV Systems – Grid connected PV systems – Maximum Power Point Tracking – Wind Energy : Introduction – types of wind machines – $C_p\lambda$ - Curve & Betz limits – Aerodynamics of wind turbine rotor – wind resource assessment – Standalone Wind Energy Conversion Systems – Grid Connected Wind Energy Conversion Systems – Hybrid Systems – Case studies.

Reference Books

1. Rai G. D., “Non conventional Energy Sources”, Khanna Publishers, New Delhi, 2007.
2. Sukhatme, S.P., “Solar Energy”, Tata McGraw - Hill Education India Private Limited, New Delhi, 2006.
3. John Twidell, Tony Wier, “Renewable Energy Sources”, Taylor & Francis Publishers, New York, 2005.
4. Godfrey Boyle, “Renewable Energy: Power for a Sustainable Future”, Oxford University Press, NewYork, 2nd Edition, 2004.
5. Bob Everett, Godfrey Boyle, Stephen Peake, Janet Ramage, “Energy Systems and Sustainability Power for a Sustainable Future”, Oxford University Press, NewYork, 2nd Edition, 2004.

14EE2032 RENEWABLE ENERGY – II

Credits 3:0:0

Course Objective

- To know the basics of Biomass Energy.
- To know the basics of Hydro, Geothermal, Wave and Oceanic energies.
- To know the power generation techniques using the Bio-waste and water.

Course Outcome

The student will be able to

- Simulate power generation systems using Bio-waste and water based energies.
- Model energy efficient biomass plant and energy conversion systems for water based energy systems.

Description

Biomass resources and their classification - chemical constituents and physicochemical characteristics of biomass - Biomass conversion processes (Thermo chemical conversion, biochemical conversion & chemical conversion) – Bio-gasifier – Biogas plants - Hydrogen: Thermodynamics and electrochemical principles - production methods – Biophotolysis - Storage gaseous, cryogenic and metal hydride and transportation – Fuel Cells – Hydro systems - Hydro System resources – types of hydro turbine – small hydro systems; Geothermal, wave energy, ocean energy – Case studies.

Reference Books

1. Khan B.H., “Non-Conventional Energy Resources”, Tata Mc-Graw Hill Publishing Company Ltd, New Delhi 2006.
2. Rai G. D., “Non conventional Energy Sources”, Khanna Publishers, New Delhi, 2007.
3. Thomas .b. Johansson, Henry Kelly, Amulya K.N .Reddy, Robert .H. Williams, “Renewable Energy Sources for Fuels and Electricity”, Island Press, Washington DC, 2009.
4. Anthony San Pietro, “Biochemical and Photosynthetic aspects of Energy Production”, Academic Press, 1983.
5. Khandelwal K.C, Mahdi S.S., Biogas Technology - A Practical Handbook, Tata Mc Graw Hill, 1986.

14EE2033 HARMONICS AND POWER QUALITY

Credits 3:0:0

Course Objective

- To Study the different causes of power quality issues.
- To study the effect of harmonics and voltage fluctuations on power system performance.
- To study the design aspects of filters to mitigate harmonics and voltage fluctuations.

Course Outcome

The student will be able

- To devise suitable harmonic elimination technique to improve power quality.
- To assess the power quality.
- Follow the International standards of power quality.

Description

Electric power quality phenomena- IEC and IEEE definitions - power quality disturbances-voltage fluctuations-transients-unbalance-waveform distortion-power frequency variations - Voltage variations – Voltage sags and short interruptions flicker-longer duration variations sources range and impact on sensitive circuits-standards solutions and mitigations equipment and techniques – Transients – origin and classifications – capacitor switching transient – lightning-load switching – impact on users – protection – mitigation – Electrostatic Discharge - Harmonics – sources – definitions & standards – impacts - calculation and simulation - Harmonic power flow - mitigation and control techniques – filtering – passive and active – Power Quality conditioners – shunt and series compensators – Dynamic Voltage restorer – Unified Power Quality Conditioners.

Reference Books

1. Roger C. Dugan, Mark F. McGranaghan, Surya Santoso , H. Wayne Beaty, " Electrical Power Systems Quality", McGraw Hill, New York, 3rd Edition, 2012
2. Arrillaga J., Watson N.R., Chen S., "Power System Quality Assessment", Wiley Publications Limited, New York, 2000.
3. Bollens M.H.J., "Understanding Power Quality Problems: Voltage Sags and Interruptions", IEEE Press, New York, 2000.
4. Heydt G.T., "Electric Power Quality, Stars in a Circle Publications, Indiana, 2nd Edition, 1994.
5. Sankaran C., "Power Quality", C.R.C Press, New York, 2001.

14EE2034 POWER SYSTEM RELIABILITY

Credits 3:0:0

Prerequisite: 14EE2013 Transmission and Distribution

Course Objective

- To understand the importance of reliability.
- To study the reliability evaluation.
- To understand the basic reliability indices.

Course Outcome

The student will be able to

- Evaluate the reliability of a power system.
- Evaluate the reliability of other physical system.
- Develop new reliability evaluation methods.

Description

Basic Probability Theory: Review of probability concepts, probability distributions, application of binomial distribution to engineering problems, network modeling and system reliability evaluation using probability distributions, frequency and duration techniques. Generation, Transmission and Distribution System Reliability Evaluation: Concept of LOLP and E(DNS), evaluation of these indices for isolated systems.

Reference Books

1. Roy Billinton, Ronald N. Allan, "Reliability Assessment of Large Electric Power Systems (Power Electronics and Power Systems)", Kluwer Academic Publishers,2013.
2. AlessendroBirolini, "Reliability Engineering: Theory and Practice", Springer India Limited, New Delhi, 6th Edition, 2010.
3. Roy Billinton, "Power System Reliability Evaluation", Springer (India) Private Limited, New Delhi, 2006.
4. Endrenyi J., "Reliability Modeling in Electrical Power Systems", Wiley & Sons, Australia, 1978.
5. Roy Billinton, Rajesh Karki, Ajit Kumar Verma, "Reliability and Risk Evaluation of Smart Power Systems(Reliable and Sustainable Electric Power and Energy System Management ", Springer (India) Private Limited, New Delhi, 2014.

14EE2035 SWITCHED MODE POWER SUPPLIES

Credits 3:0:0

Prerequisite: 14EE2010 Power Electronics

Course Objective

- To understand the basics of Switched Mode Power Supplies.
- To study the control behind the switching mode power supplies.
- To know the various hardware modules available.

Course Outcome

The student will be able to

- Design and fabricate a power source using static switches.
- Devise new techniques to make the power source more energy efficient.
- Design proper protective scheme against EMI.

Description

Introduction - Topologies of SMPS – Buck –Boost – Buck boost – Cuk – Polarity inverting topologies – Push pull and forward converters half bridge and full bridge – Fly back converters Voltage fed and current fed topologies EMI issues - Magnetic Circuits and design – Transformer design - Inductor design - Power semiconductor selection and its drive circuit design – snubber circuits. Design and closing the feedback loop – Voltage Mode Control of SMPS - Transfer Function and Frequency response of Error Amp. Transconductance Error Amps . PWM Control ICs (SG 3525,TL 494,MC34060 etc.) Current Mode Control and its advantages. Current Mode Vs Voltage Mode. Current Mode PWM Control IC(eg. UC3842). Active front end – power factor correction – High frequency power source for fluorescent lamps - power supplies for portable electronic gadgets – Resonant Converters: Principle of operation – modes of operation – quasi resonant operation- advantages.

Reference Books

1. Abraham I Pressman, "Switching Power Supply Design", Mc-Graw Hill Publishing Company. 3rd Edition, New York, 2009.
2. Keith H Billings, "Switch Mode Power Supply Handbook", Mc-Graw Hill Publishing Company, New York, 1989.
3. Sanjaya Maniktala, "Switching power supplies A to Z", Elsevier Incorporation, Oxford, UK, 2006.
4. Daniel M Mitchell, "DC-DC Switching Regulator Analysis", McGraw Hill Publishing Company, 3rd Edition, US, 2011.
5. Ned Mohan et.al, "Power Electronics", John Wiley and Sons, New York, 2003.
6. Otmar Kilgenstein, "Switched Mode Power Supplies in Practice", John Wiley and Sons, 1989
7. Mark J Nave, "Power Line Filter Design for Switched-Mode Power Supplies", Van Nostrand Reinhold, New York, 2nd Edition, 2010.

14EE2036 SMART GRID

Credits 3:0:0

Prerequisite: 14EE2013Transmission and Distribution

Course Objective

- To understand the structure of a smart grid
- To understand various functional units of smart grid
- To understand the impacts of renewable resources to the grid and the various issues associated with integrating such resources to the grid

Course Outcome

The student will be able to

- Construct the smart grid network
- Apply various communication technologies for smart grid network
- Implement the various power electronic modules in the network

Description
Introduction to Smart Grid-Need of smart grid- Smart grid communications: Two way digital communications paradigm, power Line communication-Information security for smart grid-Smart metering – Distribution management systems- Pricing and Energy Consumption Scheduling-Renewable Energy resource interconnection issues-Wide Area Measurements-Power electronics in the smart grid- Energy Storage-Future of smart grid

References Books

1. JanakaEkanayake, Nick Jenkins "Smart Grid Technology and applications", John Wiley & Sons Ltd, 2012
2. A.Mazer, "Electric Power Planning for Regulated and Deregulated Markets", John Wiley & Sons, 2007.
3. Ali Keyhani , "Design of Smart Power Grid Renewable Energy Systems", John Wiley & Sons, 2011
4. NouredineHadjsaid (Editor), Jean-Claude Sabonnadiere (Editor) "Smart Grids", John Wiley & Sons Ltd, May 2012.

14EE2037 COMPUTER AIDED GRAPHICS FOR ELECTRICAL ENGINEERS

Credits 0:0:2

Course Objective
- To understand the usage of computer graphics for electrical engineering.
- To understand the 3D view of a Machine.
- To understand the layout of a power system.

Course Outcome
The student will be able to
- Use graphical software for the design of electrical systems
- Draw layout diagram for electrical installations

Description
This laboratory demonstrates the students about the usage of Computer Graphics for Electrical Engineering.

Experiments:
The faculty conducting the laboratory will prepare a list of 12 experiments and get the approval of HOD/Director and notify it at the beginning of each semester.

14EE2038 ADVANCED TOPICS IN POWER ELECTRONICS

Credits 3:0:0

Prerequisite: 14EE2010 Power Electronics

Course Objective
- To give exposure to new emerging devices in the field of Power Electronics.
- To study the advanced inverters for the control of Electric Drives.
- To impart knowledge on protection of power electronic devices.

Course Outcome
The student will be able to
- Select the power devices based on the requirement of control.
- Select suitable power electronic controller for control applications.
- Construct new power electronic circuits.

Description

Review of devices – Power Diode – Power BJT – Power MOSFET – Power IGBT – Power IGCT – FCT – RCT – MCT – emerging devices - input and output characteristics - Gate drive circuits and their limitations and effects of turn-on and turn-off characteristics - Thermal models and the cooling of devices - Experimental circuit protection - Multilevel concept – diode clamped – flying capacitor – cascade type multilevel inverters - Comparison of multilevel inverters - application of multilevel inverters – PWM techniques for MLI – Single phase & Three phase Impedance source inverters – Matrix Converters - Series and parallel resonant inverters - voltage control of resonant inverters – Class E resonant inverter – resonant DC – link inverters.

Reference Books

1. Muhammad H. Rashid, "Power Electronics - Circuits, Devices and Applications", Pearson Education, New Delhi, 2011.
2. Ned Mohan, et.al, "Power Electronics converters, Applications and Design", Wiley India, New Delhi, 3rd Edition 2007.
3. JayantBaliga B., "Fundamentals Of Power Semiconductor Devices", Springer-Verlag Publications, New Delhi, 1st Edition, 2008
4. Robert Perret, "Power Electronics Semiconductor Devices", Wiley-ISTE Publications, New Delhi, New Edition, 2009.
5. Bhimbra P.S., "Power Electronics", Khanna Publishers Ltd., New Delhi, 2011.

14EE3001 POWER SEMICONDUCTOR DEVICES

Credits: 3:0:0

Course Objective

- To understand various static and dynamic performances of static switches.
- To familiarize the student on switching and steady state characteristics power electronic devices.
- To analyze the control circuits and switching losses in power devices.

Course Outcome

- Design switching circuits using power semiconductor devices.
- Specify design criteria (power, efficiency, ripple voltage and current, harmonic distortions, power factor).
- Selecting the components, interpreting the terminal characteristics of the components, modeling components, designing the circuit, and understanding operation of power electronics circuits.

Description

Status of Development of power semiconductor Devices - Types of static Switches, Static and dynamic performance – Power Diodes – Switching and steady state characteristics – Series and parallel operation – Thyristors – Switching and steady state characteristics – Switching techniques – Series and parallel operation – Family of Thyristors, Power Integrated Circuit, Intelligent Power Modules - Power Transistors – Static and switching characteristics - Power MOSFETS, IGBT'S, GTO – Switching characteristics – Heat Sink Design – Recent Power Electronic Devices.

Reference Books

1. Muhammad H. Rashid, "Power Electronics - Circuits, Devices and Applications", Pearson Education, New Delhi, 2011.
2. Ned Mohan, et.al, "Power Electronics converters, Applications and Design", Wiley India, New Delhi, 3rdEdition 2007.
3. JayantBaliga B., "Fundamentals Of Power Semiconductor Devices", Springer-Verlag Publications, New Delhi, 1stEdition, 2008
4. Robert Perret, "Power Electronics Semiconductor Devices", Wiley-ISTE Publications, New Delhi, New Edition, 2009.
5. Bhimbra P.S., "Power Electronics", Khanna Publishers Ltd., New Delhi, 2011

14EE3002 POWER CONVERTERS AND ANALYSIS - I

Credits: 3:0:0

Course Objective

- To give in depth knowledge of the various power electronics circuits
- To analyze the behavior of the Power Electronic circuits along with the design.
- To understand the control methods of various power converters.

Course Outcome

- Analyze the converter circuits and select them for the suitable applications.
- Trouble shooting the power electronic circuits
- Design various driver circuits for the converters

Description

Half controlled and fully controlled converters with RL, RLE loads - Dual converter - Effect of source impedance - Single Phase Series Converter operation - twelve pulse converter - Analysis of buck, boost, buck-boost and Cuk Regulators - Single phase and three phase controllers, PWM Control, Matrix Converter – Single phase and three phase cycloconverters, Applications – Resonant Converters.

Reference Books

1. Muhammad H. Rashid, “Power Electronics - Circuits, Devices and Applications”, Pearson Education, New Delhi, 2011.
2. Ned Mohan, et.al, “Power Electronics converters, Applications and Design”, Wiley India, New Delhi, 3rd Edition 2007.
3. Joseph Vithayathil, “Power Electronics: Principles and Applications”, Tata McGraw- Hill Education India Private Limited, New Delhi, 2010.
4. VedamSubrahmanyam, “Power Electronics”, New Age International (P) Limited, New Delhi, Revised 2nd Edition, 2011.
5. Muhammad H. Rashid, “Power Electronics Handbook: Devices, Circuits, and Applications”, Butterworth-Heinemann, 2010.
6. Bhimbra P.S., “Power Electronics”, Khanna Publishers Ltd., New Delhi, 2012.

14EE3003 POWER CONVERTERS AND ANALYSIS - II

Credits: 3:0:0

Course Objective

- To give in depth knowledge of the inverters and its configurations
- To analyze the behavior of the Power Electronic circuits along with their design
- To understand the control methods of various power converters

Course Outcome

- Analyze the converter circuits and select them for the suitable applications
- Construct PE system for specific applications
- Design various driver circuits for the converters

Description

Principle of operation of half and full bridge inverters – Performance parameters – Design of Inverters – Voltage control of using PWM techniques – Harmonic Elimination techniques - 180° and 120° conduction mode operation – Sinusoidal PWM – Space vector modulation techniques - Single phase CSI with ideal switches, Capacitor Commutated and Auto sequential commutated inverter, Comparison of CSI and VSI - Multilevel concept, Diode clamped, Flying capacitor and Cascade type multilevel inverters, Comparison and Applications - Series and parallel resonant inverters – Voltage control – Class E resonant inverter – Resonant DC-link inverters.

Reference Books

1. Muhammad H. Rashid, “Power Electronics - Circuits, Devices and Applications”,Pearson Education, New Delhi, 2011.
2. Ned Mohan, et.al, “Power Electronics converters, Applications and Design”, Wiley India, New Delhi, 3rd Edition 2007.
3. Joseph Vithayathil, “Power Electronics: Principles and Applications”, Tata McGrawHill Education India Private Limited, New Delhi, 2010.
4. VedamSubrahmanyam, “Power Electronics”, New Age International Private Limited, New Delhi, Revised 2nd Edition, 2011.
5. Muhammad H. Rashid, “Power Electronics Handbook: Devices, Circuits, and Applications”, Butterworth-Heinemann, 2010.
6. BhimbraP.S., “Power Electronics”, Khanna Publishers Limited, New Delhi, 2012.

14EE3004 SOLID STATE DC DRIVES

Credits: 3:0:0

Prerequisite: 14EE3002 Power Converter Analysis -I

Course Objective

- To understand the fundamentals of various electromechanical systems.
- To understand the basic concept of DC Drives.
- To understand the various control techniques involved with DC Drives.

Course Outcome

- Design and Analyze different control techniques of DC Drives.
- Select suitable DC Drive for different requirements
- Apply appropriate control method for the application.

Description

Dynamics of Electrical Drives-Torque Equation-Multi quadrant Operation-Speed control and Drive Classifications-DC motor Drives-Speed control – Analysis of series and separately excited DC motors with single-phase and three-phase converters - Class A, B, C, D and E chopper controlled DC motor – Chopper based implementation of braking schemes - Multi-phase chopper – Modeling of drive elements – Equivalent circuit - Closed loop control of Drives, Simulation of converter and chopper fed DC drive - Phase Locked Loop and micro-computer control of DC drives.

Reference Books

1. Gopal K Dubey, “Fundamentals of Electric Drives”, Narosa Publishing House, 2nd Edition, New Delhi, 2006.
2. Pillai S.K., “Analysis of Thyristor Power Conditioned Motors”, University Press, 2005.
3. Krishnan. R, “Electric Motor Drives: Modeling, Analysis and Control”, Prentice Hall of India Private Limited, New Delhi, 2009.
4. Sen P.C., “Thyristor DC Drives”, John Wiley, New York, 1981.
5. Vedam Subrahanyam, “Electric Drives: Concepts & Applications”, McGraw-Hill Education, New Delhi, 2010.
6. Singh M.D., K Khanchandani, “Power Electronics”, McGraw-Hill Education Private Limited, New Delhi, 2006.

14EE3005 SOLID STATE AC DRIVES

Credits: 3:0:0

Prerequisite: 14EE3003 Power Converter Analysis -II

Course Objectives

- To understand various operating regions of the induction motor drives.

- To study and analyze the operation of VSI & CSI fed induction motor control.
- To understand the speed and torque control techniques of induction motor drive from the rotor.
- To understand the field oriented control of induction machine.
- To understand the control of synchronous motor drives.

Course Outcome
- Design and Analyze different control techniques of AC Drives
- Select suitable AC Drive for different requirements
- Apply appropriate control method for the application

Description
Induction Motor Drives: Variable voltage, constant frequency operation – Variable frequency operation, constant Volt/Hz operation. Drive operating regions, variable stator current operation, different braking Methods-AC voltage controller circuit – six step inverter voltage control-closed loop variable frequency PWM inverter with dynamic braking-CSI fed IM variable frequency drives-Static rotor resistance control - injection of voltage in the rotor circuit – Static Scherbius drives -power factor considerations – modified Kramer drives-Field oriented control of induction machines– DC drive analogy – Direct and Indirect methods – Flux vector estimation - Direct torque control of Induction Machines – Torque expression with stator and rotor fluxes, DTC control strategy- Power factor control– starting and braking, self control –Load commutated Synchronous motor drives - Brush and Brushless excitation - Sensor-less Vector Control of AC Drives.

Reference Books

1. Bimal K Bose, "Modern Power Electronics and AC Drives", Pearson Education Asia 2002.
2. Vedam Subramanyam, "Electric Drives – Concepts and Applications", Tata McGraw Hill Publishing Limited, New Delhi, 2nd Edition, 2011.
3. Gopal K Dubey, "Power Semiconductor controlled Drives", Prentice Hall Inc., New Jersey, 1989.
4. W.Leonhard, "Control of Electrical Drives", Springer – Verlag Berlin Heidelberg, NewYork, 3rd Edition, 2001.
5. Murphy J.M.D and Turnbull, "Thyristor Control of AC Motors", Pergamon Press, Oxford, 1988.
6. R.Krishnan, "Electric Motor Drives – Modeling, Analysis and Control", Prentice-Hall of India Private Ltd., New Delhi, 2003.

14EE3006 WASTE TO ENERGY CONVERSION

Credits 3:0:0

Course Objective
- To understand the waste processing techniques, its treatment and disposal
- To study the different conversion process involved.
- To understand the environmental and health impacts of waste to energy conversion.

Course Outcome
- The student will be able to identify different types of waste and its processing techniques.
- The student will be mastering in Recovering Energy from Waste and thereby help in developing a green society.
- Gain knowledge about the eco-technological alternatives for waste to energy conversions.

Description
Municipal Solid Waste (MSW) - Industrial waste and Biomedical Waste (BMW) - waste processing-size reduction, separation; waste minimization and recycling of MSW; Life Cycle Analysis (LCA), Material Recovery Facilities (MRF)-Aerobic composting – incineration - land fill - preliminary design of landfills – pyrolysis - gasification of waste using gasifiers - briquetting, - strategies for reducing environmental impacts - Anaerobic digestion of sewage and municipal wastes - direct combustion of MSW - refuse derived solid fuel - industrial waste, - agro residues - anaerobic digestion biogas production - land fill gas generation and utilization - present status of technologies for conversion of waste into energy - design of waste to energy plants for cities, small townships and villages - case

studies of commercial waste to energy plants, - eco-technological alternatives for waste to energy conversions – Rules related to the handling, treatment and disposal of MSW and BMW in India.

Reference Books:

1. Gary C. Young, "Municipal Solid Waste to Energy Conversion Processes: Economic, Technical, and Renewable Comparisons", John Wiley & Sons, 2010.
2. Christian Furedy, Alison Doig, "Recovering Energy from Waste Various Aspects", Science Publishers, Inc. Enfield (NH) USA, 2002.
3. Shah, Kanti L., "Basics of Solid & Hazardous Waste Management Technology", Prentice Hall, 2000.
4. Parker, Colin, Roberts, "Energy from Waste - An Evaluation of Conversion Technologies", Elsevier Applied Science Publisher, London, 1985.
5. Robert Green, "From Waste to Energy", Cherry Lake Publishing limited, USA, 2009.
6. Dieter D., Angelika S., "Biogas from Waste and Renewable Resources", Wiley-VCH Verlag GmbH & Company, Germany, 2010.

14EE3007 GENERALIZED THEORY OF ELECTRICAL MACHINES

Credits: 3:0:0

Course Objective

- To impart knowledge on the generalized representation and model of electrical machines.
- To impart knowledge on the steady state and analysis of electrical machines using the model
- To impart knowledge on various reference frames

Course Outcome

The students will be able to

- Describe the Generalized Representation of machines and their analysis.
- Describe the steady state analysis and transient analysis of various machines.
- Describe the performance of Induction and Synchronous machines and their representation.

Description

Basic two pole machines - Transformer with movable secondary –Transformer voltage and speed voltage - Kron's Primitive Machine - Analysis of Electrical Machines - Invariance of power - Transformations from displaced brush axis – three phases to two phase – Rotating axis to stationary axes-Transformed impedance matrix - Generalized Representation of DC Machine - Generator and motor operation - Operation with displaced brushes - Steady state and transient analysis - Sudden short circuit - Sudden application of inertia load - Electric braking of DC motors – Circuit Model of a Three-phase Induction Machine – Machine Model in Arbitrary dq0 Reference frame – dq0 stationary and Synchronous Reference frames –Steady state model – Transient Model – Mathematical Model of Synchronous Machines – Transformation to the Rotor's dq0 Reference frame – Flux Linkages in terms of Winding Currents – Referring rotor Quantities to the stator – Voltage Equations in the rotor's qd0 Reference frame – Electromagnetic Torque – Steady State Operation – Transient Operation.

Reference Books

1. Bimbhra P.S., "Generalized Theory of Electrical Machines", Khanna Publishers Limited,New Delhi, 5thEdition, 2011.
2. Chee-Mun Ong., "Dynamic Simulation of Electric Machinery using Matlab/Simulink", Prentice Hall PTR, Upper Saddle River, New Jersey, 1998.
3. Bandyopadhyay M. N., "Electrical Machines: Theory and Practice" PHI Learning, NewDelhi, 2007.
4. Gupta J B." Theory & Performance of Electrical Machines", S. K. Kataria & Sons, New Delhi, 2011.
5. Paul C.Krause, Oleg Wasynczuk, Scott D.Sudhoff., "Analysis of Electric Machinery and Drive Systems", Wiley India Private Ltd, New Delhi, 2nd Edition, 2010.

14EE3008 SPECIAL MACHINES AND CONTROLLERS

Credits: 3:0:0

Course Objective

- To impart knowledge on the construction, principle of operation and the control techniques of stepper motor and Switched Reluctance Motors.
- To study the characteristics of permanent magnet brushless DC motor
- To understand the control methods, applications of PMSM and linear motors

Course Outcome

- Differentiate the working of different drives and performance
- Select a suitable special machine drive based on the application
- Incorporate an appropriate control scheme for the application specified

Description

Constructional features of Stepper – variable reluctance motor – Hybrid motor – Single and Multi stack configurations – torque equation –characteristics –Open loop and Closed loop control– applications - Constructional features of Switched Reluctance Motor –Torque equation – Power Converters – Torque Speed characteristics – Voltage, Current and Single Pulse Control Techniques – Torque Control – applications - Principle of operation of Permanent Magnet Brushless DC Motor – types –magnetic circuit analysis – EMF and Torque equations – Power Controllers – Motor characteristics and control - Principle of operation of Permanent Magnet Synchronous Motor – EMF and torque equations – reactance – phasor diagram – power controllers - converter - torque speed characteristics - microprocessor based control - Linear Induction Motor (LIM) Classification – Construction – Principle of operation – Concept of Current sheet – Goodness factor – DC Linear Motor (DCLM) types –Circuit equation – DCLM control applications.

Reference Books

1. Venkataratnam K., "Special Electric Machines", CRC Press, Boca Raton, U.S.A., 2008.
2. R.Krishnan, "Switched Reluctance Motor Drives: Modeling, Simulation, Analysis, Design, and Applications", CRC Press, BocaRaton, U.S.A., 2001.
3. Miller, T.J.E. "Brushless Permanent Magnet and Reluctance Motor Drives", ClarendonPress, Oxford, 1989.
4. Kenjo, T, "Stepping Motors and Their Microprocessor Control", Clarendon Press,Oxford, 1989.
5. Naser A, Boldea I, "Linear Electric Motors: Theory, Design And Practical Application",Prentice Hall Inc., New Jersey, 1987
6. Kenjo, T, Naganori, S "Permanent Magnet and Brushless DC Motors", Clarendon Press,Oxford, 1989.

14EE3009 POWER ELECTRONICS LABORATORY

Credits: 0:0:1

Corequisite: 14EE3002 Power Converter Analysis – I
14EE3003 Power Converter Analysis – II

Course Objective

- Learn the principles of operation, simulation and design procedures of ac-dc rectifiers.
- Learn the principles of operation, simulation and design procedures of dc-dc converter.
- Learn the principles of operation, simulation and design procedures of Cycloconverter and resonant Converter.

Course Outcome

- Students are introduced to hardware, software, and measurement techniques used in power electronic systems
- Students are exposed to analysis, design, and applications of power electronic converters.

Description
This laboratory demonstrates the students the simulation and design of various converters.
Experiments:
The faculty conducting the laboratory will prepare a list of 6 experiments and get the approval of HOD/Director and notify it at the beginning of each semester.

14EE3010 ELECTRIC DRIVES AND CONTROL LABORATORY

Credits: 0:0:1

Corequisite: 14EE3004 Solid State DC Drives
14EE3005 Solid State AC Drives

Course Objective

- To prepare students for the processes of design and operation for electric drive systems requiring knowledge of the specifics and characteristics of electric motors as objects of control.

Course Outcome
The student will be able to

- Derive expressions for forces and torques in electromechanical devices. Understand how power electronic converters and inverters operate.
- Possess an understanding of feedback control theory.
- Develop control algorithms for electric drives which achieve the regulation of torque, speed, or position in the above machines.
- Develop Simulink® models which dynamically simulate electric machine and drive systems and their controllers.

Description
The lab will consist of giving the students hands-on experience with electric machines (AC and DC), power electronic circuitry, and control algorithms for electric drives.

Experiments:
The faculty conducting the laboratory will prepare a list of 6 experiments and get the approval of HOD/Director and notify it at the beginning of each semester.

14EE3011 PHOTOVOLTAIC SYSTEMS

Credits: 3:0:0

Course Objective

- To provide necessary knowledge about the modeling, design and analysis of various PV systems
- To show that PV is an economically viable, environmentally sustainable alternative to the world's energy supplies
- To understand the power conditioning of PV system's power output.

Course Outcome

- Model, analyze and design various photovoltaic systems
- Know the feasibility of PV systems as an alternative to the fossil fuels
- Design efficient stand alone and grid connected PV power systems

Description
Historical development of PV-Overview of PV usage-Solar Radiation and spectrum of sun- geometric and atmospheric effects of sunlight-Photovoltaic effect. Solar cells and arrays- Structure and characteristics- modeling of solar-PV Generators- Energy storage alternatives for PV Systems-Types – Modeling - Inverter control topologies for standalone and grid connected system-Power conditioning and maximum power point tracking (MPPT)- Active

power filtering with real power injection-Modeling and simulation of complete stand-alone and grid-connected PV systems.

Reference Books

1. Castaner L., Silvestre S., "Modeling Photovoltaic Systems Using PSpice", John Wiley & Sons, England, 2002.
2. Komp R.J., "Practical Photovoltaics: Electricity from solar cells", Aatec Publications, Michigan, 2001.
3. Patel M. R., "Wind and Solar Power Systems Design, Analysis, and Operation", CRC Press, New York, 2005.
4. Jenny Nelson, "The physics of solar cells", Imperial College Press, London, 2004.
5. Goetzberger, Hoffmann V. U., "Photovoltaic Solar Energy Generation", Springer-Verlag, Berlin, 2005.

14EE3012 POWER ELECTRONIC CIRCUITS

Credits 3:0:0

Course Objective

- To impart the knowledge of various conversion techniques of electrical energy using power electronic components.
- To establish the link between efficient usage of power and conservation of energy resources of the world.
- To provide the design details of various power electronic converters.

Course Outcome

- Understand the significance of the characteristics of various power semiconductor switches
- Design of power electronic conversion systems
- Understand various modulation (control) techniques such as pulse width modulation and selective harmonic elimination.

Description

Semiconductor power switching devices used in power electronic circuits- AC to DC Converters-Single phase and three phase bridge Rectifiers-Evaluation of performance parameter- Design of converter circuits– Control circuit strategies - DC Choppers- Switching mode regulators – Chopper circuit design - Single phase and Three phase bridge inverters - CSI –Resonant Switch – Quasi-Resonant Converters – Multi resonant Converters-Principle of phase control- Principle of operation – single phase and three phase - Cycloconverters – Control circuit strategies.

Reference Books

1. Rashid M.H., "Power Electronics Circuits, Devices and Applications", Prentice Hall India, New Delhi, 2003.
2. Sen P.C., "Modern Power Electronics", Tata McGraw-Hill Education India Private Limited, New Delhi, 2004.
3. Ned Mohan, Tore M. Undeland, William P, Robbins, "Power Electronics: Converters, Applications, and Design", John Wiley and Sons Inc., New York, 2003.
4. Joseph Vithayathil, "Power Electronics", New Age International Private Limited, New Delhi, 2010.
5. Singh M.D., Khanchandani K B, "Power Electronics", Tata McGraw-Hill Education India Private Limited, New Delhi, 2ndEdition, 2006.

14EE3013 ENERGY ENGINEERING

Credits: 3:0:0

Course Objective

- To create environment-friendly and energy-efficient systems.
- To deal with actively harnessing renewable natural resources like solar energy and utilizing materials that cause the least possible damage to the global commons – water, soil, forests and air.
- To deal with global and Indian energy scenario.

Course Outcome

- Effectively manage the energy requirements
- Work out for the new available sources and its utilization
- Manage the environmental issues regarding the energy sources

Description

Introduction to Energy and its conservation, Origin of fossil fuels, National and Global Energy Scenario, Various Renewable Energy Systems, Funding agencies - Kyoto Protocol, Environmental Degradation due to Energy Production and Utilization; Evolution of Smart Grids – Smart Grid Components – Risks to Smart Grid – Wireless Sensor Networks and its Applications – Introduction to Deregulation.

Reference Books

1. Vaclav Smil, Energy: A Beginner's Guide, One world Publications, Oxford, 2006.
2. Stuart Borlase, "Smart Grids: Infrastructure, Technology, and Solutions" Taylor and Francis, Boca Raton, 2010
3. NarendraJadhav, Rajiv Ranjan, SujanHajra, "Re-Emerging India - A Global Perceptive", The ICFAI University Press, Hyderabad, 2005.
4. Eric Jeffs, "Green energy: sustainable electricity supply with low environmental impact" CRC Press, USA, 2010.
5. Kishore V. V .N., "Renewable Energy Engineering And Technology Principles and Practice", Earthscan Publications Ltd, UK, 2009.
6. Steve Doty, Wayne C. Turner, "Energy Management Handbook" Fairmont Press, Lilburn, 2009.

14EE3014 WIND ENERGY

Credits: 3:0:0

Course Objective

- To develop a detailed understanding of the issues associated with the development of wind energy for electrical energy supply.
- To know the current state of wind energy development domestically and internationally
- To understand the issues of location and grid connection of wind energy power plants.

Course Outcome

- Understand the role which wind energy plays and can play in the electricity supply system and its role in meeting the country's obligations in terms of greenhouse gas abatement.
- Gain knowledge regarding wind energy resources and the ability to assess those resources.
- Gain knowledge of construction, characteristics, control and performance of wind turbines.

Description

Power Contained in Wind, Principal Wind Turbine Components, Materials & Topologies, Wind Turbine Power Curve, Economic Assessment of Wind Energy Systems, Value of Wind Energy - General Characteristics of Wind Resource & Atmospheric Boundary Layer, Wind Data Analysis and Resource Estimation, Wind Turbine Energy Production Estimates, Wind Prediction and Forecasting, Wind Measurement and Instrumentation, Wind Turbine Siting, Installation & Operational Issues, Offshore Wind Energy, Environmental impacts of Wind Energy Systems - Airfoils and Concepts of Aerodynamics, Blade Design for Modern Wind Turbines, Momentum Theory and Blade Element Theory, Generalized Rotor Design Procedure, Classification of Schemes with Variable-speed Turbines, Induction Generators, Stand-alone configurations, Wind Turbine Control System, Wind Turbines and Wind Farms in Electrical Grids, Hybrid Power Systems.

Reference Books

1. Manwell, J.F., McGowan, J.G. and Rogers A.L., "Wind Energy Explained – Theory, Design and Application", Second Edition, John Wiley & Sons, UK, 2009.
2. Bhadra S. N., Kastha D., Banerjee S,. "Wind Electrical Systems", Oxford University Press, New Delhi, 2013.
3. Heier, S., "Grid Integration of Wind Energy", Third Edition, John Wiley & Sons, UK, 2014.

4. Burton, T., Sharpe, D., Jenkins N. and Bossanyi, E., “Wind Energy Handbook”, Second Edition, John Wiley & Sons, UK, 2011.
5. Ackermann, T., “Wind Power in Power Systems”, Second Edition, John Wiley& Sons, UK, 2012.
6. Olimpo Anaya-Lara, Nick Jenkins, JanakaEkanayake ,Phill Cartwright, Michael Hughes, “Wind Energy Generation: Modelling and Control”, John Wiley& Sons, UK, 2009.

14EE3015 HYDROGEN AND FUEL CELLS

Credits: 3:0:0

Course Objective

- To understand hydrogen energy technology
- To understand fuel cell technology
- To enlighten the student community on various technological advancements, benefits and prospects of utilizing hydrogen/fuel cell for meeting the future energy requirements.

Course Outcome

- Know detail on the hydrogen production methodologies, possible applications and various storage options.
- Know the working of a typical fuel cell, its types and to elaborate on its thermodynamics and kinetics
- Analyze the cost effectiveness and eco-friendliness of Hydrogen and Fuel Cells.

Description

Hydrogen – physical and chemical properties– Production of hydrogen- Hydrogen storage options –Hydrogen transmission systems – Applications of Hydrogen – History, principle, working of a fuel cell – thermodynamics and kinetics of fuel cell process – performance evaluation of fuel cell – comparison on battery vs fuel cell- Types of fuel cells –relative merits and demerits – Microbial Fuel Cell - Fuel cell usage for domestic power systems – large scale power generation – Automobile, Space. Economic and environmental analysis on usage of Hydrogen and Fuel cell – Future trends in fuel cells.

Reference Books

1. Bent Sorensen, “Hydrogen and Fuel Cells: Emerging Technologies and Applications”, Elsevier Science Technology, United Kingdom, 2005
2. Rebecca L., Busby, “Hydrogen and Fuel Cells: A Comprehensive Guide”, Penn Well Corporation, USA, 2005
3. Jeremy Rifkin, “The Hydrogen Economy”, Penguin Group, New York, 2002
4. Viswanathan B., AuliceScibioh M, “Fuel Cells – Principles and Applications”, Universities Press, India, 2006.
5. Thomas B.Johansson, Henry Kelly, AmulyaK.N.Reddy, Robert.H.Williams, “Renewable Energy Sources for Fuels and Electricity”, Island Press, Washington DC, 2009.
6. Bruce E. Logan, “Microbial fuel cells”, John Wiley & Sons, Inc., Hoboken, New Jersey, 2008

14EE3016 ENERGY MANAGEMENT AND AUDIT

Credits: 3:0:0

Prerequisite: 14EE3013 Energy Engineering

Course Objective

- To understand various energy management techniques.
- To understand energy auditing techniques.
- To familiarize with energy related policies.

Course Outcome

- Become efficient energy managers
- Know different energy auditing methods.
- Suggesting energy saving methods.

Description

Energy Management in Electrical Utilities and Thermal Utilities – Definition of energy audit – Needs – Types - Approaches; Energy Audit Instruments, Duties and Responsibilities of Energy Auditors. Action Planning: Key Elements, Force Field Analysis, Energy Policy- Purpose, Perspective, Contents, Formulation, Ratification; Location of Energy Management

Reference Books

1. Clive Beggs, "Energy: Management, Supply and Conservation" Butterworth-Heinemann Publications, Oxford, 2009
2. Albert Thumann, William J. Younger, Terry Niehus, "Handbook of Energy Audits" Fairmont Press, Lilburn, 2010.
3. Steve Doty, Wayne C. Turner, "Energy Management Handbook" Fairmont Press, Lilburn, 2009.
4. Barney L. Capehart, Wayne C. Turner, William J. Kennedy, "Guide to Energy Management", Fairmont Press, Lilburn, 2008.
5. MoncefKrarti, "Energy Audit of Building Systems: An Engineering Approach" Taylor & Francis, Boca Raton, 2010.
6. World on transition-Towards sustainable Energy systems, German Advisory council on global change Handbook, Earthscan publication, 2004

14EE3017 ENERGY MODELING, ECONOMICS AND PROJECT MANAGEMENT

Credits: 3:0:0

Prerequisite: 14EE3013 Energy Engineering

Course Objective

- To impart greater understanding of energy modeling in renewable energy technology.
- To throw light on the economic aspects involved in renewable energy technology.
- To enlighten the students on the various techniques involved in project management.

Course Outcome

- Gain clear perspective on energy economy.
- Forecast the energy demand and plan wisely.
- Become excellent managers of the energy resources.

Description

Modeling Approaches, Input-Output Analysis, Energy Demand Analysis and Forecasting – Economics of Renewable Sources of Energy, Waste Heat Recovery and Cogeneration - Energy Conservation Economics - Cost Analysis – Budgetary Control - Financial Management - Techniques for Project Evaluation.

Reference Books

1. Munasinghe M., Meier P., "Energy Policy Analysis and Modeling", Cambridge University Press, New York, 2008.
2. Spyros Makridakis, Steven C. Wheelwright, Rob J. Hyndman, "Forecasting Methods andApplications", Wiley, Singapore, 2008.
3. James Stock, Mark Watson, "Introduction to Econometrics", Pearson Education,2nd Edition, New Delhi, 2006.
4. Kurt Campbell, Jonathon Price, "The Global Politics of Energy", The Aspen University, Washington, 2008.
5. Bob Shivley, John Ferrare, "Understanding Today's Electricity Business", Enerdynamics, Laporte, 2010

14EE3018 SOLAR ENERGY LABORATORY

Credits: 0:0:1

Corequisite: 14EE3011 Photovoltaic Systems

Course Objective

- To learn the characteristics of a solar cell and PV array.
- To learn the algorithms for efficient and optimal power tracking of PV modules.

Course Outcome

The student will be able to

- Select suitable solar cell.
- Use suitable measurement technique for solar insolation level.
- Use suitable control algorithm for achieving maximum power point.

Description

This laboratory demonstrates the students to study the characteristics of a PV cell, PV array and control the PV array for maximum power point tracking.

Experiments:

The faculty conducting the laboratory will prepare a list of 6 experiments and get the approval of HOD/Director and notify it at the beginning of each semester.

14EE3019WIND ENERGY LABORATORY

Credits: 0:0:1

Corequisite: 14EE3014Wind Energy

Course Objective

- To study the various wind power forecasting techniques.
- To learn the control algorithm for maximum power operation.
- To learn the modeling techniques for wind power system.

Course Outcome

The student will be able to

- Assess the wind resources at a site.
- Model a suitable wind power system and implement a suitable controller for maximum wind power.

Description

This laboratory demonstrates the students the modeling and control of a wind power system.

Experiments:

The faculty conducting the laboratory will prepare a list of 6 experiments and get the approval of HOD/Director and notify it at the beginning of each semester.

14EE3020 POWER ENGINEERING SIMULATION LABORATORY

Credits: 0:0:1

Course Objective

- To simulate any power electronic circuit or solve any power engineering problem.

Course Outcome

The student will be able to

- Simulate any circuit for an application using technical softwares.

- Solve the power engineering problems by programming.

Description
This laboratory demonstrates the students the usage of technical softwares like MATLAB/SIMULINK, PSIM, PSCAD etc.
Experiments:
The faculty conducting the laboratory will prepare a list of 6 experiments and get the approval of HOD/Director and notify it at the beginning of each semester.

14EE3021FLEXIBLE AC TRANSMISSION SYSTEMS
Credits: 3:0:0

Course Objective:
- To introduce the students to the concept of FACTS, and familiarize them with the basic design and principle of operation of HVDC systems.
- To understand the implementation of UPFC in real time applications.
- To the design the FACTS controllers for various non-linear structure controls.

Course Outcome
- Identify, formalize, model and analyze problems in a power network
- Select the suitable FACTS devices to enhance the security, capacity and flexibility of Power transmission systems.
- Increase existing transmission network capacity while maintaining or improving the operating margins necessary for grid stability.

Description
Concept and general system considerations of flexible alternating current Transmission Systems (FACTS). A review of power semiconductor devices Static shunt and series compensators such as SVC, STATCOM, GCSC, TSSC, TCSC, and SSSC. Static voltage and phase angle Regulation using TCVR and TCPAR. Unified and Interline Power Flow Controllers. Special Purpose Facts Controllers: NGH-SSR Damping Scheme and Thyristor-Controlled Braking Resistor. Application Examples.Modern FACTS Devices-location of FACTS Devices.

Reference Books

1. Xiao-ping Zhang, Christian Rehtanz, Bikash Pal, “Flexible Ac Transmission Systems: Modelling and Control”, Springer-verlag Publisher, New Delhi, 1st Edition, 2006.
2. Narain G. Hingorani, “Understanding FACTS”, Standard Publishers Distributors, New Delhi, 1st Edition, 2001
3. Padiyar.K.R., “Facts Controllers In Power Transmission and Distribution”, Anshan Publisher, Kent (United Kingdom), 1stEdition, 2009.
4. Song Yong Hua, “Flexible AC Transmission Systems”, Shankar's Book Agency Pvt. Ltd., Kolkata, 2009.
5. R. Mohan Mathur, Rajiv K. Varma, Mathur, “Thyristor-Based FACTS Controllers For Electrical Transmission Systems”, IEEE Computer Society Press, New Delhi, Annotated Edition, 2002.

14EE3022 HVDC TRANSMISSION
Credits: 3:0:0

Course Objective
- To have an overview about HVDC system, Converters and various means of control
- To analyze the various malfunctioning of the HVDC system
- To study the basics of harmonics and their reduction mechanism

Course Outcome
- Outline the benefits of using dc transmission and its operation & control
- Use the various power electronics resources for the betterment of HVDC system

- Analyze the challenges and its solutions available in high voltage engineering

Description

Introduction – Comparison of AC and DC Transmission – Applications of DC Transmission – Description of DC Transmission Systems – Planning for HVDC Transmission – Modern Trends in HVDC Technology – Operating Problems – HVDC Transmission Based on Voltage Sourced Converts - Line Commutated Converter – Voltage Source Converter – Analysis of Line Commutated Converter, Bridge Characteristics, Twelve Pulse Converter, Detailed Analysis – Capacitor Commutated Converters – Analysis of VSC - Principles of DC Link Control – Converter Control Characteristics – System Control Hierarchy – Firing Angle Control – CEA Control – Starting and Stopping of a DC Link – Power Control – Higher Level Controllers – Tele Communication Requirements – Control of VSC - Converter Faults – Protection against Overcurrents, Overvoltages in a Converter Station, Surge Arrestors, Protection against Overvoltages – Protection against Faults in VSC.

Reference Books

1. Erich Uhlmann, “Power Transmission by Direct Current”, Springer International Edition, 2004.
2. Padiyar. K. R, “HVDC Power Transmission Systems”, New Age International Publishers Private Ltd., New Delhi, 2012.
3. Neville R. Watson, Y. H. Liu, J. ArrillagaArrilaga J., “Flexible Power Transmission: The HVDC Options”, John Wiley & Sons, 2007.
4. Chan-ki Kim, Vijay K. Sood, Gil-soo Jang, Seong-joo Lim, Seok-jin Lee, “HVDC Transmission: Power Conversion Applications In Power Systems”, John Wiley (IEEE Press), 2009.
5. Kamakshaiah. S, Kamaraju. V, “HVDC Transmission”, Tata McGraw Hill Education Pvt. Ltd., New Delhi, 2011.
6. Jos Arrillaga, High Voltage Direct Current Transmission, The Institution of Electrical Engineers, London,United Kingdom, Second Edition, 1998.

14EE3023 INDUSTRIAL POWER SYSTEM ANALYSIS AND DESIGN

Credits: 3:0:0

Course Objective

The students will be able to

- Understand operational and maintenance requirements of power system
- Apply the appropriate industry recognized design standards to a design
- Study various disturbing power system parameters

Course Outcome

Students will be able to

- Understand the terminology used in the context of an electrical distribution system
- Use simple "rules of thumb" to estimate the performance and economics of an electrical distribution systems design
- Design an industrial power system with appropriate safety, economic reliability

Description

Power Factor Correction Studies-Frequency Scan Analysis-Voltage Magnification Analysis-Sustained Over voltages-Switching Surge Analysis-Harmonic Analysis: Harmonic Sources-System Response to Harmonics-Harmonic Filters-Harmonic Evaluation-Flicker Analysis: Sources of Flicker-Flicker Criteria-Data for Flicker analysis- Minimizing the Flicker Effects-Summary-Ground Grid Calculations- Improving the Performance of the Grounding Grids

Reference Books

1. Ramasamy Natarajan, “Computer-Aided Power System Analysis”, Marcel Dekker Inc., CRC Press, New York, 2002.
2. Shoaib Khan, Sheeba Khan, “Industrial Power system”, CRC press, Boca Raton, 2007.

3. Duncan GloverJ., Mulukutla S. Sarma, Thomas Overbye,“Power System Analysis and Design”, Thomson Learning Group, Canada, 4th Edition, 2008.
4. Dunki - Jacobs J.R., Shields F.J., Conrad St. Pierre, “Industrial Power system Grounding Design Handbook”, Electric Power Consultants, 2007.
5. Hemant Joshi, “Residential, Commercial and Industrial Electrical System”,Tata McGraw Hill Education Private Limited, New Delhi, 2005.

14EE3024 DISTRIBUTED GENERATION

Credits: 3:0:0

Course Objective

- To understand the structure of an regulated or deregulated market conditions
- To understand power architecture and control strategies
- To understand the impacts of renewable resources to the grid and the various issues associated with integrating such resources to the grid

Course Outcome

Students will be able

- To implement Distributed Generation network
- To install various Distributed Generation Units
- To realize various power electronic modules in the network

Description

Distributed Generation (DG) - Overview and technology trends - The electric grid vs. Microgrids-Distributed Generation units. Microturbines, reciprocating engines, wind generators, photovoltaic generators, fuel cells, and other technologies- Power electronics interfaces: AC-DC and DC-AC-Power architectures: distributed and centralized. Dc and ac distribution-Controls: distributed, autonomous, and centralized systems-Grid interconnection. Issues, planning, advantages and disadvantages both for the grid and the microgrid.

Reference Book

1. Math H. Bollen, Fainan Hassan, Integration of Distributed Generation in the Power System, Wiley-IEEE Press, July 2011
2. Suleiman M. Sharkh, Mohammad A. Abu-Sara, Georgios I. Orfanoudakis, Babar Hussain, Power Electronic Converters for Microgrids, Wiley-IEEE Press, March 2012
3. Qing-Chang Zhong, Tomas Hornik, Control of Power Inverters in Renewable Energy and Smart Grid Integration, IEEE Press, January 2013.
4. A.Mazer , “Electric Power Planning for Regulated and Deregulated Markets
John Wiley & Sons, 2007.

14EE3025 COMMUNICATIONS AND CONTROL IN SMART GRID

Credit: 3:0:0

Course Objective

The students will be able to

- Comprehend the new multi-disciplinary field of Smart Grid
- Study communication protocols
- Understand various control Technology

Course Outcome

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

- Design and Implement the concept of a smart grid.
- Integrate the latest communication system with smart grid.

- Develop customized cyber security system

Description
Smart Grid Definition-Smart Grid Communications: Two-way Digital Communications Paradigm- Power Line Communications-Advanced Metering Infrastructure- Pricing and Energy Consumption Scheduling- Phasor Measurement Units-Communications Infrastructure- Cyber Security Challenges in Smart Grid – SCADA – DCS.

Reference Book

1. EkramHossain,Zhu Han,H. Vincent Pool, " Smart Grid Communications and Networking", Cambridge University Press, 2012.
2. James Mamoh, "Smart Grid : Fundamentals of Design and Analysis", IEEE press, second edition, 2007
3. JanakaEkanyake, " Smart Grid Technology and application", John Wiley,2012
4. Communications Requirements Of Smart Grid Technologies-Hand book, Department of Energy, United States , 2007
5. D.P.Kothari, I.J.Nagrath, " Modern Power Ssytem Analysis, Tata McrawHill education, 2003.

14EE3026 ELECTRICAL TRANSIENTS IN POWER SYSTEMS

Credit: 3:0:0

Course Objectives
- To study the fundamentals of travelling waves on transmission line
- To analyze the various computation methods for power system transients
- To study the behavior of lightning, winding oscillation and insulation coordination

Course Outcome
- Able to analyze the transients with suitable computation method
- Able to learn the behavior of winding, insulation and lightning under transients conditions
- Able to use the optimization method to solve the problems of transients

Description
Impact of power electronics switches in power systems, Lumped and Distributed Parameters, Wave Equation, Reflection, Refraction, Behavior of Travelling waves at the line terminations, Lattice Diagrams, Attenuation & Distortion, Multi-conductor system and Velocity wave. Principle of digital computation, Switching: Short line or kilometric fault, Energizing transients: closing and re-closing of lines, line dropping. Voltage induced by fault, Very Fast Transient Overvoltage (VFTO) Initial and Final voltage distribution, Winding oscillation, Behavior of the transformer core under surge condition. Rotating machine, Surge in generator and motor. IEC and IEEE standards.

Reference Books

1. Pritindra Chowdhari, "Electromagnetic Transients in Power Systems", PHI Ltd. 2nd Edition, New Delhi, 2012.
2. Allan Greenwood, "Electrical Transients in Power System", Wiley India Pvt. Ltd. 2nd Edition, India, 2012.
3. Rakosh Das Begamudre, "Extra High Voltage AC Transmission Engineering", 4th Edition, New Age International (P) Ltd., New Delhi, 2011.
4. Naidu M S and Kamaraju V, "High Voltage Engineering", Tata McGraw-Hill Publishing Company Ltd., 5th Edition, New Delhi, 2013.
5. Indulkar, C. S., Kothari, D. P., Ramalingam, K., "Power System Transients: A Statistical Approach", Prentice Hall of India Limited, New Delhi, 2nd Edition, 2012.

14EE3027 POWER ELECTRONICS FOR HIGH POWER APPLICATIONS

Credit: 3:0:0

Course Objectives
- To study the fundamentals of parameters of HV lines

- To analyze the application of Power electronics in High voltage lines
- To study the effects of corona and electrostatic field effect in EHV lines

Course Outcome
- Able to choose the optimal values of resistant, inductance and capacitance for multiconductor lines
- Able to analyze the voltage gradients, corona effects and effect of electrostatic field of HV line.
- Able to design appropriate converter and controllers

Description
Introduction: Introduction to AC and DC Transmission – application of DC Transmission – description of DC transmission – selection of power electronic switches for high voltage application. Converter: Converter configuration. HVDC Controllers: General principle of DC link control – converter control characteristics PROTECTION: Basics of protection -EHV and UHV lines, Line parameters. Effect of EHV line on heavy vehicles, humans, animals, and plants, Electrostatic fields. IEC and IEEE standards for EHV and HVDC transmission.

Reference Books

1. Rakosh Das Begamudre, "Extra High Voltage AC Transmission Engineering", Second Edition, New Age International Pvt. Ltd., 2011.
2. Power Engineer's Handbook, Revised and Enlarged 6th Edition, TNEB Engineers' Association, October 2002.
3. Jesus C. De Sosa, "Analysis and Design of High-Voltage Transmission Lines", Luniverse Publisher, 2010.
4. Naidu, M., & Kamaraju. V., "High Voltage Engineering", Tata Mcgraw-Hill India Pvt. Ltd., New Delhi, 2013.
5. Anthigh, "High Voltage Engineering, Theory and Practice", BSP Books Pvt. Ltd., New Delhi, 2000.

14EE3028 POWER SYSTEM PLANNING AND RELIABILITY

Credit: 3:0:0

Course Objectives
- To study the fundamentals of load forecasting and its types
- To analyze the generation and transmission system reliability
- To study the expansion planning in transmission and distribution system.

Course Outcome
- Able to understand effect of load forecasting
- Able to analyze the generation and transmission system reliability
- Able to learn expansion planning in transmission and distribution system.

Description
Objectives of forecasting, Load growth patterns and their importance in planning, Multiple regression technique, Weather sensitive load forecasting, Annual forecasting, Use of AI in load forecasting, Probabilistic generation and load models, Determination of LOLP and reliability of ISO and interconnected generation systems, Deterministic contingency analysis-probabilistic load flow-Fuzzy load flow probabilistic transmission system reliability analysis, Determination of reliability indices like LOLP and expected value of demand not served. Expansion planning procedures followed for integrated transmission system planning, Capacitor placing problem in transmission system and radial distributions system. Sub transmission lines and distribution substations-Design primary and secondary systems-distribution system protection and coordination of protective devices.

Reference Books

1. Fawwaz Elkarmi&Nazih Abu-Shikhah, "Power System Planning Technologies and Applications: Concepts, Solutions and Management", Engineering Science Reference, 2012.
2. Roy Billinton & Ronald N. Allan, "Reliability Evaluation of Power System", Springer India Pvt. Ltd., 2nd Edition, 2006.

3. Hossein Seifi&Mohd. Sadegh Sepasian, "Electric Power System Planning: Issues, Algorithms and Solutions", Springer, 2013.
4. Juergen Schlabbach & Karl-Heinz Rofalski, "Power System Engineering: Planning, Design and Operation of Power System Equipments", Wiley-vch VerlagGmbh, 2010.
5. Peschon. J, "Power System Planning and Reliability", Stanford Research Institute, 1968.

14EE3029 ELECTRIC AND HYBRID VEHICLES

Credit 3:0:0

Course Objective

- To understand the concept of Electric Vehicle Technology.
- To understand various types Electric Vehicle (EV) technology.
- To know about various Electrical propulsion system.

Course Outcome

- The students will be able to understand the need of Hybrid Vehicles and Electric vehicles.
- The students will be able to design different types of Electric & Hybrid Vehicles.
- The student will be able to use the energy on-board optimally.

Description

Environmental Impact and History of Modern Transportation – Configuration of EV – Need and advantages over fuelled vehicle – Performance of Electric Vehicles –Types of Electric Vehicle - Configuration and Types of HEV and its merits and demerits - Fuel Cell Vehicles – Battery – principle and Chemical reaction of Lead acid and Lithium Batteries –Electric Propulsion Systems - DC Motor Drives Principle and Performance - Induction Motor Drives - Principles – Steady state Performance - Permanent Magnetic Brush-Less DC Motor Drives - Basic Principles of BLDC Motor Drive – SRM - Principles – Steady state Performance –Fundamentals of Regenerative Braking - Ultra capacitors – Fly Wheels.

Reference Books

1. MehrdadEhsani, YiminGao, Sebatien Gay and Ali Emadi, "Modern Electric, Hybrid Electric and Fuel cell vehicles: Fundamentals, Theory and Design", CRC press, 2004.
2. James Larminie and John Loury, "Electric Vehicle Technology – Explained", John Wiley & Sons Ltd, 2003.
3. Sandeep Dhameja, "Electric Vehicle Battery Systems", Butterworth – Heinemann, 2002.
4. Ronald K Jurgen, "Electric and Hybrid – Electric Vehicles", SAE, 2002.
5. Ron Hodkinson and John Fenton, "Light Weight Electric/Hybrid Vehicle Design", Butterworth – Heinemann, 2001.

14EE3030 MODELLING AND DESIGN OF ELECTRIC AND HYBRID VEHICLE

Credit 3:0:0

Prerequisite: 14EE3029 Electric and Hybrid Vehicles

Course Objective

- To understand the factors those influence the performance of EHV.
- To understand need for mathematical modelling of EHV.
- To understand the modelling for EHV drives.

Course Outcome

- The students will be able to understand the merits and demerits of various mathematical models of Electric and Hybrid Vehicle.
- The students will be able to design the EHV using the mathematical Model.
- The students will be able to simulate and observe the behaviour of the EHV.

Description

Vehicle Architecture - Tractive Effort - Aerodynamic Considerations - Consideration of Rolling Resistance - Transmission Efficiency- Consideration of Vehicle Mass - Electric Vehicle Chassis and Body Design – Vehicle Linear, Dynamic Model and reference Model - Modelling Vehicle Acceleration - Modelling Electric Vehicle Range – IC Engine for Hybrid Vehicle Modelling - Battery Modelling – Modelling DC Motor drive and Controller - Induction Motor drive and controller - SRM drive and controller drive – PMSM drive and Controller.

Reference Books

1. MehrdadEhsani, YiminGao, Sebatien Gay, Ali Emadi, "Modern Electric, Hybrid Electric and Fuel cell vehicles: Fundamentals, Theory and Design", CRC press, 2004.
2. James Larminie, John Loury, "Electric Vehicle Technology – Explained", John Wiley & Sons Ltd, U.K., 2003.
3. Seref Soylu, "Electric Vehicles – Modelling and Simulations", InTech, Croatia, 2011.
4. Haitham Abu-Rub, Atif Iqbal, Jaroslaw Guzinski , "High Performance Control of AC Drives with Matlab / Simulink Models", John Wiley, U.K., 2012.
5. Thipse S. S., "Internal Combustion Engines", Jaico Publishing House, New Delhi, 2010.

14EE3031 POWER MANAGEMENT FOR HEV

Credit 3:0:0

Course Objective

- To understand the need for power management of HEV.
- To understand analytical controller.
- To understand the Controller modelling for EHV drives.

Course Outcome

- The students will be able to understand the need of mathematical Modelling the Electric and Hybrid Vehicle.
- The students will be able to design the EHV using the mathematical Model.
- The students will be able to simulate and observe the behaviour of the EHV.

Description

Vehicle Configuration – Vehicle Fuel Consumption and Performance – Power demand in drive cycles – objective of Vehicle Power Management (VPM) – VPM in conventional and HEV – Analytical approach for VPM – Wavelet Technology – Dynamic and quadratic programming – Intelligent System approach for VPM – Application of Fuzzy Logic and Neural Network in VPM – Sliding mode and Fuzzy Logic based powertrain controller for Series HEV – Management of Energy Storage Systems in EV, HEV and PHEV – HEV Component design and optimisation for fuel economy – Future trends

Reference Books

1. Xi Zhang, Chris Mi, "Vehicle Power Management: Modelling, Control and Optimisation" Springer – Verlag, London, 2011.
2. Wei Liu, "Introduction to Hybrid Vehicle System Modelling and Control", Wiley Publication, 2013.
3. Danil Prokhorov, "Computational Intelligence in Automotive Applications", Springer, 2008

14EE3032 HYBRID-ELECTRIC VEHICLE POWERTRAINS

Credits: 3:0:0

Prerequisite:14EE3029 Electric and Hybrid Vehicles

Course Objective

- Study the energy requirements for hybrid electric vehicles.
- Understand the operation and characteristics of various motors used in electric vehicles

- Study the operation of various converters for driving motors in electric vehicles and hybrid electric vehicles.

Course Outcome

The student will be able to

- know the energy requirements for hybrid electric vehicles and importance of using high efficiency motors and converters.
- know the selection and usage of various electric motors in electric and hybrid electric vehicles.
- select suitable power electronic converter for driving motors in EV and EHV so as to deliver maximum efficiency and energy regeneration.

Description:

Hybrid Powertrains for Commercial Vehicles-Classification-Hybrid Powertrain Architecture Evolution -Energy Power Requirements for HEV Power Train Modeling and Control- IC Engines for commercial vehicles-Clutches and transmission for commercial vehicles – Electric Machines in Hybrid Powertrain- Electric Machines and their Controllers for EV- DC and AC Electric Machines-Operation, characteristics, Efficiency- Converters for Electric vehicle- DC–DC Converters Applied in Hybrid Vehicle Systems, DC–AC Inverter-Design Requirements of an Energy Storage Unit Equipped with Battery-BMS design, Battery and Ultra capacitor in hybrid power train, voltage equalization- Basic Hybrid Powertrains Modeling- Hybrid-electric Power Conversion Systems-Hybrid-electric System Design and Optimization-Characteristics of Hybrid-electric Powertrains -Hybrid System Selection- Fuel Cell Hybrid Powertrain Systems-operation-PEM vehicles, SOFC vehicles- Future Powertrain Technologies.

Reference books

1. AntoniSzumanowski, "Hybrid Electric Power Train Engineering and Technology: Modeling, Control, and Simulation", Warsaw University of Technology, Idea Group,U.S.; 1st edition, May, 2013
2. Haoran Hu, Simon Baseley and Rudolf M. Smaling, "Advanced Hybrid Powertrains for Commercial Vehicles", SAE International, Warrendale, Pennsylvania, USA, 2012
3. Iqbal Husain, "Electric and Hybrid Vehicles: Design Fundamentals", Second Edition, CRC Press, 2003
4. Gianfranco Pistoia , "Electric and Hybrid Vehicles: Power Sources, Models, Sustainability, Infrastructure and the Market", Elsevier Publication, 1st Edition , 2010.
5. James Larminie and John Loury, " Electric Vehicle Technology – Explained", John Wiley & Sons Ltd, 2003.
6. Wei Liu, "Introduction to Hybrid Vehicle System Modeling and Control", Wiley Publication, 2013.

14EE3033 VEHICLE ENERGY STORAGE SYSTEMS

Credits: 3:0:0

Course Objective

- Study the methods of energy storage in electric vehicles.
- Understand the operation of various storage devices, their characteristics and maintenance.
- Study the various parameters affecting the service life of battery and other storage devices.

Course Outcome

The student will be able to

- know the usage of various storage devices that can be particularly used in electric vehicles.
- •manage the energy requirement when multiple sources are used for storing and/or generation.
- •Select a suitable storage device; interpret their characteristics and parameters.

Description:

Essential of energy storage in Electric vehicles- Energy storage, conversion and power systems from the perspective of HEV propulsion systems -Types of energy sources for EV- Electrochemical storage systems- Batteries- Principle-Battery Parameters- Lead Acid Batteries, Nickel-Based Batteries, Lithium Batteries, Metal–Air Batteries- Battery Modeling- Constant Current Discharge Approach- Standard Driving Cycles- Power Density Approach- Fuel Cells-Characteristics- Types -Fuel cell EV- Supercapacitors- Flywheels -Energy management-Methods of determining storage charge- Energy storage systems requirements-Service life in partial-state-of-charge (PSOC) Operation-

Dynamic charge acceptance- Multiple Energy Sources Hybridization-Maintenance-Recycling-Future trends of Hybrid Vehicle Storage Technology.

Reference books:

1. James Larminie and John Loury, " Electric Vehicle Technology – Explained", John Wiley & Sons Ltd, 2003.
2. Christopher D. Rahnand Chao-Yang Wang, "Battery Systems Engineering", Wiley Publication, New Delhi, India, 2013
3. Iqbal Husain, "Electric and Hybrid Vehicles: Design Fundamentals",2nd Edition, CRC Press, 2003
4. Adam Stienecker ,"Hybrid Energy Storage Systems: An Ultracapacitor-Battery Energy Storage System for Hybrid Electric Vehicles", VDM Verlag Publication, 2009
5. Rodrigo Garcia-Valle and João A. Peças Lopes "Electric Vehicle Integration into Modern Power Networks (Power Electronics and Power Systems)", Springer Publication, 2012 Edition.
6. Wei Liu, "Introduction to Hybrid Vehicle System Modeling and Control", Wiley Publication, 2013
7. Davide Andrea "Battery Management Systems for Large Lithium Battery Packs", Artech House Publishers, 2010

14EE3034 ELECTRIC VEHICLE BATTERY TECHNOLOGY

Credits: 3:0:0

Course Objective

- Study in detail about the various types of batteries for EV, their operation and characteristics.
- Understand the equivalent circuit and modeling of battery.
- Study the battery management system and its function in EV.

Course Outcome

The student will be able to

- know the performance of various types of batteries for EV.
- model a battery based on the parameters of the battery.
- know the functions of energy management system and deploying it in an EV.

Description:

Battery Electric Vehicles-Technology details-Vehicle Energy Efficiency Performance-EV Battery Capacity- Battery Parameters-Types of Battery for EV- Technical Characteristics-Battery Modeling- Purpose of Battery Modeling-Battery Equivalent Circuit- EV Battery Charging And Discharging- Battery Performance- Battery Storage System Modeling and Control- Methods of Determining State of Charge - Estimation of Battery Power Availability- PNGV HPPC, Based on Electrical Circuit Equivalent Model- Battery Life Prediction- Aging Behavior and Mechanisms-State of Life- Cell Balancing- SOC Balancing, Hardware Implementation of Balancing, Cell Balancing Control Algorithms and Evaluation- Estimation of Cell Core Temperature- EV Battery System Efficiency, Battery Management Systems-Functionality, Technology, Topology -Functions-Measurement, Management, Evaluation-Deploying a BMS- Battery Manufacturing Process-Maintenance- Recycling and Disposal.

Reference Books:

1. Sandeep Dhameja ,"Electric Vehicle Battery Systems" ,Newnes Publication, 1st Edition, 2002.
2. Christopher D. Rahn, Chao-Yang Wang, "Battery Systems Engineering", Wiley Publication 2013.
3. Wei Liu, "Introduction to Hybrid Vehicle System Modeling and Control", Wiley Publication 2013
4. James Larminie and John Loury, " Electric Vehicle Technology – Explained", John Wiley & Sons Ltd, 2003.
5. Davide Andrea "Battery Management Systems for Large Lithium Battery Packs", Artech House Publishers 2010

14EE3035 MODELING OF POWER CONVERTERS

Credits: 3:0:0

Prerequisite: 14EE3002 Power Converter Analysis – I
14EE3003 Power Converter Analysis – II

Course Objective

- To impart the knowledge of latest advances in the field of power electronics.
- To understand the basics of modeling of power converters.
- To introduce the phenomena of non-linearity in power converters.

Course Outcome

- To understand the effect of power electronic converter in a system using their models and transfer functions
- Ability to design filters for converters
- To understand the impact of non-linear phenomena in power electronic circuits

Description

Basic AC modeling approach – State-space averaging – Circuit averaging and averaged switch modeling – Canonical circuit model .Analysis of converter transfer functions – Graphical construction of impedances and transfer functions – Graphical construction of Converter transfer functions .Effect of an input filter on converter transfer functions – Design of a damped input filter. Border collision bifurcations in the current mode controlled boost converter -Bifurcations and chaos in the latched voltage controlled buck converter - Saddle-node and Neimark bifurcations in PWM DC-DC converters .Non-Linear Phenomena in Power Electronics Circuits and Analysis of stability and bifurcation in power electronic induction motor drive systems.

Reference Books

1. Erickson R.W., Maksimovic D., "Fundamentals of Power Electronics", Kluwer Academic Publishers, USA, 2nd Edition, 2004.
2. Banerjee S., Varghese G. C., "Non-linear phenomena in Power Electronics: Attractors, Bifurcations, Chaos and Non-linear control", IEEE press, New York, 2001.
3. Chi Kong Tse, "Complex Behaviour of Switching Power Converters", CRC Press, New York, 2004.
4. Ned Mohan, T. M. Undeland, W. P. Robbins, "Power Electronics: Converters, Applications and Design", John Wiley & Sons, USA, 3rd Edition, 2003.
5. Hua Bai, Chris Mi, "Transients of Modern Power Electronics", John Wiley & Sons, UK, 2011.

14EE3036 POWER ELECTRONICS IN WIND AND SOLAR POWER CONVERSION

Credits: 3:0:0

Course Objective

- To study the role of power electronics in various photovoltaic energy conversion and wind energy conversion.
- To analyze the performance of various converters and inverters.
- To learn the integration of renewable energy conversion system with the grid.

Course Outcome

- Design PV systems to meet the requirement of battery operated vehicle and other related applications
- Understand various factors which affect the wind energy conversion system.
- Design isolated power generators used in wind energy conversion system.

Description

Photovoltaic Energy Conversion: Solar radiation and measurement and availability - solar cells and their characteristics - influence of insulation and temperature - Electrical storage with batteries–Switching devices-DC Power conditioning converters – MPPT- AC and DC power conditioners -Line commutated inverters – synchronized operation with grid supply- Harmonic problem–Applications - Wind energy conversion(WEC):Principle, classification, components-Power in the wind- Performance of induction generators for

WECS - Self excited induction generator for isolated power generators - Theory of self-excitation - Capacitance requirements – Power conditioning schemes - Controllable DC Power from Self excited induction generators (SEIGs) -system performance. Grid Connected WECS: Grid connectors concepts - wind farm and its accessories - Grid related problems - Generator control- Performance improvements – Different schemes - AC voltage controllers - Harmonics and PF improvement - Wind/solar PV integrated systems -Optimization of system components - storage – Reliability evaluation.

Reference Books

1. Rai, G.D., "Non-conventional Energy Sources", Khanna Publishers Limited, New Delhi, 1st Edition, 2004.
2. Rai, G.D., "Solar Energy Utilization", Khanna Publishers Limited, New Delhi, 2000.
3. Mukund R Patel, "Wind and Solar Power Systems", Taylor & Francis Group, United Kingdom, 2nd Edition, 2005.
4. Thomas Markvart and Luis Castaser, "Practical Handbook of Photo-Voltaics", Elsevier Science & Technology, New Delhi, 2003.
5. Hermann-josef Wagner, JyotirmayMathur, "Introduction To Wind Energy Systems: Basics, Technology and Operation", Springer International, United Kingdom, 2009.

14EE3037 DSP CONTROLLERS FOR POWER CONVERTERS AND DRIVES

Credits: 3:0:0

Course Objective

- Basics of motion control Digital Signal Processor and generation of PWM Signals
- Concept of Event Handling, Interrupts and Interface Conversion
- Control of Motor using a DSP

Course Outcome

- Select a suitable Digital Signal Processor for the control of the machine.
- Implement the DSP based Control for the machine.
- Use real time DSP system for online control

Description

TMS320C28XX architecture overview – Memory – Central Processing Unit – General Purpose I/O functionality – Interrupts – Event Managers – General Purpose Timers – Compare Units – Capture Units – Quadrature Encoded Pulse Circuitry – Analog to Digital Converters – Instruction sets - Clarke's & Parke's Transformation – Space Vector PWM Technique – control of DC buck –boost converter, Multilevel & Matrix DC Motor - Induction Motor control –Converter - Stepper Motor Control – Control of Permanent Magnet Synchronous Motor – Switched Reluctance Motor control – BLDC Motor Control.

Reference Books

1. Hamid A. Toliyat, Steven G.Campbell, "DSP based Electromechanical Motion Control", CRC Press 2004.
2. Bimal K. Bose, "Power Electronics and Variable Frequency Drives – Technology and Applications", IEEE Press, 1997.
3. Peter Vas, "Vector Control of AC Machines", Oxford University Press, 1990.
4. Ned Mohan, "Advanced Electric Drives: Analysis, Control and Modeling using SIMULINK", John Wiley & Sons Ltd., 2001.

14EE3038 POWER QUALITY

Credits 3:0:0

Course Objectives

- To study the power quality problems in grid connected system and isolated systems.
- To study the various power quality issues and mitigations techniques.
- To study about the various harmonics elimination methods.

Course Outcomes

- Ability to apply knowledge of power quality and harmonics in power systems, and engineering to the analysis and design of electrical circuits.
- Ability to design a system, components or process to meet desired needs within realistic constraints and to mitigate PQ problems such as economic, environmental, social, ethical, health and safety.
- Ability to function on multi-disciplinary teams for power quality improvement.

Description

Power quality – Voltage quality - Power quality issues - Electro Magnetic Compatibility (EMC) Standards - CBEMA & ITI curves - Short interruptions - End user issues - Long Interruptions - Voltage Sag - Mitigation methods – Transients and Over voltage protection - Utility capacitor switching transients - Utility lightning protection – Waveform Distortion - Definition and terms in Harmonics - Principles of controlling harmonics - Mitigation and control techniques - Introduction - Power quality monitoring - Deregulation effect on power quality monitoring - Brief introduction to power quality -measurement equipments and power conditioning equipments - Planning, Conducting and Analyzing power quality survey.

Reference Books

1. Barry W. Kennedy, "Power Quality Primer", McGraw-Hill, New York, 2000.
2. Sankaran C., "Power Quality", Washington, CRC Press, 2001.
3. Math H.J. Bollen, "Understanding Power Quality Problems: Voltage Sags and Interruptions", New York, IEEE Press, 1999.
4. J. Arriliaga, N.R. Watson and S. Chen, "Power System Quality Assessment", John Wiley, & Sons, England, 2000.
5. Dugan, Mark F. Mc Granaghan and H. Wayne Beaty, "Electrical Power Systems Quality", McGraw-Hill, NewYork, 2002.

14EE3039 TIDAL ENERGY

Credits 3:0:0

Course Objective

- To provide necessary knowledge about the basics, design and analysis of tidal energy.
- To make the learner to understand the operation of tidal power plants.
- To impart the basic knowledge about integration of tidal power plants with grid

Course Outcome

- Have awareness about the possibilities of power generation from tides
- Suggest new mechanisms to harvest energy from tides
- Design efficient tidal power plants

Description

Tides – Generating Forces – Enumerate and discuss all forces and periodicities related to tides – Analysis and prediction of tides and tidal current – methods to analyze sea level and current by classic harmonic analysis and by selected modern tools related to energy spectra. Structure of tidal currents – effects of intense turbulence generated by tides which erases vertical stratification and forms the tidal fronts in shallow water domains – Tidal dynamics – Using Kelvin and Sverdrup Waves to explain primary features of the observed tides – Introduction to numerical solution of the tidal equation – Tidal Power – Basic laws of tidal energy generation, transport and dissipation – Harnessing the power of tides for the generation of electricity – Impacts of tides on Climate.

Reference Books:

1. Oceanography Course Team, "Waves, tides and shallow-water processes". Pergamon Press, 1993.
2. Pugh D.T., "Tides, Surges and Mean Sea-Level: A Handbook for Engineers and Scientists", Wiley, Chichester, 2004.
3. Massel S. R. , "Fluid mechanics for Marine Ecologists", Springer Verlag Berlin Heidelberg, 1st Edition, 1999..

4. Mann, K. H., J. R. N. Lazier, “Dynamics of Marine Ecosystems”, Blackwell Scientific Publication, 1991.
5. Charles D. Keeling , Timothy P. Whorf , “Possible forcing of global temperature by the oceanic tides”, Proceedings of the National Academy of Sciences of the United States of America, Vol 94, No. 16, 1997, pp 8321 – 8328.

14EE3040 SIMULATION OF POWER ELECTRONIC SYSTEMS

Credits: 3:0:0

Prerequisite: 14EE3014 Power Electronic Circuits/
14EE3002 Power Converter Analysis – I &
14EE3003 Power Converter Analysis - II

Course Objective

- To study the basics of static and dynamic models of power electronic switches
- To learn the usage of the software tools like MATLAB, PSIM and PSPICE
- To understand the operation of different types of power electronic converters using the above mentioned tools

Course Outcome

- do the mathematical modeling of power devices under steady state and dynamic conditions
- use the various functional blocks available in the simulation packages for the problems specified
- design and simulate any power electronic circuits and compare the performance with other simulation tools

Description

Need for simulation - Challenges in simulation, Mathematical modeling of power electronic systems -MATLAB PROGRAMMING:Basic Operations, Plotting. MATLAB Programs to analyze power electronic circuits - Model analysis using SIMULINK – Simpower systems- Simulating Induction Motor Drive- Performing Harmonic Analysis - PSIM: Power circuit components – Control circuit & other components Simulation of PWM inverters- Simulation of BLDC and SRM - PSPICE:File formats– Dot commands - SPICE models of Power Electronic Devices - Simulation of inverters.

Reference Books

1. Shailendra Jain, “Modelling & Simulation using MATLAB & Simulink”,Wiley-India,2011
2. Rashid .M.H., “SPICE for Power Electronics and Electric Power”, CRC Press, New Delhi, 3rd Edition, 2012.
3. Rashid, M.H., “Power Electronics Handbook”, Academic Press, USA, 2011.
4. SimPowersystems User Guide, 2011.
5. PSIM User’s Guide”, Powersim Inc., 2011.

14EE3041 POWER ELECTRONICS APPLICATIONS TO POWER SYSTEMS

Credits: 3:0:0

Course Objective

- To understand the safe and secure operation of simple power system.
- To suggest suitable possibilities to extend power system operation.
- To understand the recent advancements in power systems using the power electronic systems.

Course Outcome

- Find the solutions for eliminating harmonics and EMI present in the output due to fast switching devices.
- Apply power system fundamentals to the design of a system that meet specific needs.
- Design necessary filter circuit require to the distributed network.

Description

High power devices - Characteristics - Single and three phase converters - Harmonics – Effects of source and load impedance - Gate control - Basic means of control - Control characteristics - Stability of control - Reactive power control - Power flow analysis - Wind Energy Conversion System HVDC & FACTS SYSTEMS: Static VAR control - Sources of reactive power - Harmonics and filters - Static VAR compensators - Thyristor Controlled Reactor – Thyristor Switched Capacitor - Static Condenser - Controllable Series Compensation.

Reference Books

1. Padiyar. K.R., "HVDC Power Transmission System", New Age International Private Limited, New Delhi, Reprint 2010.
2. Erich Uhlmann, "Power Transmission by Direct Current", Springer International Edition, New Delhi, 1st Indian Reprint, 2004.
3. Rai, G.D., "Solar Energy Utilization", Khanna Publishers Limited, New Delhi, 2000.
4. Kimbark, E.X., "Direct Current Transmission", Wiley Inderscience, New York, 1971.
5. Rao S., "EHV-AC, HVDC Transmission and Distribution Engineering (Theory, Practice and Solved Problems)", Khanna Publishers, New Delhi, 2006.

14EE3042 NEURO-FUZZY CONTROLLERS FOR ELECTRIC DRIVES

Credits3:0:0

Course Objective

- To impart the knowledge on the fundamental concept of neurons and their artificial models
- To understand the Structure of fuzzy logic controller and its application to electric drives
- To provide comprehensive knowledge of fuzzy logic and neuro controllers

Course Outcome

- Explain the various learning algorithms derived from the biological neurons
- Apply the concept of neural network for optimization of any system problem
- Use appropriate network for fault diagnosis and pattern recognition.

Description

Introduction to Neural Networks - Biological neurons and their artificial models - Learning, adaptation and neural network's learning rules - Types of neural networks, Neural network for non-linear systems -Schemes of Neuro control – Introduction to Fuzzy Logic - Fuzzy sets- Fuzzy operation -Fuzzy arithmetic - Fuzzy relations, Fuzzy measure –Approximate reasoning -Fuzzy propositions - Fuzzy quantifiers , Structure of fuzzy logic controller - Fuzzification models, defuzzification module - Non-linear fuzzy control - Neuro controllers & Fuzzy Controllers for AC Drives – Hybrid Neuro- Fuzzy Controllers & Adaptive Neuro – Fuzzy Controllers for Motor Drives.

Reference Books

1. Jang Jyh-shing Roger, Sun Chuen-tsai, MizutaniEiji," Neuro-Fuzzy And Soft Computing: A Computational Approach To Learning And Machine Intelligence" PHI Learning Private limited,2009
2. Timothy Ross, "Fuzzy Logic with Engineering Applications", Wiley India Private Ltd, New Delhi, 2011.
3. Jacek M Zurada, "Introduction to Artificial Neural Systems", Jaico Publishing House, New Delhi, 2001.
4. LaureneFausett, "Fundamentals of Neural Networks: Architectures, Algorithms and Applications", Pearson Education India, New Delhi, 2009.
5. Driankov, Hellendroon, "Introduction to Fuzzy Control", Narosa Publishers Limited, New Delhi, 2001.
6. Sivanandam S.N., Sumathi. S and Deepa S.N., "Introduction to Neural Networks using MATLAB 6.0", Tata MCGraw-Hill Education India Private Limited, New Delhi, 2006.
7. Sivanandam S.N., Sumathi. S and Deepa S.N., "Introduction to Fuzzy Logic using MATLAB", Springer Verlag Berlin Heidelberg Publisher, New York, 2007.

14EE3043 ADVANCED CONTROL TECHNIQUES FOR INDUCTION GENERATORS

Credits: 3:0:0

Prerequisite: 14EE3014 Wind Energy

Course Objective

- To understand the transient and steady state modeling of induction generators.
- To give an in-depth knowledge about the different control techniques of induction generators.
- To enhance the students' perspective on optimized control of induction generators which are widely used in renewable energy systems.

Course Outcome

- Understand the complex control concepts
- Ensuring energy economy and efficiency.
- Apply the optimization techniques for maximum performance

Description

Steady State Model, Performance Characteristics, Modified Equivalent Circuits – Effect of Rotor-Injected EMF – Dynamic d-q Axis Model, Induction Machine in Transient State, State Space Based Induction Generator Modeling, DFIG, Partition of the SEIG State Matrix with an RLC load, Problems - Constant–voltage, Constant–frequency Generation, Reactive Power Compensation ,Variable-voltage, Variable-frequency Generation, Scalar Control Schemes, Direct Vector Control, Indirect Vector Control, HCC based Maximum Power Search, Fuzzy Logic Controller based Maximum Power Search – island issues.

Reference books

1. Godoy Simões M., Farret F. A., "Alternative Energy Systems: Design and Analysis withInduction Generators," 2ndEdition, CRC Press, Boca Raton, 2007.
2. Bhadra S. N., Kastha D., Banerjee S., "Wind Electrical Systems", Oxford University Press, New Delhi, 2013.
3. VladislavAkhmatov, "Induction Generators for Wind Power", Multi-Science PublishingCompany, UK, 2007.
4. Ion Boldea, "Variable Speed Generators", CRC Press, Boca Raton, 2006.
5. Loi Lei Lai, Tze Fun Chan, "Distributed Generation: Induction and Permanent Magnet Generators", John Wiley & Sons, England, 2008
6. Abad G., Lopez J., Rodriguez M., Marroyo L., Iwanski G. "Doubly Fed Induction Machine, Modeling and Control for Wind Energy Generation", Wiley - IEEE Press, England, 2011.

14EE3044 OPTIMAL CONTROL OF WIND ENERGY SYSTEMS

Credits: 3:0:0

Prerequisite: 14EE3014 Wind Energy

Course Objective

- To understand the importance of optimal control in wind energy systems
- To impart the basics of modeling of wind energy conversion system
- To introduce the various parameters that need to controlled in wind energy systems

Course Outcome

- Learn the various techniques that can be used to obtain optimal control
- Lay the basics of efficient control of wind energy systems and thus to make wind power a
- main source of renewable energy
- Ability to innovate on new control techniques for a efficient wind energy conversion system

Description

Electrical Generator Modeling - Drive Train Modeling Power Electronics Converters & Grid Modeling – Linearization & Eigen value analysis – Case study – Control of generators in WECS – Control System for Grid connected operation and Energy Quality Assessment - MPPT strategies – PI , ON/OFF & Sliding mode control – Feedback Linearization & QFT Robust Control. LQ control of WECS – 2LFSP applied to WECS with Rigidly-coupled generator and flexibly- coupled generator - Voltage and Reactive Power Control:

Reference Books

1. IulianMunteanu, AntonetaIulianaBratcu, Nicolaos-Antonio Cutululis, Emil Ceang, "Optimal Control of Wind Energy Systems - Towards a Global Approach", Springer- Verlag, London, 2008.
2. Thomas Ackermann, "Wind Power in Power Systems", John Wiley & Sons Ltd., England, 2005.
3. Fernando D. Bianchi, Hernan De Battista, Ricardo J. Mantz, "Wind Turbine Control Systems: Principles, Modelling and Gain Scheduling Design", Springer-Verlag, London, 2007.
4. Olimpo Anaya-Lara, Nick Jenkins, JanakaEkanayake, Phill Cartwright, Mike Hughes, "Wind Energy Generation- Modelling and Control", John Wiley & Sons Ltd., UK, 2009.
5. Siegfried Heier, "Grid Integration of Wind Energy Conversion System", 2nd Edition, John Wiley & Sons Ltd., England, 2006.

14EE3045 WIND RESOURCE ASSESSMENT AND FORECASTING METHODS

Credits: 3:0:0

Prerequisite: 14EE3014 Wind Energy

Course Objective

- To understand the basics of assessing potential sites for wind farms
- To learn the mathematical basics involved in forecasting of data
- To equip the student with the latest forecasting techniques

Course Outcome

- Ability to understand the technical and economical aspect of wind resource assessment
- Ability to understand the basics of available forecasting models
- Ability to develop accurate forecasting models

Description

Forecasting Techniques –Time Series and Cross-sectional Data- Measuring Forecast Accuracy - Principles of Decomposition – Moving Averages– Local Regression Smoothing – Census Bureau Method - Forecasting Scenario - Averaging Methods – Smoothing Methods - Regression Methods and Forecasting – ARIMA Models: Time Series Data – Forecasting with ARIMA Models -Intervention analysis – State space models – Non-linear models – Neural network forecasting.

Reference Books

1. Makridakis S., S. C. Wheelwright, R.J. Hyndman, "Forecasting – Methods and Applications", 3rd Edition, Wiley-India Edition, New Delhi, 2011
2. Wind Resource Assessment Handbook, AWS Scientific Inc., New York 1997.
3. Michael Brower, Daniel W. Bernadett, Kurt V.Elsholz, Matthew V. Filippelli, Michael J. Markus, Mark A. Taylor, Jeremy Tensen, "Wind Resource Assessment: A Practical Guide to Developing a Wind Project", John Wiley & Sons, London, 2012.
4. J. Scott Armstrong, "Principles of Forecasting: A Handbook for Researchers and Practitioners", Springer Science + Business Media Inc., USA, 2001.
5. Douglas C. Montgomery, Cheryl L. Jennings, Murat Kulahci, "Introduction to Time Series Analysis and Forecasting", John Wiley & Sons, New Jersey, 2008.

14EE3046 TURBINES FOR RENEWABLE ENERGY SYSTEMS

Credits 3:0:0

Course Objective

- To expose the students to different turbines used for renewable energy systems
- To equip the students to design turbines for different power generation schemes

- To enable the students to identify any flaws and faults related to turbines and its design

Course Outcome
- Clear idea about the turbines, its operation under various conditions.
- Ability to design and develop turbines for different power generation systems
- Ability to bring out finer and more efficient designs for turbines

Description
Energy Conversion – Types of Turbines – General Turbine Design Aspects- Solar Based Power Generation Types – Turbine Models for Solar Applications - Horizontal and Vertical Axis Wind Turbines – Design - Problems Softwares for Turbine Design - Overview – Turbine Design for Solar Based Power Generation - Conventional, Pumped Storage - Hydro Turbine Designs- Francis, Pelton, Kaplan turbines - Turbine Design for Tidal Power- Turbines for Geothermal Plant, Ocean Thermal Energy Conversion Systems. Design Issues- Problems

Reference Books
1. David M. Eggleston., "Wind Turbine Engineering Design", Amazon publications, 1st Edition, 1987.
2. Peter Jamieson, "Innovation in Wind turbine design", Wiley, 1st Edition, 2011.
3. Jeremy Thake., "The Micro-Hydro Pelton Turbine Manual: Design, Manufacture and Installation for Small-Scale Hydro-Power" Amazon, 2001.
4. Shylakhin., "Steam Turbines: Theory and Design" Amazon, 2005.

14EE3047 DATA MINING FOR RENEWABLE ENERGY TECHNOLOGY

Credits: 3:0:0

Course Objective
- To enlighten the students' on the basic concepts of data mining.
- To improve the students' competence in the algorithms and learning schemes of data mining.
- To enable the students to exploit the data mining techniques for research in renewable energy.

Course Outcome
- Understand the importance of data-driven performance optimization of renewable energy technology.
- Exploit the vast data base available in the renewable energy sector and devise ways to make renewable energy a competitive source of supply.
- Find the various research opportunities provided by this field.

Description
Data Mining, Functionalities, Classification, Primitives, Data Preprocessing, Data Warehousing, Multidimensional Data Model, Data Warehouse Architecture & Implementation, Mining Frequent Patterns, Associations, Mining Multilevel Association Rules - Decision tree Induction, Bayesian Classification, Lazy Learners, Other Classification Methods, Prediction, Accuracy and Error Measures, Categorization of Major Clustering Methods, Partitioning Methods, Hierarchical Methods, Mining Stream, Time-Series and Sequence Data - Application of Data Mining in Wind Power System, Wind Power Prediction, Modeling and Forecasting of Solar Radiation Data, Analyzing Solar Power Plant Performance.

Reference Books
1. Jiawei Han, MichelineKamber, "Data Mining : Concepts and Techniques", II Edition, Morgan Kaufmann Publishers, San Francisco, 2006
2. Ian Witten, Eibe Frank, "Data Mining: Practical Machine Learning Tools and Techniques", III Edition, Morgan Kaufmann Publishers, San Francisco 2011.
3. Sumathi S., S. N. Sivanandam, "Introduction to Data Mining and its Applications", Springer-Verlag Berlin Heidelberg 2006.
4. David Hand, HeikkiMannila, Padhraic Smyth, "Principles of Data Mining", A Bradford Book, The MIT Press, Cambridge, Massachusetts London, England, 2001.
5. Michael J A Berry, Gordon S Linoff, "Data Mining Techniques", II Edition, Wiley India, 2004.

14EE3048 GRID CONVERTERS FOR WIND POWER SYSTEMS

Credits: 3:0:0

Prerequisite: 14EE3012 Power Electronic Circuits
14EE3014 Wind Energy

Course Objective

- To illustrate key concepts about converter structures and grid requirements
- To enlighten the students about the latest power conversion and control technology in photovoltaic and wind power systems
- To provide in-depth understanding about grid synchronization

Course Outcome

The student will be able to

- Know about the stringent grid requirements due to high penetration of renewable energy systems
- Understand the topologies, modulation and control of grid converters for both photovoltaic and wind power applications.
- Understand the advanced functions of grid converters like dynamic control of active and reactive power, voltage ride-through capability, grid services support etc.

Description

Introduction – Grid Converter Structures for Wind Turbine System – Grid Requirements for Wind Turbine System – Grid Synchronization in Three-Phase Power Converters – Grid Converter Control for Wind Turbine System - Control of Grid Converters under Grid Faults – Grid Filter Design – Grid Current Control

Reference Books

1. Teodorescu R., Liserre M., Rodriguez P., "Grid Converters for Photovoltaic and Wind Power System", John Wiley & Sons Ltd., UK, 2011.
2. Wu B., Lang Y., Zargari N., Kouro S., "Power Conversion and Control of Wind Energy", John Wiley & Sons, New Jersey, 2011.
3. Zhong Q.C., Hornik T., "Control of Power Inverters in Renewable Energy and Smart Grid Integration", John Wiley & Sons, UK, 2013.
4. Gevorkian P., "Large-Scale Solar Power System Design – An Engineering Guide for Grid-Connected Solar Power Generation", Mc-Graw Hill, New York, 2011.
5. Vittal V., Ayyanar R., "Grid Integration and Dynamic Impact of Wind Energy", Springer, New York, 2013.

14EE3049 OFFSHORE WIND POWER

Credits: 3:0:0

Course Objective

- To have an overview of the complete range of offshore wind issues.
- To understand the fundamental and electrical aspects of offshore wind turbines, regulatory framework, grid integration and market incentives
- To instigate interest in the minds of students to know the advantages and ecological impacts of offshore wind

Course Outcome

The student will be able to

- Know the design optimization of offshore wind to support cheaper installation and hauling, incurring lower project costs to improve profitability.
- Understand the latest technology in offshore wind energy, foundation design and turbine materials
- Deal with on-site complications, mitigate potential problems up-front and know the intricacies of successful installation

Description

Introduction – Offshore Wind Energy System Components – Leasing and Stages of Offshore Development – Cost Factors - Offshore Wind Energy Technology – New Concepts and Components – Analysis and Design Tools for Wind Turbines – Offshore Floating Turbines – Foundation Design in Deep Waters – Turbine Materials - Transport, Installation and Logistics – Evaluation of Harmonic Risk in Offshore Wind Farms – Upkeep of Offshore Wind Farms – Grid Integration of Offshore Wind Power – Ecological Impacts of Offshore Wind Energy.

Reference Books

1. Twidell J., Gaudiosi G., "Offshore Wind Power", Multiscience Publishing Co. Ltd., UK, 2009
2. Jos Beurskens, "Converting Offshore Wind into Electricity", Eburon Academic Publishers, The Netherlands, 2011.
3. Kurt Thomsen., "Offshore Wind: A Comprehensive Guide to Successful Offshore Wind Farm Installation", Elsevier, US, 2012.
4. 4.Koller J., Koppel J., Peters W., "Offshore Wind Energy – Research on Environmental Impacts", Springer, New York, 2006
5. Zubiaga M., et al., "Energy Transmission and Grid Integration of AC Offshore Wind Farms", InTech Publishers, Croatia, 2012

14EE3050 WIND POWER IN POWER SYSTEMS

Credits: 3:0:0

Course Objective

- To understand the power system impacts of wind power, technical regulations and interconnections.
- To present the basic concepts of power quality standards for wind turbines
- To address the modeling and control of smart grid renewable energy systems

Course Outcome

The student will be able to

- Understand the technical, economic and safety issues inherent in the integration of wind power in the power system
- Know the basic interconnection issues, electrical design of wind power plant and importance of power system stability
- Understand the necessity of dynamic modeling of wind turbines and smart grid technology.

Description

Introduction – Power System Impacts of Wind Power – Power Quality Standards for Wind Turbines – Measurement of Electrical Characteristics – Technical Regulations for Interconnection of Wind Power Plants to Power Systems - Electrical Design of Wind Power Plant – Transmission Systems for Offshore Wind Power Plants – Wind Power and Storage - Dynamic Modeling of Wind Turbines for Power System Studies – Generic Wind Power Plant Model – High-Order Models of Doubly Fed Induction Generators – Impacts of Wind Power on Power System Stability - Wind Power and Smart Grid – Active Management of Distribution Systems – Reactive Power Capability and Voltage Control with Wind Turbines.

Reference Books

1. Ackermann T., "Wind Power in Power System", Wiley Publications, Germany, 2nd Edition,2012
2. Wu B., Lang Y., Zargari N., Kouro S., "Power Conversion and Control of Wind Energy", John Wiley & Sons, New Jersey, 2011.
3. Bollen M., Hassan F., "Integration of Distributed Generation in the Power System", John Wiley & Sons, New Jersey, 2011.
4. Keyhani A., "Design of Smart Power Grid Renewable Energy Systems", John Wiley & Sons, New Jersey, 2011.
5. Vittal V., Ayyanar R., "Grid Integration and Dynamic Impact of Wind Energy", Springer, New York, 2013.

14EE3051 SOLAR CELL AND MODULE TECHNOLOGY

Credits 3:0:0

Course Objective

- Study the properties of semiconductors
- Understand the need for purity and minimization of crystal imperfections for making high performance solar cells
- Understand the pros and cons of manufacturing methods.

Course Outcome

The student will

- Be able to describe the uniqueness of different PV cells
- have a good understanding of semiconductors used for PV cell manufacturing
- be able to describe and discuss the making, calibration of different solar cell devices.

Description

The physics of solar cell-properties of semiconductors-PN Junction diode electrostatics-Solar cell fundamentals-Efficiency and band gap-spectral response-parasitic resistance effects-production of metallurgical grade silicon-production of semiconductor grade silicon-requirements of silicon for crystalline solar cells-routs to solar grade silicon-Bulk crystal growth and wafering for PV-Crystalline silicon solar cells -manufacturing process-crystalline silicon photovoltaic modules-Thin film silicon solar cells-Amorphous silicon solar cells-Dye sensitized and Organic solar cells-Organic Electronic Materials-fabrication-Rating PV Performance-Current versus voltage measurements-Primary reference cell calibration methods-spectral responsitivity measurements-Module qualification and certification.

Reference Books

1. Antonio Luque, Steven Hegedus, “Hand book of Photovoltaic Science and Engineering”, John Wiley& Sons Ltd, England, 2011.
2. Larry D. Partain, “Solar Cells and Their Applications”, John Wiley & Sons Ltd, England, 2010.
3. Tom Markvart, “Solar Cells: Materials, Manufacture and Operation”, Elsevier, USA, 2nd Edition, 2013.
4. JefPoortmans, Vladimir Arkhipov, “Thin Film Solar Cells: Fabrication, Characterization and Applications”,John Wiley & Sons, 2006
5. Solanki Chetan Singh, “Solar Photovoltaics: Fundamentals, Technologies and Applications”, PHI Learning Pvt. Ltd. 2011.

14EE3052 PV SYSTEM DESIGN AND INSTALLATION

Credits: 3:0:0

Prerequisite: 14EE3011 Photovoltaic Systems

Course Objective

- Study the different photovoltaic Energy systems
- Understand the System design procedures
- Know the sizing of different components used in the PV System

Course Outcome

The student will

- Be able to calculate the energy demand
- Identify the correct system and its components
- Do the correct sizing procedure for optimal system design

Description

An overview of Photovoltaic- Photovoltaic Electric Principles- The solar resource-Photovoltaics and weather-Calculating the solar Energy-Site survey- Electrical Load Analysis-Photovoltaic modules performance-Photovoltaic

Modules- Module Performance-Mounting Photovoltaic Modules- Batteries- Battery Sizing exercise- Battery wiring configuration- PV Controllers- Controller sizing exercise- Inverters-The four configurations for solar power-system selection-Planning, Regulations and Approvals-Grid Interconnection requirements- Residential Design, Commercial Design, Utility Design- Photovoltaic Installation- PV Components maintenance- Appliances Maintenance-Troubleshooting-Hazards- Safety.

Reference Books

1. "Photovoltaics: Design and Installation Manual", Solar Energy International, Canada, 2004.
2. Steven Magee, "Solar photovoltaic Design for residential, commercial and Utility Systems"2010
3. Michael Boxwell, "Solar Electricity Handbook: A simple practical guide to solar Energy-Designing and Installing Photovoltaic Solar Electric Systems", Greenstream Publishing, UK, 2012.
4. Geoff Stapleton, Susan Neill, "Grid-connected Solar Electric Systems: The Earthscan Expert Handbook for Planning, Design and Installation", Earthscan, Oxon, 2012.
5. John R. Balfour, Michael Shaw, "Advanced Photovoltaic System Design", Jones and Bartlett Learning, 2011.
6. Deutsche Gesellschaft für Sonnenenergie "Planning and Installing Photovoltaic Systems", Earthscan, USA, 2008.

14EE3053 MATERIALS FOR SOLAR POWER

Credits 3:0:0

Course Objective

- Study the different materials used in manufacturing process
- Understand the physics of solar cell
- Know the technology of silicon extraction

Course Outcome

- Able to understand the properties and characteristics of materials used in energy applications
- Basic design concepts and technologies for manufacturing the solar cells will be acquired.
- Be familiar about various cell fabrication techniques.

Description

Materials: Glazing materials, Properties and Characteristics of Materials, Reflection from surfaces, Selective Surfaces: Ideal coating characteristics, Types and applications, Anti-reflective coating, Preparation and characterization, Reflecting Surfaces and transparent materials, Insulation and properties. Physics of Solar Cells, Electrical conductivity, Density of electrons and holes, Carrier transport: Drift, diffusion, Absorption of light, Recombination process, Materials for Photovoltaic Conversion. Technology for Si Extraction, Cell fabrication and metallization techniques: Preparation of metallurgical, electronic and solar grade Silicon, Production of single crystal Silicon: Procedure of masking, photolithography and etching, Design of complete silicon, GaAs, InP solar cell – Nanomaterials.

Reference Books

1. William D. Callister, Jr, "Materials Science and Engineering: An Introduction", John Wiley, New York, 2010.
2. Srinivasan, "Engg Materials and Metallurgy", , Tata McGraw-Hill Education Limited, 2nd Edition 2010.
3. Jenny Nelson, "The Physics of Solar Cells" Imperial College Press, 2003.
4. Arthur Willoughby, "Solar Cell Materials: Developing Technologies", John Wiley and Sons, 2010.
5. Tom Markvart, "Solar Cells: Materials, Manufacture and Operation" Elsevier, USA, 2nd Edition, 2013.

14EE3054 PASSIVE SOLAR ARCHITECTURE

Credits: 3:0:0

Course Objective

- To understand the building laws and architectural design.
- To understand the role of the site selection and its context play in designing a building, with an emphasis on the climate and other environmental conditions.
- To understand the concepts of a comfortable thermal environment and the passive solar design principles, passive ventilation and solar shading to create a comfortable thermal environment.

Course Outcome

- Analyze the site and its context in preparation for designing a building, particularly with respect to climate and other environmental conditions and translate the analysis data into useable design data and design concepts.
- Design and build environments that are both thermally comfortable and thermally delightful by utilizing passive solar design principles.
- Utilize the combined site-specific potentials of sun, light, wind and rain for creating a sustainable, comfortable and delightful built environment.

Description

Art of Building Design- Energy Management-Thermal comfort- solar temperature and its significance - heat gain through building envelope; solar radiation on buildings; building orientation - shading devices - Overhangs; Ventilation- Air-conditioning systems with Energy conservation. Passive cooling and Heating-Types - Heat transfer-Parameters- Solar temperature - Decrement factor - Phase lag. Design of day lighting; Estimation of building loads: method, correlations - Computer packages for carrying out thermal design of buildings -Bioclimatic classification of India - Passive concepts appropriate for the various climatic zones in India - Typical design of selected buildings in various climatic zones - Thumb rules for design of buildings and building codes.

Reference Books

1. Daniel D. Chiras, “The Natural House”, Chelsea Green Publishing Company, Vermont, 2001.
2. Daniel D. Chiras, “The New Ecological Home”, Chelsea Green Publishing Company, Vermont, 2004.
3. Colin Porteous, Kerr Macgregor, “Solar architecture in cool climates”, Earthscan Publications Ltd., UK, 2005.
4. Daniel D. Chiras,” The Solar House: Passive Heating and Cooling”, Chelsea Green Publising Company, Vermont, 2002.
5. James Kachadorian, “Passive Solar House” Chelsea Green Publising Company, Vermont, 2006.

14EE3055 OCEANIC ENERGY

Credits: 3:0:0

Course Objective

- To provide necessary knowledge about the basics, design and analysis of two important oceanic energy components i.e., tidal and wave.
- To make the learner to understand the operation of tidal power plants and wave power plants
- To impart the basic knowledge about integration of tidal and wave power plants with grid

Course Outcome

- Have awareness about the possibilities of power generation from ocean
- Suggest new mechanisms to harvest energy from ocean
- Design efficient tidal and wave power plants

Description

Historical Development Tidal phenomenon Propagation of tides in estuaries -Coriolis effect -Barrage effects Tidal Schemes Basin Schemes Retiming of tidal energy physiography of the estuary Geology Tides Waves currents Ecosystem characteristics Hydraulic and numerical models Hybrid models Barrier Modeling and effects Utility system planning and simulation - Civil works Design parameters Dikes Construction schedules Electromechanical equipment generating equipment turbines Transmission Integration of output with electric utility systems considerations - Wave structure Global wave energy potential technologies concentration effects Tapered channel Oscillating water column Mighty whale design Turbines for wave energy Ocean wave conversion system power distribution Grid connection Environmental impacts

Reference Books

1. Robert H. Clark, “Elements of Tidal-Electric Engineering”, Wiley-IEEE Press, USA, 2007.
2. Boyle, “Renewable Energy”, Oxford University Press, UK, 2013.
3. Jack Hardisty , “The Analysis of Tidal Stream Power”, Wiley, , UK, 2009
4. Michael E. McCormick, “Ocean Wave Energy Conversion” Dover Publications, USA, 2009
5. Joao Cruz, Ocean Wave Energy: Current Status and Future Perspectives, Springer, Berlin, 2010.

14EE3056 GEOTHERMAL ENERGY

Credits: 3:0:0

Course Objective

- To develop an in-depth understanding of the issues associated with the development of geothermal energy.
- To make the students to realize the current state of geothermal energy resources and technologies.
- To impart the knowledge of energy analysis applicable to geothermal systems.

Course Outcome

- Ability to understand the role which geothermal energy plays in the energy sector
- Gain knowledge regarding the future of geothermal energy resources
- Ability to analyze geothermal energy resources based on energy efficiencies

Description

Model of a hydrothermal geothermal resource, Hot dry rock, HDR-Geo pressure Magma energy Phases of an exploration program Synthesis interpretation Geothermal well drilling reservoir well flow testing Calcite scaling in well casings modeling and simulation - Single-Flash Steam power plants Gathering system design considerations Energy conversion system flash plants conversion system Scale potential in waste brine Equipment list flash plants Origins and nature of dry-steam resources Equipment list for dry-steam plants Binary cycle power plants Working fluid selection Hybrid flash systems binary systems Total-flow systems Hybrid fossil Combined heat and power plants Hot dry rock (enhanced geothermal systems) Power plants for hypersaline brines - First law for open, steady systems - Second law for open, steady systems -Exergy -Exergy accounting for open, steady systems -Exergy efficiencies and applications to geothermal plants.

Reference Books

1. Ronald DiPippo, Geothermal Power Plants: Principles, Applications and Case Studies and environmental impact, 2nd Edition, Elsevier Science, USA, 2012.
2. Boyle,”Renewable Energy”, Oxford University Press, 2nd Edition, UK, 2012.
3. Ernst Huenges, Patrick Ledru, “Geothermal Energy Systems: Exploration, Development and Utilization”, Wiley, 1st Edition, Weinhim, 2010.
4. Harsh K. Gupta ,Sukanta Roy, “Geothermal Energy: An Alternative Resource for the 21st Century” Elsevier Science; 1st Edition, The Netherlands, 2006.

14EE3057 POLICY AND REGULATORY ASPECTS OF RENEWABLE POWER GENERATION

Credits 3:0:0

Prerequisite: 14EE3013Energy Engineering

Course objective

- Study the policy and regulatory framework to make renewable power generationeconomically viable.

- Understand the problems of high transmission and distribution (T&D) losses, frequent disruption in supply of grid power, practical problems and financial non viability of the transmission grids.
- Students will be encouraged to simulate some case studies using RETScreen& HOMER softwares.

Course Outcome

The students will be able to

- know the policy frameworks for various renewable energy sources including distributed and decentralized energy solutions also.
- understand the advantages and challenges associated with the deployment of these technologies.
- evaluate the economical and technical viability of renewable power generation.

Description

Renewable energy credit schemes,Statuary requirements and activities of various states in this regards -Tariff determination issue - National Solar Mission - Regulations regarding grid interconnections of renewable energy systems - Need and advantage of Decentralized energy solutions - Emergence of policy and regulatory framework for decentralized electricity (Gokak Committee report) -Status of grid connected and off grid distributed generation (national and International) - Electrification and off grid status/scenario in India - Scope and challenges in implementing off grid solutions - Policy & regulatory Framework for rural electrification - Relevant policies and frameworks in other countries - Recent off grid programs started by Govt. of India for enhancing the rural electrification through off-grid solutions - DDG scheme under Rajiv Gandhi GrameenVidyutikaranYojana (RGGVY) - DDG scheme under Rajiv Gandhi GrameenVidyutikaranYojana (RGGVY) - Remote Village Electrification Program - Village Energy Security Program (VESP) - Off grid Program under JNNSM.

Reference Books:

1. Distributed Power Generation Planning and Evaluation, H.Lee Willis, Walter G. Scott, IET Power Marcel Dekker, Inc. (2000).
2. Comparative Study on Rural Electrification Policies in Emerging Economies: Keys To Successful Policies; International Energy Agency.
3. Best practices of the Alliance for Rural Electrification: what renewable energy can achieve in developing countries; Alliance for Rural Electrification.
4. Gokak Committee Report on DDG & Report on the Working Group on Power for Eleventh Plan (2007-12).

Journals and Magazines:

1. The Zambian ESCO project.
2. Sunlight Power Maroc (Morocco).
3. Solar Energy Supplies in Zimbabwe.
4. Off grid solutions applied in various parts of India (e.g. LaBL- SMU, NTPC DDG, VESP, DESI Power, Husk Power, etc).
5. SHP in Nepal and Sri Lanka
6. IDCOL/Grammen Shakti model in Bangladesh

14EE3058 NUCLEAR ENGINEERING

Credits 3:0:0

Course objective

- Get knowledge on Nuclear reaction materials and various reprocessing techniques.
- Understand the nuclear waste disposal techniques and radiation protection aspects.
- Awareness on future nuclear reactor systems with respect to generation of energy, fuel breeding, incineration of nuclear material and safety.

Course Outcome

The students will be able to

- knowin detail about the on fundamentals of nuclear reactions.

- understandnuclear fuels cycles, characteristics, fundamental principles governing nuclear fission chain reaction and fusion and kinetics.
- select the appropriate type of nuclear materials and preprocessing methods for power generation.

Description

Nuclear reactions - Mechanism of nuclear fission - Nuclides - Radioactivity – Decay chains - Neutron reactions - Fission process - Reactors – types, design and construction of nuclear reactors - Heat transfer techniques in nuclear reactors - Reactor materials- Nuclear Fuel Cycles - Characteristics of nuclear fuels - Uranium –Production and purification of Uranium - conversion to UF4 and UF6 - other fuels like Zirconium, Thorium – Berylium - Reprocessing - Nuclear fuel cycles - Role of solvent extraction in reprocessing - Solvent extraction equipment - Separation of reactor products - Processes to be considered - 'Fuel Element' dissolution - Precipitation process – ion exchange - Redox - Purex- TTA - chelation -U235 - Hexone - TBP and thorax Processes - Oxidative slaging and electro - Refining - Isotopes - Principles of Isotope separation - Types of nuclear wastes - Safety control and pollution control and abatement - International convention on safety aspects - Radiation hazards prevention.

Reference Books

1. Raymond LeRoy Murray, “Nuclear energy: an introduction to the concepts, systems, and applications of nuclear processes”, 6thEdition, Butterworth-Heinemann, 2009.
2. John R. Lamarsh, “Introduction to Nuclear Reactor Theory”, American Nuclear Society, 2002.
3. Glasstone, S. and Sesonske, A, “Nuclear Reactor Engineering”, 4thEdition, Springer, 1994.
4. Winterton, R.H.S., “Thermal Design of Nuclear Reactors”, Pergamon Press, 1981.

14EE3059 HYDRO POWER TECHNOLOGY

Credits 3:0:0

Course objective

- Understand the basic concepts of aerodynamics, horizontal and vertical axis wind turbines, small hydro system components and design
- Know economical and electrical aspects of Small, mini and micro hydro turbines.
- Study about the selection, testing and governing of turbines.

Course Outcome

The students will be able to

- prepare a detailed report and plan for the construction of hydro power plant.
- develop prototype hydro systems.
- select and analyze the particular turbine for specific need.

Description

Overview of Hydropower systems - Rainfall and Run of measurements - Hydrographs- Determination of site selection- Types of hydroelectric power plants- General arrangements and Layouts- Preparation of Reports, estimates, project feasibility and load prediction - Design and Construction of Hydroelectric Power Stations-Trends in Development of Generating Plant and Machinery-Plant Equipment for pumped Storage Schemes - Measurement of pressure head, Velocity- Selection of turbines based on Specific quantities- Performance characteristics – Testing &Governingof hydraulic turbines -Functions of Turbine Governor - Condition for Governor Stability - Surge Tank Oscillation and Speed Regulative Problem of Turbine Governing - Remaining Lifecycle Analysis - Analysis of Small, mini and micro hydro turbines – Economical and Electrical Aspects of Small, mini and micro hydro turbines-Potential developments – Design and reliability of Small, mini and micro hydro turbines.

Reference Books:

1. P.K Nag, “Power plant Engineering”, Tata McGraw-Hill Education, 2008.
2. - Jyotirmay Mathu “Introduction to Hydro Energy Systems”, Springer, 2011.
3. A.K.Raja, Amit Prakash Srivastava, “Power Plant Engineering”, New Age International, 2013.
4. Finn R. Forsund , “Hydropower economics”, Springer, 2007.

5. Scott Davis," Microhydro: Clean power from water", New Society Publishers, 2005.

14EE3060 DESIGN AND DEVELOPMENT OF WIND TURBINES

Credits: 3:0:0

Course Objective

- To introduce the concepts dynamics and acoustics of wind turbines
- To enlighten the students about the latest technologies for turbine design
- To provide in-depth understanding about the challenges in wind power generation

Course Outcome

The student will be able to

- Design and develop wind turbines of different rating
- Understand the aerodynamic and structural aspect of wind turbines.
- Understand the recent technological advancements in wind turbine design

Description

Aerodynamics and aeroelastics of wind turbines – Structural dynamics of wind turbines – Wind turbine acoustics – Design and development of megawatt wind turbines – Design and development of small wind turbines – Development and analysis of vertical-axis wind turbines – Direct drive superconducting wind generators – Intelligent wind power unit with tandem wind rotors – New small turbine technologies - Implementation of 'smart' rotor concepts - Wind turbine power curve – Wind turbine cooling techniques – Wind turbine noise measurements and abatement.

Reference Books

1. Tong W., "Wind Power Generation and Wind Turbine Design", WIT Press, UK, 2010
2. Jamieson P., "Innovation in Wind Turbine Design", John Wiley & Sons Ltd., UK, 2011.
3. Rivkin D. A., Toomey K., Silk L., "Wind Turbine Technology and Design", Jones & Barlett Learning, USA, 2013
4. Wood D., "Small Wind Turbines: Analysis, Design and Application", Springer, Hong Kong, 2011.
5. Burton T., Jenkins N., Sharpe D., Bossanyi E., "Wind Energy Handbook", Second Edition, John Wiley & Sons, 2011

14EE3061 CONTROL AND DRIVES FOR SOLAR SYSTEMS

Credits 3:0:0

Course Objective

- To familiarize students with the concepts of control and drives and importance of embedded system
- To implement the control system for solar energy applications
- To Understand the advanced controls of solar plant

Course Outcome

The student will be able to understand and apply

- The basic concepts of process control and controllers.
- Electronic realization of controllers.
- Advanced controls in solar plants

Description

Controller Principles: Basic concepts of process control, discontinuous and continuous mode operation. Introduction to proportional, integral and derivative control. Design, characteristics and response of controllers. Electronic Realization, Selection of controllers, need for process controller, controller tuning and evaluation criteria. P/I and I/P converters. Model Representation**:** Introduction to MATLAB, matrix operation, different graphical output, integration and solution to differential equation. Types of error - Convergence and stability. Models of electro-mechanical system, solar photo voltaic cell and DC motor. Transient and steady state response of system, Simulation, Embedded System and Applications, Control of solar plants: Model based predictive control strategies, frequency domain control and robust optimal control. Introduction to fuzzy logic control and LABVIEW

Reference Books

1. Eduardo F. Camacho, Manuel Berenguel, Francisco R. Rubio, Diego Martinez, "Control of Solar Energy Systems", Springer, 2012.
2. Johnson C.D., "Process control and instrumentation", 8th ed., Pearson, 2006.
3. Palm W.J., "Introduction to Matlab for Engineers", 3rd ed., Tata McGraw-Hill Book co, 2010.
4. Meyer W.J., "Concepts of Mathematical Modeling", Dover Publ., 2004.
5. Dym C.L., "Principles of Mathematical Modeling", 2nd ed., Academic Press, 2004.

14EE3062 LOGIC CONTROLLERS FOR AUTOMATION

Credits 3:0:0

Course Objective

- To understand the fundamentals of various automation methods.
- To understand the types of PLC and it's working.
- To understand the various control modules and memory concept of S7-300/400.
- To understand the wiring of I/O modules

Course Outcome

- Differentiate various PLCs and their features based on their application.
- Setup a PLC station with consistency.
- Develop SIMATIC Manager project.

Description

Concept of Automation – Advantages & Disadvantages of Different automation methods – Programmable Logic Controller – Types of PLC – PLC Working – Scan cycle – SIEMENS PLCs – Different modules in S7-300 Station – Memory concept of S7-300 – Addressing – Wiring of I/O Modules – Slot Rules – SIMATIC Manager – Project development phases- Different modules in S7-400 Station – Memory concept of S7-400 – Addressing – Wiring of I/O Modules-hardware differences.

Reference Books

1. SITRAIN Training Manual, "TIA Basic with S7-300 & Step7", R2013, V1.0.
2. SITRAIN Training Manual, "TIA Basic with S7-400 & Step7", R2013, V1.0.
3. John webb, "Programmable logic controllers principles & applications", Prentice Hall of India, 2002.
4. Hughes, T. A. Programmable Controllers, Third Edition. ISA – The Instrumentation, Systems, and Automation Society, 2000,
5. C. D. Johnson, "Process control instrumentation Technology" Prentice Hall of India, 2005

14EE3063 HMI SYSTEMS

Credits 3:0:0

Corequisite: 14EE3064 PLC Applications & Industrial Communication

Course Objective

- To understand the purpose and classification of HMI.
- To understand the concept of Tags and to do Tag management.
- To understand the features of HMI and to use them.
- To understand the "Totally Integrated" Engineering

Course Outcome

- Choose licenses based on tag requirement.
- Design and implement HMI – PLC connection.
- Configure Server-Client configuration for HMI Panels.

Description

Need for Human Machine Interface – Types of HMI (Panel based & PC based) – HMI Panels from SIEMENS – WinCC Flexible software – Concept of Tags – Power Tags – Project Creation – Designing Screens – Monitoring status of Digital I/O – Monitoring status of Analog I/O – Using Buttons – Data input to PLC from HMI – Configuring Alarms – Trends – Recipe Management – Server-Client configuration of HMI Panels – Excel communication (SOAP) - Integration of HMI project into SIMATIC Manager - Configuring HMI using TIA Portal – Applications.

Reference Books

1. SITRAIN Training Manual, "SIMATIC HMI", V1.0.
2. SITRAIN Training Manual, "TIA Porgramming I", R2012, V1.0.
3. Jean Yves Fiset, "Human Machine Interface design for Process Control Application", ISA Publication, 2009 Edition

14EE3064 PLC APPLICATIONS & INDUSTRIAL COMMUNICATION

Credits 3:0:0

Course Objective

- To understand the programming of PLC in different languages.
- To understand the advanced programming concepts.
- To understand the configuration of different communication possibilities for PLC.

Course Outcome

- Full end programming of PLC.
- Design and implement Master-Slave Communication.
- Design and implement Master-Master Communication
- Utilize all major engineering tools in the software.

Description

Project creation and Hardware configuration – Ladder programming – Bit logic operations – Data types – Timers – Counters – Comparators – Arithmetic operations – Structured Programming – FC call with parameter passing – Analog I/O – Scaling & Unscaling operations – Introduction to Data Blocks-Introduction to STL programming – Accumulator concept – Complex data types – Using FB for programming – Multi-instance FB – Indirect addressing – RTC – Diagnostic tools – PID Controller – High Speed Counter – Additional software tools – Communication need – Common communication protocols in SIEMENS – Features of different communication protocols – Master-slave communication – Master-Master communication – Netpro – PROFINET Basics - Concept of TIA - PLC Programming using TIA Portal.

Reference Books

1. SITRAIN Training Manual, "TIA Advanced with S7-300/400", V1.0.
2. SITRAIN Training Manual, "SIMATIC Net", R2013, V1.0.
3. SITRAIN Training Manual, "TIA Servicing", R2012, V1.0.
4. John webb, "Programmable logic controllers principles & applications", Prentice Hall of India, 2002.
5. Hughes, T. A. Programmable Controllers, Third Edition. ISA – The Instrumentation, Systems, and Automation Society, 2000.
6. C. D. Johnson, "Process control instrumentation Technology" Prentice Hall of India, 2005

14EE3065 INDUSTRIAL DC DRIVES

Credits 3:0:0

Course Objective

- To understand the fundamentals of various electromechanical systems.
- To understand the basic concept of DC Drives.
- To understand the various control techniques involved with DC Drives.

Course Outcome

- Design and Analyze different control techniques of DC Drives.
- Select suitable DC Drive for different requirements
- Apply appropriate control method for the application.

Description

Power Electronics (Thyristors, Power Transistors) -DC Machines: Separately Excited Motors (Constructions, Operations, Power, Applications) -Series Motors (Introduction)-Shunt Motors (Introduction)-Compound Motors (Introduction)-DC Drives: Thyristorized Drive for Separately Excited Motors-Single/Four Quadrant operations in DC Drives-DC Drives options, features, systems & configurations -DC Drives selections & applications

Reference Books

1. Gopal K Dubey, "Fundamentals of Electric Drives", Narosa Publishing House, 2nd Edition, New Delhi, 2006.
2. Pillai S.K., "Analysis of Thyristor Power Conditioned Motors", University Press, 2005.
3. Krishnan. R, "Electric Motor Drives: Modeling, Analysis and Control", Prentice Hall of India Private Limited, New Delhi, 2009.
4. Sen P.C., "Thyristor DC Drives", John Wiley, New York, 1981.
5. Vedam Subrahanyam, "Electric Drives: Concepts & Applications", McGraw-Hill Education, New Delhi, 2010.
6. Singh M.D., K Khanchandani, "Power Electronics", McGraw-Hill Education Private Limited, New Delhi, 2006.

14EE3066 INDUSTRIAL AC DRIVES

Credits 3:0:0

Course Objectives

- To understand various operating regions of the induction motor drives.
- To study and analyze the operation of VSI & CSI fed induction motor control.
- To understand the speed control of induction motor drive from the rotor side.
- To understand the field oriented control of induction machine.
- To understand the control of synchronous motor drives.

Course Outcome

- Design and Analyze different control techniques of AC Drives
- Select suitable AC Drive for different requirements
- Apply appropriate control method for the application

Description

Power Electronics (IGCT & IGBT)-AC Machines-Synchronous Machines (Constructions, Operations, Power, Applications) -Asynchronous Machines (Constructions, Operations, Power, Applications) -Special Machines (Introductions)-AC Drives-IGBT/IGCT based AC Drive for Induction Motors-Single/Four Quadrant operations in AC Drives-AC Drives options, features, systems & configurations-AC Drives Braking Methods -AC Drives selections & applications -AC Drives for Synchronous Motors

Reference Books

1. Bimal K Bose, "Modern Power Electronics and AC Drives", Pearson Education Asia 2002.

2. Vedam Subramanyam, "Electric Drives – Concepts and Applications", Tata McGraw Hill Publishing Limited, New Delhi, 2nd Edition, 2011.
3. Gopal K Dubey, "Power Semiconductor controlled Drives", Prentice Hall Inc., New Jersey, 1989.
4. W.Leonhard, "Control of Electrical Drives", Springer – Verlag Berlin Heidelberg, NewYork, 3rd Edition, 2001.
5. Murphy J.M.D and Turnbull, "Thyristor Control of AC Motors", Pergamon Press, Oxford, 1988.
6. R.Krishnan, "Electric Motor Drives – Modeling, Analysis and Control", Prentice-Hall of India Private Ltd., New Delhi, 2003.

14EE3067 DATA LOGGING AND VISUALIZATION

Credits 3:0:0

Corequisite: 14EE3064 PLC Applications & Industrial Communication

Course Objective
- To understand the features and architecture of SCADA.
- To understand the designing of SCADA animations, alarms, data logs etc.
- To understand the user authorizations possible for SCADA objects.

Course Outcome
- Design and animate process simulation.
- Configure Alarms, Trends, Data logs etc.
- Assign access rights and control to runtime project.

Description
HMI panels and SCADA Comparison – Features of SCADA – Architecture of a SCADA Station – Need of DBMS – Communication drivers – Tag management – Structure tags – Licensing – Run time settings – Project and Computer properties – Designing Screens – Making objects dynamic – Dynamic dialog – Direct connection – Scripting – Giving commands to PLC from SCADA – Picture Window – Pop-up window – Indirect Tags – Global Script – Configuring alarms – Alarms with and without acknowledgement – Alarm for negative edge – Alarm acknowledgement from PLC – Analog alarms – Status tags – Group acknowledgement – Alarm display page – Alarm line – Data logging – Configuring archives – Cyclic and event driven data logging – Logging of mean value – Trend view – Table view – User administration – Assigning access control to different objects – Login/Logoff with hot key and with buttons – Report designing – Recipe management.

Reference Books
1. SITRAIN Training Manual, "SIMATIC WinCC Basic", R2013, V1.0.
2. Stuart A Boyer: SCADA supervisory control and data acquisition, International Society of Automation, 2010
3. Gordan Clark, Deem Reynders, Practical Modem SCADA Protocols, Newnes Publisher, 2004
4. Robert Lafore, "Object Oriented Programming with C++", Course Sams Publishing, 4th Edition, 2001
5. Peter Wright, "Visual Basic 6", Wrox Press, 1998

14EE3068 ADVANCED SCADA APPLICATIONS

Credits 3:0:0

Prerequisite: 14EE3064 PLC Applications & Industrial Communication
14EE3067 Data Logging and Visualization

Course Objective
- To understand the multi-computer architecture of SCADA.
- To understand the purpose and configuration of Redundant SCADA station.
- To understand the "TIA Engineering" in SCADA.

Course Outcome

- Configure Server-client architecture for SCADA.
- Configure Server Redundancy.
- Integrate SCADA into Step7.

Description

Indirect addressing – Multi-computer projects – Server-client architecture – Advantages of Server-client configuration – Configuration steps for making a Server-client configuration – Need of Redundant server – Configuring a Redundant server – Web navigator – Data monitor – OS Project editor – Lifebeat Monitoring – Picture tree management – Integration of SCADA project in SIMATIC Manager - Configuring SCADA using TIA Portal – SCADA Applications.

Reference Books

1. SITRAIN Training Manual, "SIMATIC WinCC Advanced", R2012, V1.0.
2. SITRAIN Training Manual, "TIA Portal - WinCC", R2013, V1.0.
3. Stuart A Boyer: SCADA supervisory control and data acquisition, International Society of Automation, 2010
4. Gordan Clark, Deem Reynders, Practical Modem SCADA Protocols, Newnes Publisher, 2004

14EE3069 LOW VOLTAGE SWITCHGEAR

Credits 3:0:0

Course Objective

- To understand the switchgear and control gear (LV).
- To understand different types of fuse.
- To understand the Motor starter.

Course Outcome

- Knowledge on maintenance of MCCB.
- Use available accessory fitting on ACB.
- Knowledge on maintenance of ACB.

Description

Low-voltage control gear and switchgear - overview of products-Products Covered -ACBs - Basics , ETU settings , Hands On practice required for maintenance-MCCBs - Basics , ETU settings-Contactors, Bi-relays, Electronic relays, MPCBs, Sirius series-SDFs, Fuses-Introduction of Smart Motor Starters-Basic principles, construction and functions, selectivity, back-up protection, switching duties, protection classes-Product selection methods -Benefits for the customer, applications and solutions -Accessory fittings and hands-on training on ACB-Maintenance methods on ACB.

Reference Books

1. SITRAIN Training Manual, "LV Switchgear", V1.0.
2. Sunil S. Rao, Switchgear and Protections, Khanna Publication, 2008
3. Badri Ram and D. N. Vishwakarma, "Power System Protection and Switchgear", Tata McGraw Hill Education, 2001
4. U. A. Bakshi and M. V. Bakshi, "Protection and Switchgear", Technical Publication, 2009

14EE3070 DISTRIBUTED CONTROL SYSTEM

Credits 3:0:0

Prerequisite: 14EE3064 PLC Applications & Industrial Communication
14EE3067 Data Logging and Visualization

Course Objective

- To understand DCS architecture.

- To understand the designing of DCS project and programming.
- To understand AS-OS interconnection in DCS.

Course Outcome
- Design and implement Process Control System.
- Programming with CFC Chart.
- Create OS objects by chart compiling
- Monitor and Control process parameters from OS.

Description
Why DCS? – Key features and advantages of DCS – DCS architecture – PCS7 – Project management – SIMATIC PCS7 Engineering Tools – Projects and Libraries – Initial settings of SIMATIC Manager – Multi Project – Component View and Plant View – PC Station Configurator – Charts and blocks – Organization blocks – Run Sequence – Blocks for signal processing – Blocks for Monitoring and Controlling – Driver Blocks – CTRL_PID – SIMATIC PCS 7 – Engineering Toolset – Process Object View – Plant Hierarchy Settings – OS-AS connection – Compilation – Screen layout – Charts – User Administration – Time synchronization and Life beat monitoring – Versioning – Protection – Picture Tree – Area Buttons – SFC Visualization – Chart in Chart – Creating a FB from a chart – Introduction APL – Import Export Assistant – Process Tag Type – Models – AS-AS Connection – Connection to unspecified AS – AS-AS Communication – Group Display – Alarms – Read back – Changes of state – Forcing – Maintenance Station.

Reference Books

1. SITRAIN Training Manual, “PCS7 System Manual V7.1”, R2011, V1.0.
2. SITRAIN Training Manual, “PCS7 System Manual V8.0”, R2012, V1.0.
3. Dobrivojic Popovic and Vijay. P. Bhatkar, “Distributed Computer Control System in Industrial Automation”, CRC Press, 1990
4. Krishna Kant, “Computer Based Process Control”, PHI Learning Pvt Ltd., 2004

14EE3071 AUTOMATION LABORATORY I

Credits 0:0:2

Prerequisite: 14EE3064 PLC Applications & Industrial Communication
14EE3063 HMI Systems

Course Objective
- To understand the project creation and programming of PLC.
- To understand different programming languages of PLC.
- To understand configuration and design of screens in HMI.

Course Outcome
- Design, program and automate machines/process.
- Design and implement Master-Slave and Master-Master communication.
- Establish communication with HMI Panels and show status of PLC in HMI.

Description
This laboratory enables the students to automate a machine/process using PLC. It also makes them implement necessary communication and to show the process status in a HMI Panel.

14EE3072 AUTOMATION LABORATORY II

Credits 0:0:2

Prerequisite: 14EE3066 Industrial AC Drives
14EE3068 Advanced SCADA Applications
14EE3069 Low Voltage Switchgear

Course Objective

- To understand the parameterization and operation of a Drive.
- To understand features and design of SCADA system.
- To understand use and working of switchgear components.

Course Outcome

- Commission a SINAMICS G120 drive with or without Starter software.
- Control the operation of a Drive using PLC.
- Design and animate complete process using SCADA systems.

Description

This laboratory makes the students to commission and parameterize a Drive for standalone operation as well as to be controlled by a Master PLC. In addition, it makes them do the data logging and visualization of a complete process with a SCADA station.

14EE3073 MODELING AND SIMULATION OF DYNAMIC SYSTEMS

Credits 3:0:0

Course Objectives:

- To understand state space representation of different systems.
- To understand system modeling and simulation through bond graphs

Course Outcomes:

- Analyze stability, controllability and observability of a given system.
- Modeling and simulation with incomplete knowledge sensor modeling.
- Differentiate thick and thin film modelling

Description

Introduction, State space representation of systems of different kind. Simulation of the state model-Describing equations and different kinds of models. Eigen values and vectors, Similarity X'formation, invariants. Stability, controllability, observability, Leverrier's algorithm. Linearization of nonlinear systems-Theorem on feedback control, pole placement controller- Full order and reduced order observer design-Theory of industrial regulation, feed forward control. Application - motor speed control with disturbance rejection-Heat flow in one dimension, finite element method. Modeling and simulation through bond graphs-Qualitative reasoning: M & S with Incomplete Knowledge-Sensor modeling: Lumped parameter and distributed parameter models, Thick and thin film models-Numerical modeling techniques, model equations, application of Finite Element method-Different effects on modeling - temperature, radiation, mechanical, chemical, magnetic, electrical-Examples of modeling: micro-modeling of photodiodes, magnetic, capacitive, mechanical sensors.

Reference Books

1. W B J Zimmerman, Process Modeling and Simulation with Finite Element Methods, Univ. of Sheffield UK 2004.
2. Amalendu Mukherjee and Ranjit Karmakar, Modeling and Simulation of Engineering Systems through Bond Graphs, Narosa New Delhi 1999.
3. Benjamin Kuiper, Qualitative reasoning: Modeling and Simulation with Incomplete Knowledge, MIT Press Cambridge Mass 1994.
4. Robert D. Strum and Donald E. Kirk, Contemporary Linear Systems Using Matlab, Thomson Learning, 1999.
5. K Ogata Modern Control Engineering 4th edition Prentice Hall 2002
6. B C Kuo Automatic Control Systems 7th Edition Prentice Hall 1995
7. Patranabis, D.- Sensors and Transducers. 2nd edition, PHI, New Delhi,

14EE3074 DISTRIBUTION AUTOMATION

Credits 3:0:0

Course Objective

- To understand the purpose of Automation in Power Distribution.
- To understand the communication methodologies used in power distribution automation.
- To understand the methods for study and analysis of power distribution systems.

Course Outcome

- Configure communication for DA.
- Transfer data to management using Management Information System (MIS).
- Formulate estimation equations.

Description

Introduction to Distribution Automation (DA), Control System Interfaces, Control and Data requirements, Centralized (Vs) Decentralized Control, DA System (DAS), DA Hardware, DAS
Software-DA Capabilities, Automation system computer facilities, Management Processes, Information Management, System Reliability Management, System Efficiency Management, Voltage Management, Load Management-DA Communication Requirements, Communication Reliability, Cost Effectiveness, Data Rate Requirements, Two Way Capability, Ability to communicate during outages and faults, Ease of operation and maintenance, Conforming to the architecture of data flow -Distribution line carrier (Power line carrier), Ripple Control, Zero Crossing Technique, Telephone, Cable TV, Radio, AM Broadcast, FM SCA, VHF Radio, UHF Radio, Microwave, Satellite. Fibre Optics, Hybrid Communication Systems, Communication systems used in Field Tests-DA Benefit Categories, Capital Deferred Savings, Operation and Maintenance Savings, Interruption Related Savings, Customer-related Savings, Operational savings, Improved operation, Function Benefits, Potential Benefits for Functions, Function-shared Benefits, Guidelines for Formulation of Estimating Equations- Parameters required, Economic impact areas, Resources for determining benefits impact on Distribution System, Integration of benefits into economic evaluation-Development and Evaluation of Alternate plans, Select Study Area, Select Study Period, Project Load Growth, Develop Alternatives, Calculate Operation and Maintenance Costs, Evaluate Alternatives-Economic Comparison of Alternate Plans, Classification of Expenses and Capital Expenditures, Comparison of revenue requirements of alternative plans, Book Life and Continuing Plant Analysis, Year-by-Year Revenue Requirement Analysis, Short Term Analysis, End of Study Adjustment, Break Even Analysis, Sensitivity Analysis, Computational Aids.

Reference Books

1. D. Bassett, K. Clinard, J. Grainger, S. Purucker, and D. Ward, “Tutorial Course: Distribution Automation”, *IEEE Tutorial Publication 88EH0280-8-PWR*, 1988.
2. Dr. M.K. Khedkar, Dr. G.M. Dhole , A Textbook of Electric Power Distribution Automation, Laxmi Publishers, 2010
3. IEEE Working Group on “Distribution Automation” 1988