ACADEMIC REGULATIONS
COURSE STRUCTURE AND
DETAILED SYLLABUS

ELECTRICAL & ELECTRONICS ENGINEERING

For

M. Tech. (Power Electronics)

(Two Year **Full Time** Programme)

JNTUH COLLEGE OF ENGINEERING HYDERABAD
(Autonomous)
Kukatpally, Hyderabad – 500 085, Telangana, India.

2015

JNTUH COLLEGE OF ENGINEERING HYDERABAD
M.Tech. (Power Electronics) – Full Time w.e.f. 2015-16

I – SEMESTER

S.No.	Subject	L	T	P	Credits
1	Power Electronic Converters	4	0	0	4
2	Power Electronic Control of DC Drives	4	0	0	4
3	Elective-I	4	0	0	4
4	Elective-II	4	0	0	4
5	Elective-III	4	0	0	4
6	Elective-IV	4	0	0	4
7	Power Converters Simulation Lab	0	0	4	2
8	Seminar	0	0	4	2
	Total Credits				**28**

II – SEMESTER

S.No.	Subject	L	T	P	Credits
1	Advanced Power Electronic Converters	4	0	0	4
2	Power Electronic Control of AC Drives	4	0	0	4
3	Elective-V	4	0	0	4
4	Elective-VI	4	0	0	4
5	Elective-VII	4	0	0	4
6	Elective-VIII	4	0	0	4
7	Power Converters Lab	0	0	4	2
8	Soft Skills Lab	0	0	4	2
	Total Credits				**28**

III – SEMESTER

S.No.	Subject	L	T	P	Credits
1	Comprehensive Viva Voce				4
2	Project Phase -I				12
	Total Credits				**16**

IV – SEMESTER

S.No.	Subject	L	T	P	Credits
1	Project Phase-II & Dissertation				18
	Total credits				**18**

Elective-I
1. Machine Modeling and Analysis
2. Reactive Power Compensation and Management
3. High Frequency Magnetic Components

Elective-II
1. Analysis of HVDC Systems
2. Renewable Energy Systems
3. Electric Traction Technologies

Elective-III
1. Modern Control Theory
2. Advanced Digital Signal Processing
3. Industrial Instrumentation

Elective-IV
1. Microcontrollers and Applications
2. Embedded Systems
3. Reliability Engineering
4. Optimization Techniques
5. Energy Generation from Waste
6. Integration of Energy Sources

Elective-V
1. Dynamics of Electrical Machines
2. Special Machines
3. Smart Grid Technologies

Elective-VI
1. Flexible AC Transmission Systems
2. Switched Mode Power Supplies
3. Digital Control Systems

Elective-VII
1. Power Quality
2. Solar Photo Voltaic Systems
3. Hybrid and Electric Vehicles

Elective-VIII
1. Programmable Logic Controllers and Applications
2. AI Techniques in Electrical Engineering
3. Energy Efficient Systems
4. Software Engineering
5. Energy Storage Technologies
6. Electrical Engineering Materials

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M.Tech. I Year I-Sem (Power Electronics)

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POWER ELECTRONIC CONVERTERS
(Core Theory – 1)

Prerequisite: Power Electronics

Course Objectives:
- To understand the characteristics and principle of operation of modern power semi conductor devices.
- To comprehend the c o n c e p t s o f different power converters and their applications
- To analyze and design switched mode regulators for various industrial applications.

Learning Outcomes:
At the end of the course, the student is able to:
- Choose appropriate device for a particular converter topology.
- Use power electronic simulation packages for analyzing and designing power converters.

UNIT I: AC VOLTAGE CONTROLLERS
Single phase AC voltage controllers with Resistive, Resistive-inductive and Resistive-inductive-induced e.m.f. loads – ac voltage controllers with PWM Control – Effects of source and load inductances - Synchronous tap changers.
Three phase AC voltage controllers – Analysis of controllers with star and delta Connected Resistive, Resistive-inductive loads – Effects of source and load Inductances – Applications & Problems.

UNIT II: CYCLO-CONVERTERS
Single phase to single phase cyclo-converters – analysis of midpoint and bridge Configurations – Three phase to three phase cyclo-converters –analysis of Midpoint and bridge configurations – Limitations – Advantages – Applications & Problems - Matrix Converter.

UNIT III: SINGLE PHASE & THREE PHASE CONVERTERS
Single phase converters – Half controlled and Fully controlled converters – Evaluation of input power factor and harmonic factor – continuous and Discontinuous load current – single phase dual converters – power factor Improvements Techniques– Extinction angle control – symmetrical angle control, PWM – single phase sinusoidal PWM – single phase series converters – overlap analysis – Applications & Problems.
Three phase converters – Half controlled and fully controlled converters – Evaluation of input power factor and harmonic factor – continuous and Discontinuous load current – three phase dual converters – power factor Improvements Techniques– three phase PWM - twelve pulse converters – Applications – Problems – Design of converters.

UNIT IV: D.C. TO D.C. CONVERTERS
Analysis of step-down and step-up dc to dc converters with Resistive and Resistive-inductive loads – Switched mode regulators – Analysis of Buck Regulators - Boost regulators – buck and boost regulators – Cuk regulators – Condition for continuous inductor current and

capacitor voltage – comparison of regulators –Multi output boost converters – advantages – Applications – Problems.

UNIT V: PULSE WIDTH MODULATED INVERTERS

Principle of operation – performance parameters – single phase bridge inverter- evaluation of output voltage and current with resistive, inductive and Capacitive loads– Voltage control of single phase inverters – single PWM – Multiple PWM – sinusoidal PWM – modified PWM – phase displacement Control – Advanced modulation techniques for improved performance – Trapezoidal, staircase, stepped, harmonic injection and delta modulation – Advantages – Applications & Problems.

Three phase inverters – analysis of 180 degree conduction for output voltage And current with resistive, inductive loads – analysis of 120 degree Conduction – voltage control of three phase inverters – sinusoidal PWM – Third Harmonic PWM – 60 degree PWM – space vector modulation – Comparison of PWM techniques – harmonic reductions – Problems.

TEXT BOOKS:

1. Mohammed H. Rashid "Power Electronics" Pearson Education Third Edition – First Indian reprint 2004.
2. Ned Mohan, Tore M. Undeland and William P. Robbins, "Power Electronics" - John Wiley & Sons – Second Edition.

REFERENCE BOOKS:

1. Milliman Shepherd and Lizang –"Power converters circuits" – Chapter 14 (Matrix converter) PP- 415-444,
2. M.H.Rashid - Power electronics hand book –
3. Marian P. Kaźmierkowski, Ramu Krishnan, FredeBlabjerg Edition:" Control in power electronics" illustrated Published by Academic Press, 2002.

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M.Tech. I Year I-Sem (Power Electronics)

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POWER ELECTRONIC CONTROL OF DC DRIVES
(Core Theory – 2)

Prerequisite: Power Electronics

Course Objectives:
- To introduce drive system, characteristics of drive, and operating modes of drive
- To comprehend the principle and operation of phase control & Chopper controlled of dc drives.
- To design a current and speed controllers to achieve closed loop operation of dc drives.

Course Outcomes:
After completing this course, student will be able to:
- Perform simulations of phase and chopper controlled dc drive both for open loop and closed loop operations.
- Choose proper gain values for speed and current controllers.
- Distinguish the difference between PWM controller and hysteresis controller.

UNIT–I: SINGLE-PHASE RECTIFIER CONTROLLED DC MOTOR
Separately excited DC motors and DC series motors with rectified single phase supply – singlephase semi converter and single phase full converter for continuous and discontinuous modes of operation – power and power factor.

UNIT–II: THREE-PHASE RECTIFIERS CONTROLLED DC MOTOR (SEPARATELY EXCITED & SERIES)
Three-phase controlled converter, control circuit, control modeling of three phase converter – Steady state analysis of three phase converter control DC motor drive – Two quadrant, Three phase converter controlled DC motor drive – DC motor and load, converter.

UNIT–III: CLOSED LOOP CONTROL OF DC DRIVE
Current and speed controllers - Current and speed feedback – Design of controllers – Current and speed controllers – Motor equations – filter in the speed feedback loop speed controller – current reference generator – current controller and flow chart for simulation – Harmonics and associated problems – sixth harmonics torque.

UNIT–IV: CHOPPER CONTROLLED DC MOTOR DRIVES
Principle of operation of the chopper – Chopper with other power devices – model of the chopper – input to the chopper – steady state analysis of chopper controlled DC motor drives – rating of the devices – Pulsating torque.
Closed loop operation: Speed controlled drive system – current control loop – pulse width modulated current controller – hysteresis current controller – modeling of current controller – design of current controller.

UNIT–V: FOUR QUADRANT OPERATION OF DC DRIVES
Introduction to Four quadrant operation – Motoring operations, Electric Braking – Plugging, Dynamic and Regenerative Braking operations.Four quadrant operation of D.C motors by single phase, three phase dual converters and Choppers – Closed loop operation of DC motor.

TEXT BOOKS:

1. Power Electronics and motor control – Shepherd, Hulley, Liang – II Edition Cambridge University Press.
2. Electronic motor drives modeling Analysis and control – R. Krishnan – I Edition Prentice Hall India.
3. Power Electronics circuits, Devices and Applications – MH Rashid – PHI – 1 Edition 1995.
4. Power Semiconductor Drives – G. K. Dubey, Narosa Publishers –

REFERENCES:

1. Fundamentals of Electric Drives – GK Dubey, Narosa Publishers 1995
2. Power Semiconductor drives – SB Dewan and A Straughen -1975.

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ELECTIVE – 1.1: MACHINE MODELING AND ANALYSIS

Prerequisite: Electrical Machines

Course Objectives:
- Identifying the methods and assumptions in modeling of machines.
- Recognize the different frames for modeling of AC machines.
- To write voltage and torque equations in state space form for different machines.

Course Outcomes:
At the end of the course, the student is able to:
- Develop the mathematical models of various machines like, induction motor and Synchronous machines using modeling equations.
- Analyze the developed models in various reference frames.

UNIT-I:
Basic Two-pole DC machine - primitive 2-axis machine – Voltage and Current relationship – Torque equation.
Mathematical model of separately excited DC motor and DC Series motor in state variable form – Transfer function of the motor - Numerical problems.
Mathematical model of D.C. shunt motor D.C. Compound motor in state variable form – Transfer function of the motor - Numerical Problems

UNIT-II:
Linear transformation – Phase transformation (a, b, c to α, β, o) – Active transformation (α .β, o to d, q).
Circuitmodel of a 3 phase Induction motor – Linear transformation - Phase Transformation – Transformation to a Reference frame – Two axis models for induction motor - dq model based DOL starting of Induction Motors

UNIT-III:
Voltage and current Equations in stator reference frame – equation in Rotor reference frame – equations in a synchronously rotating frame – Torque equation - Equations in state – space form.

UNIT-IV:
Circuits model of a 3ph Synchronous motor – Two axis representation of Synchronous Motor.
Voltage and current Equations in state – space variable form – Torque equation - dq model based short circuit fault analysis- emphasis on voltage, frequency and recovery time.

UNIT-V:
Modeling of Permanent Magnet Synchronous motor – Modeling of Brushless DC Motor.

TEXT BOOKS:

1. Generalized Machine theory - P.S. Bimbhra, Khanna Publishers
2. Analysis of electric machinery and Drives systems - Paul C. Krause, Oleg wasynezuk, Scott D. Sudhoff.
3. Thyristor control of Electric Drives - VedamSubranmanyam.
4. Power System Stability and Control –PrabhaKundur, EPRI.

REFERECE BOOKS:

1. Performance optimization of induction motors during Voltage-controlled soft starting, Article inIEEE Transactions On Energy Conversion, July 2004.
2. A Novel Method for Starting of Induction Motor with Improved Transient Torque Pulsations, Nithin K.S, Dr.Bos Mathew Jos, MuhammedRafeek, Dr.Babu Paul. International Journal of Engineering and Innovative Technology (IJEIT) Volume 2, Issue 8, February 2013.

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ELECTIVE – 1.2: REACTIVE POWER COMPENSATION AND MANAGEMENT

Prerequisite: Power Systems

Course Objectives:
- To identify the necessity of reactive power compensation
- To describe load compensation
- To select various types of reactive power compensation in transmission systems
- To illustrate reactive power coordination system
- To characterize distribution side and utility side reactive power management.

Course Outcomes:
Upon the completion of this course, the student will be able to
- Distinguish the importance of load compensation in symmetrical as well as un symmetrical loads
- Observe various compensation methods in transmission lines
- Construct model for reactive power coordination
- Distinguish demand side reactive power management & user side reactive power management

UNIT-I: LOAD COMPENSATION
Objectives and specifications – reactive power characteristics – inductive and capacitive approximate biasing – Load compensator as a voltage regulator – phase balancing and power factor correction of unsymmetrical loads- examples.

UNIT-II: STEADY–STATE REACTIVE POWER COMPENSATION IN TRANSMISSION SYSTEM
Uncompensated line – types of compensation – Passive shunt and series and dynamic shunt compensation – examples
Transient state reactive power compensation in transmission systems:
Characteristic time periods – passive shunt compensation – static compensations - series capacitor compensation – compensation using synchronous condensers – examples

UNIT-III: REACTIVE POWER COORDINATION
Objective – Mathematical modeling – Operation planning – transmission benefits – Basic concepts of quality of power supply – disturbances- steady –state variations – effects of under voltages – frequency –Harmonics, radio frequency and electromagnetic interferences

UNIT-IV: DEMAND SIDE MANAGEMENT
Load patterns – basic methods load shaping – power tariffs- KVAR based tariffs penalties for voltage flickers and Harmonic voltage levels
Distribution side Reactive power Management:
System losses –loss reduction methods – examples – Reactive power planning – objectives – Economics Planning capacitor placement – retrofitting of capacitor banks

UNIT-V: USER SIDE REACTIVE POWER MANAGEMENT
KVAR requirements for domestic appliances – Purpose of using capacitors – selection of capacitors – deciding factors – types of available capacitor, characteristics and Limitations

Reactive power management in electric traction systems and are furnaces:
Typical layout of traction systems – reactive power control requirements – distribution transformers- Electric arc furnaces – basic operations- furnaces transformer –filter requirements – remedial measures –power factor of an arc furnace

TEXT BOOKS:

1. Reactive power control in Electric power systems by T.J.E.Miller, John Wiley and sons, 1982.
2. Reactive power Management by D.M.Tagare, Tata McGraw Hill, 2004.

REFERENCE BOOKS:

1. Wolfgang Hofmann, JurgenSchlabbach, Wolfgang Just “Reactive Power Compensation: A Practical Guide, April, 2012, Wiely publication.

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ELECTIVE – 1.3: HIGH FREQUENCY MAGNETIC COMPONENTS

Prerequisite: None

Course Objectives:
- To have a knowledge on magnetic circuits
- To know the skin effect and proximity effect

Course Outcomes:
Upon the completion of this course, the student will be able to
- Design of magnetic components (i.e., inductor and transformer) in a converter.
- Perform steady-state analysis of switched mode power supply.
- Understand core loss in an electromagnetic device, recognize& describe its effect.
- Describe the engineering uses of electromagnetic waves, by frequency band, and the respective hazards associated with them

UNIT-I:
Fundamentals of Magnetic Devices: Introduction, Magnetic Relationships, Magnetic Circuits, Magnetic Laws, Eddy Currents, Core Saturation, Volt-Second Balance, Inductance, Inductance Factor, Magnetic Energy, Self-Resonant Frequency, Classification of Power Losses in Magnetic Components, Non-inductive Coils.
Magnetic Cores: Introduction, Properties of Core Materials, Magnetic Dipoles, Magnetic Domains, Curie Temperature, Magnetization, Magnetic Materials, Hysteresis, Core Permeability, Core Geometries, Iron Alloy Cores, Amorphous Alloy Cores, Nickel–Iron and Cobalt–Iron Cores, Ferrite Cores, Powder Cores, Nano-crystalline Cores, Superconductors, Hysteresis Core Loss, Eddy-Current Core Loss, Total Core Loss, Complex Permeability.

UNIT-II:
Skin Effect & Proximity Effect: Introduction, Magnet Wire, Wire Insulation, Skin Depth, Ratio of AC-to-DC Winding Resistance, Skin Effect in Long Single Round Conductor, Current Density in Single Round Conductor, Impedance of Round Conductor, Magnetic Field Intensity for Round Wire, Other Methods of Determining the Round Wire Inductance, Power Density in Round Conductor, Skin Effect on Single Rectangular Plate. Proximity and Skin Effects in Two Parallel Plates, Anti-proximity and Skin Effects in Two Parallel Plates, Proximity Effect in Multiple-Layer Inductor, Appendix: Derivation of Proximity Power Loss.
Winding Resistance at High Frequencies: Introduction, Winding Resistance, Square and Round Conductors, Winding Resistance of Rectangular Conductor, Winding Resistance of Square Wire, Winding Resistance of Round Wire, Leakage Inductance, Solution for Round Conductor Winding in Cylindrical Coordinates, Litz Wire, Winding Power Loss for Inductor Current with Harmonics, Effective Winding Resistance for Non-sinusoidal Inductor Current, Thermal Model of Inductors.

UNIT-III:
Transformers: Introduction, Neumann's Formula for Mutual Inductance, Mutual Inductance, Energy Stored in Coupled Inductors, Magnetizing Inductance, Leakage Inductance, Measurement of Transformer Inductances, Stray Capacitance, High-Frequency Transformer Model, Non-interleaved Windings, Interleaved Windings, AC Current Transformers, Winding Power Losses with Harmonics, Thermal Model of Transformers.

Design of Transformers: Introduction, Area Product Method, Optimum Flux Density, Transformer Design for Fly-back Converter in CCM, Transformer Design for Fly-back Converter in DCM, Transformer Design for Fly-back Converter in CCM, Transformer Design for Fly-back Converter in DCM.

UNIT-IV:

Integrated Inductors: Introduction, Resistance of Rectangular Trace, Inductance of Straight Rectangular Trace, Construction of Integrated Inductors, Meander Inductors, Inductance of Straight Round Conductor, Inductance of Circular Round Wire Loop, Inductance of Two-Parallel Wire Loop, Inductance of Rectangle of Round Wire, Inductance of Polygon Round Wire Loop, Bond-wire Inductors, Single-Turn Planar Inductor, Inductance of Planar Square Loop, Planar Spiral Inductors, Multi-metal Spiral Inductors, Planar Transformers, MEMS Inductors, Inductance of Coaxial Cable, Inductance of Two-Wire Transmission Line, Eddy Currents in Integrated Inductors, Model of RF Integrated Inductors, PCB Inductors.

Design of Inductors: Introduction, Restrictions on Inductors, Window Utilization Factor, Temperature Rise of Inductors, Mean Turn Length of Inductors, Area Product Method, AC Inductor Design, Inductor Design for Buck Converter in CCM, Inductor Design for Buck Converter in DCM method.

UNIT-V:

Self-Capacitance: Introduction, High-Frequency Inductor Model, Self-Capacitance Components, Capacitance of Parallel-Plate Capacitor, Self-Capacitance of Foil Winding Inductors, Capacitance of Two Parallel Round Conductors, Capacitance of Round Conductor and Conducting Plane, Self-Capacitance of Single-Layer Inductors, Self-Capacitance of Multi-layer Inductors, Capacitance of Coaxial Cable.

TEXT BOOKS:

1. Design of Magnetic Components for Switched Mode Power Converters, Umanand L., Bhat,S.R., ISBN:978-81-224-0339-8, Wiley Eastern Publication, 1992.

REFERENCES:

1. High-Frequency Magnetic Components, Marian K. Kazimierczuk, ISBN: 978-0-470-71453-9 John Wiley& Sons, Inc.
2. G.C. Chryssis, High frequency switching power supplies, McGraw Hill, 1989 (2nd Edn.)
3. Eric Lowdon, Practical Transformer Design Handbook, Howard W. Sams& Co., Inc., 1980
4. “Thompson --- Electrodynamic Magnetic Suspension.pdf”
5. Witulski --- “Introduction to modeling of transformers and coupled inductors” Beattie --- “Inductance 101.pdf”
6. P. L. Dowell, "Effects of eddy currents in transformer windings.pdf"
7. Dixon--- “Eddy current losses in transformer windings.pdf”
8. J J Ding, J S Buckkeridge, “Design Considerations For A Sustainable Hybrid Energy System” IPENZ Transactions, 2000, Vol. 27, No. 1/EMCh.
9. Texas Instruments --- “Windings.pdf”
10. Texas Instruments --- “Magnetic core characteristics.pdf” Ferroxcube --- “3f3 ferrite datasheet.pdf” Ferroxcube --- “Ferrite selection guide.pdf” Magnetics, Inc., Ferrite Cores (www.mag-inc.com).

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ELECTIVE – 2.1: ANALYSIS OF HVDC SYSTEMS

Prerequisite: Power Electronics and Power Systems

Course Objectives:

- To Comprehend the conversion principles of HVDC Transmission
- Analysis of 3, 6, 12 pulse converters, rectifier and inverter operations of HVDC converters
- To identify the different types of Harmonics and its suppression methods including Filters
- To comprehend the requirement of grounding and grounding electrodes for HVDC systems.

Course Outcomes:

Upon the completion of this course, the student will be able to

- Find the applications of HVDC transmission in the power system with the acquired knowledge.
- Analyze different converter topologies viz. 3, 6 and 12 Pulse converters and understand it's control aspects.
- Understand the filter configuration and harmonic suppression methods.
- Have knowledge on grounding electrodes and their design for HVDC systems.

UNIT-I

INTRODUCTION: General consideration, Power Handling Capabilities of HVDC Lines Basic Conversion principles, static converter configuration.

STATIC POWER CONVERTERS: 3-pulse, 6-pulse, and 12-pulse converters, converter station and Terminal equipment, commutation process, Rectifier and inverter operation, equivalent circuit for converter – special features of converter transformers

UNIT-II

CONTROL OF HVDC CONVERTERS AND SYSTEMS: Introduction – Mechanism of AC power transmission – principles of control – necessity of control in case of a DC link – Rectifier control – compounding of rectifiers – power reversal in a DC link – VDCOL Characteristics of converter – System control hierarchy – Inverter extinction angle control – pulse phase control – starting and stopping of a DC link – constant power control – control systems for HVDC converters inverter operation problems control of VSC converters.

UNIT-III

HARMONICS IN HVDC SYSTEMS: Introduction – Generation of harmonics by converters – Characteristic harmonics on DC side – Characteristic Current harmonics – Characteristic variation of Harmonic currents – Effect of control modes on harmonics – Non-characteristic harmonics – Harmonics in VSC converters.

UNIT-IV

HARMONIC SUPPRESSION IN HVDC SYSTEMS – FILTERS: Introduction – Harmonic model and Equivalent circuit – use of filters – filter configuration – design of band-pass filter – minimum cost of tuned AC filters – design of high-pass filters – protection of filters – Reactive power considerations – DC filters – Power line communication and RI noise –

Active filters and their applications – Filters with VSC HVDC schemes – other methods of harmonic elimination.

UNIT-V

GROUNDING AND GROUNDING ELECTRODES FOR HVDC SYSTEMS: Introduction – Advantages and problems with ground return – HVDC systems grounding – The current field in earth near an electrode – Resistance of electrodes-electric current field –Distribution of current field between the electrodes – natural current field due to the Earth's magnetic field – Effect of ground return on buried objects – requirements of electrodes – basic parameters of design of ground electrodes – design of land electrodes.

TEXT BOOKS:

1. E.W. Kimbark: Direct current Transmission, Wiely Inter Science – New York.
2. HVDC Transmission by S. Kamakshaiah, V. Kamaraju, Tata McGraw Hill Education Private Limited.
3. J. Arillaga HVDC Transmission Peter Peregrinus ltd. London UK 1983.

REFERENCE BOOKS:

1. K. R. Padiyar, "High Voltage Direct current Transmission", Wiely Eastern Ltd New Delhi – 1992.
2. E. Uhlman, "Power Transmission by Direct Current", Springer Verlag, Berlin Helberg. 1985.

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ELECTIVE – 2.2: RENEWABLE ENERGY SYSTEMS

Prerequisite: None

Course Objectives:

- To create the awareness of energy conservation in students
- To identify renewable energy sources for electrical power generation
- To analyze different energy storage methods
- To have knowledge on environmental effects of energy conversion

Course Outcomes:

Upon the completion of this course, the student will be able to

- Find different renewable energy sources to produce electrical power
- Estimate conventional energy sources to produce electrical energy
- Role-play the fact that the conventional energy resources are depleted
- Arrange Stored energy and to avoid the environmental pollution

UNIT- I: SOLAR ENERGY SYSTEMS:

Introduction – solar radiation - solar thermal energy conversion - Flat plate collector - concentric collectors- solar pond - central receiver system- solar pumping - Solar photovoltaic systems - characteristics of PV cell- Photo voltaic modules - Types of Photo voltaic systems.

UNIT-II: WIND ENERGY AND BIO GAS:

Basics of wind energy - classification of turbines - wind characteristics - energy extraction - Betz limit - Modes of wind power generation- Bio Mass energy conversion - Anaerobic Digestion - Aerobic Digestion - Gasification-Bio Gas Plants.

UNIT-III: OCEAN ENERGY CONVERSION:

Tidal Energy generation - characteristics of Tides - Power generation schemes - Components in Tidal power plant- Wave Energy - Principle of wave energy plant - Wave energy conversion machines - Ocean Thermal Energy conversion - Principle - cycles of operation - Types of OTEC plants - Applications

UNIT-IV: GEO-THERMAL ENERGY AND FUEL CELLS : HYBRID ENERGY SYSTEMS:

Geothermal Energy - Structure of Earth's interior - Geothermal fields, gradient, resources - Geothermal power generation - Fuel cells – Introduction - Principle of operation - Types of Fuel cells - State of art fuel cells-energy output of a fuel cell - operating characteristics of fuel cells - thermal efficiency - Need for Hybrid systems - Types of Hybrid systems.

UNIT-V : ENVIRONMENTAL ASPECTS OF ELECTRIC ENERGY GENERATION:

Introduction - Thermal pollution - Hydel power projects - Impact on environment - Nuclear power generation – Impact on environment - Impact of renewable energy generation on environment - Global environmental awareness.

TEXT BOOKS:

1. D.P.Kothari, K.C.Singal, R.Ranjan ,"Renewable Energy Resources and emerging technologies"- PHI 2/e 2011
2. John Twidell and Tony Weir,"Renewable Energy Resources" - 2^{nd} edition, CRC Press
3. Rakosh Das Begamudre,"Energy conversion systems"- New Age International Publishers, New Delhi - 2000.
4. "Energy conversion systems" by Rakosh das Begamudre, New age International publishers, New Delhi - 2000.
5. "Renewable Energy Resources" by John Twidell and Tony Weir, 2^{nd} Edition, Fspon & Co.

REFERENCES:

1. "Understanding Renewable Energy Systems" , by Volker Quaschning, 2005, UK.
2. "Renewable Energy Systems-Advanced Conversion, Technologies & Applications" by Faner Lin Luo Honer Ye, CRC press, Taylor & Francis group.

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ELECTIVE – 2.3: ELECTRIC TRACTION TECHNOLOGIES

Prerequisite: None

Course Objectives:

- To be able to understand various systems of track electrification, power supply system and mechanics of electric train.
- To understand various motors used in the electric traction and their converters.

Course Outcomes:

Upon the completion of this course, the student will be able to

- Distinguish the importance of single and three phase traction system.
- Observe various Traction mechanics
- Construct model HV arrangements, Semi conductor converter controlled drives.

UNIT – I

Traction Systems : Electric drives - Advantages & disadvantages - System of track electrification - DC, 1-Phase low frequency, 3-Phase low frequency and composite systems, Problems of 1-phase traction system - Current unbalance, Voltage unbalance, Production of harmonics, Induction effects, Booster transformer - Rail connected booster transformer. Comparison between ac and dc systems.

UNIT – II

Traction mechanics: Types of services, Speed - time curves - Construction of quadrilateral and trapezoidal speed time curves, Average & schedule speeds. Tractive effort - Speed characteristic, Power of traction motor, specific energy consumption - Factors affecting specific energy consumption, Coefficient of adhesion, slip - Factors affecting slip, magnetically suspended trains.

UNIT – III

Power supply arrangements : High voltage supply, Constituents of supply system - Substations, Feeding post, Feeding & sectioning arrangements, Remote control center, Design considerations of substations, Over head equipment - principle of design of OHE, Polygonal OHE - Different types of constructions, Basic sag & tension calculations, Dropper design, Current collection gear for OHE.

UN IT – IV

Traction motors : Desirable characteristics, D.C. series motors, A.C. series motors, 3-Phase induction motors, linear induction motors, D.C. motor series & parallel control - Shunt bridge transition – Drum controller, Contact type bridge transition control, Energy saving, Types of braking in a.c. and d.c. drives, Conditions for regenerative braking, Stability of motors under regenerative braking.

UNIT – V

Semi conductor converter controlled drives: Advantages of 25KV of AC Traction - Control of d.c. motors - single and two stage converters, Control of ac. motors - CSI fed squirrel cage induction motor, PWM VSI induction motor drive, D.C. traction — Chopper controlled d.c. motors, composite braking, Diesel electric traction — D.C. generator fed d.c. series motor, Alternator fed d.c. series motor, Alternator fed squirrel cage induction motor, Locomotive and axle codes.Introduction to new technologies in superspeed electric locomotives.

TEXT BOOKS :

1. Partab.H - Modern Electric Traction, DhanpatRai& Sons – 1998.
2. Dubey. G.K. - Fundamentals of Electrical Drives, Narosa Publishing House - 2001.
3. C.LWadhwa — Generation, Distribution and Utilization of Electrical Energy, New AgeInternational - 2006.
4. J.B. Gupta - Utilization of Electrical Power and Electric Traction, S.K. Kataria& Sons publications, 9th edition2004.

REFERENCE:

1. www.siemens.com/mobility/locomotives
2. www.abb.com/railway

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ELECTIVE – 3.1: MODERN CONTROL THEORY

Prerequisite: Control Systems

Course Objectives:

- To explain the concepts of basics and modern control system for the real time analysis and design of control systems.
- To explain the concepts of state variables analysis.
- To study and analyze non linear systems.
- To analyze the concept of stability for nonlinear systems and their categorization.
- To apply the comprehensive knowledge of optimal theory for Control Systems.

Course Outcomes:

Upon completion of this course, students should be able to:

- Various terms of basic and modern control system for the real time analysis and design of control systems.
- To perform state variables analysis for any real time system.
- Apply the concept of optimal control to any system.
- Able to examine a system for its stability, controllability and observability.
- Implement basic principles and techniques in designing linear control systems.
- Formulate and solve deterministic optimal control problems in terms of performance indices.
- Apply knowledge of control theory for practical implementations in engineering and network analysis.

UNIT-I

Mathematical Preliminaries and State Variable Analysis: Fields, Vectors and Vector Spaces – Linear combinations and Bases – Linear Transformations and Matrices – Scalar Product and Norms – Eigen values, Eigen Vectors and a Canonical form representation of Linear systems – The concept of state – State space model of Dynamic systems – Time invariance and Linearity – Non uniqueness of state model – State diagrams for Continuous-Time State models - Existence and Uniqueness of Solutions to Continuous-Time State Equations – Solutions of Linear Time Invariant Continuous-Time State Equations – State transition matrix and it's properties. Complete solution of state space model due to zero input and due to zero state.

UNIT II

Controllability and Observability: General concept of controllability – Controllability tests, different state transformations such as diagonalization, Jordon canonical forms and Controllability canonical forms for Continuous-Time Invariant Systems – General concept of Observability – Observability tests for Continuous-Time Invariant Systems – Observability of different State transformation forms.

UNIT III

State Feedback Controllers and Observers: State feedback controller design through Pole Assignment, using Ackkermans formula– State observers: Full order and Reduced order observers.

UNIT IV

Non-Linear Systems: Introduction – Non Linear Systems - Types of Non-Linearities – Saturation – Dead-Zone - Backlash – Jump Phenomenon etc; Linearization of nonlinear systems, Singular Points and its types– Describing function–describing function of different types of nonlinear elements, – Stability analysis of Non-Linear systems through describing functions. Introduction to phase-plane analysis, Method of Isoclines for Constructing Trajectories, Stability analysis of nonlinear systems based on phase-plane method.

UNIT V

Stability Analysis: Stability in the sense of Lyapunov, Lyapunov's stability and Lypanov's instability theorems - Stability Analysis of the Linear continuous time invariant systems by Lyapunov second method – Generation of Lyapunov functions – Variable gradient method – Krasooviski's method.

TEXT BOOKS:

1. M.Gopal, Modern Control System Theory, New Age International - 1984
2. Ogata. K, Modern Control Engineering, Prentice Hall - 1997
3. N K Sinha, Control Systems, New Age International – 3rd edition.

REFERENCES:

1. Donald E.Kirk, Optimal Control Theory an Introduction, Prentice - Hall Network series - Firstedition.

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ELECTIVE – 3.2: ADVANCED DIGITAL SIGNAL PROCESSING

Prerequisite: Digital signal processing

Course Objectives:

- To emphasize the advanced concepts of digital signal processing and the mathematical basis of discrete time signal analysis.
- To introduce the implementation of DSP algorithms and power spectrum analysis.

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

- Solve the various types of practical problems of DSP processors.
- Develop DSP based real time systems.
- Design and analyze various filters.

UNIT–I
DIGITAL FILTER STRUCTURES: Block diagram representation – Equivalent Structures – FIR and IIR digital filter Structures AII pass Filters - tunable IIR Digital Sine-cosine generator - Computational complexity of digital filter structures.

UNIT-II
DIGITAL FILTER DESIGN: Preliminary considerations- Bilinear transformation method of IIR filter design –design of Low pass high pass – Band pass, and Band stop- IIR digital filters – Spectral transformations of IIR filters – FIR filter design – based on Windowed Fourier series – design of FIR digital filters with least – mean square-error – constrained Least – square design of FIR digital filters.

UNIT-III
DSP ALGORITHM IMPLEMENTATION: Computation of the discrete Fourier transform- Number representation – Arithmetic operations – handling of overflow – Tunable digital filters – function approximation.

UNIT-IV
ANALYSIS OF FINITE WORD LENGTH EFFECTS: The Quantization process and errors- Quantization of fixed –point and floating –point Numbers – Analysis of coefficient Quantization effects – Analysis of Arithmetic Round-off errors- Dynamic range scaling – signal –to- noise in Low –order IIR filters- Low – Sensitivity Digital filter – Reduction of Product round-off errors feedback – Limit cycles in IIR digital filter – Round – off errors in FFT Algorithms.

UNIT-V
POWER SPECTRUM ESTIMATION: Estimation of spectra from Finite Duration Observations signals- Non-parametric methods for power spectrum Estimation- parametric method for power spectrum Estimation- Estimation of spectral form-Finite duration observation of signals- Non-parametric methods for power spectrum estimation – Walsh methods – Blackman and torchy method.

TEXT BOOKS:

1. Sanjit K. Mitra, Digital signal processing – TMH second edition
2. Alan V. Oppenheim, Ronald W, Shafer, Discrete Time Signal Processing – PHI 1996 1st Edition reprint
3. John G. Proakis, Digital Signal Processing principles – Algorithms and Applications – PHI – 3rd edition 2002.

REFERENCE BOOKS:

1. S Salivahanan. A. Vallavaraj C. Gnanapriya, Digital Signal Processing – TMH – 2nd reprint 2001.
2. Lourens R RebinarandBernold, Theory and Applications of Digital Signal Processing.
3. Auntoniam, Digital Filter Analysis and Design, TMH.

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ELECTIVE – 3.3: INDUSTRIAL INSTRUMENTATION

Prerequisite: None

Course Objectives:
- To study the characteristics of instruments
- Analyze the various type s of transducers
- Principle of operation and selection of transducers depend s on their applications.
- Basic knowledge of displacement, strain, pressure, temperature, flow, level, density, and viscosity measurements.

Course Outcomes:
After completion of this course, the students will be able to
- Select the transducers and their types, usage and operation and different characteristics of transducers.
- Calibrate the various instruments and application of various instruments to different fields.
- Implement process techniques, instrumental setups as well as controlling and monitoring of various processes in the industries.

UNIT – I: INTRODUCTION:
Introduction to Instrumentation system - Static and Dynamic characteristics of Instruments - Principles of transducers.

UNIT- II: MEASUREMENT OF DISPLACEMENT & STRAIN:
Displacement and proximity gauges - Linear Variable Differential Transformer (LVDT) - Measurement of strain: Strain Gauge - unbalanced Wheatstone bridge.

UNIT – III: MEASUREMENT OF TEMPERATURE:
Thermocouples - Resistance Temperature Detector (RTD) - Thermisters and radiation pyrometer.

UNIT- IV : MEASUREMENT OF FLOW:
Measurement of level: Capacitance based and Float based method.Differential pressure flow meters - variable area flow meters- variable reluctance flow meters - Turbine flow meter - Ultrasonic flow meter (Both transit time and Doppler Shift) - Electromagnetic flow meter and mass flow meter.

UNIT – V: MEASUREMENT OF PRESSURE & OTHER QUANTITIES:
Elastic transducers- Low pressure measurement-McLeod and ionization gauge-Load cell - Torque Cell - pH probe and viscosity measurement - Basics of Data transmission - Synchro and Servo motor - Pneumatic and Hydraulic Instrumentation system.

TEXT BOOK:
1. E. Doeblin," Industrial Instrumentation"- CRC Press
2. A.K.Sawhney,Course in Electrical and Electronics Measurements and Instrumentation, DhanpatRai& Company

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ELECTIVE – 4.1: MICROCONTROLLERS AND APPLICATIONS

Prerequisite: Microprocessors and Interfacing Devices

Course Objectives:
- To relate the basic architecture and addressing modes of a microcontroller.
- To explain the principles of top down design to microcontroller software development
- To demonstrate assembly language programs for the advanced Microcontroller , assembly language code for high-level language structures such as IF-THEN-ELSE and DO-WHILE
- To analyze a typical I/O interface and to discuss timing issues
- To identify different types of memory used in microcontrollers

Course Outcomes:
Upon the completion of this course, the student will be able to
- Distinguish types of computers & microcontrollers,
- Know 8-Bit, 16- Bit & 32 Bit advanced Microcontrollers.
- DevelopReal time Applications of Microcontrollers & Demonstrate RTOS for Microcontrollers.
- Translate Hardware applications using Microcontrollers.

UNIT-I: OVERVIEW OF ARCHITECTURE & MICROCONTROLLER RESOURCES
Architecture of a microcontroller – Microcontroller resources – Resources in advanced and next generation microcontrollers – 8051 microcontroller – Internal and External memories – Counters and Timers – Synchronous serial-cum asynchronous serial communication - Interrupts.

UNIT-II: 8051- MICROCONTROLLERS INSTRUCTION SET
Basic assembly language programming – Data transfer instructions – Data and Bit-manipulation instructions – Arithmetic instructions – Instructions for Logical operations on the test among the Registers, Internal RAM, and SFRs – Program flow control instructions – Interrupt control flow.

UNIT-III: REAL TIME CONTROL
INTERRUPTS: Interrupt handling structure of an MCU – Interrupt Latency and Interrupt deadline – Multiple sources of the interrupts – Non-maskable interrupt sources – Enabling or disabling of the sources – Polling to determine the interrupt source and assignment of the priorities among them – Interrupt structure in Intel 8051.
TIMERS: Programmable Timers in the MCU's – Free running counter and real time control – Interrupt interval and density constraints.

UNIT-IV: SYSTEMS DESIGN
DIGITAL AND ANALOG INTERFACING METHODS: Switch, Keypad and Keyboard interfacings – LED and Array of LEDs – Keyboard-cum-Display controller (8279) – Alphanumeric Devices – Display Systems and its interfaces – Printer interfaces – Programmable instruments interface using IEEE 488 Bus – Interfacing with the Flash Memory – Interfaces – Interfacing to High Power Devices – Analog input interfacing –

Analog output interfacing – Optical motor shaft encoders – Industrial control – Industrial process control system – Prototype MCU based Measuring instruments – Robotics and Embedded control – Digital Signal Processing and digital filters.

UNIT-V: REAL TIME OPERATING SYSTEM FOR MICROCONTROLLERS:
Real Time operating system – RTOS of Keil (RTX51) – Use of RTOS in Design – Software development tools for Microcontrollers.
16-BIT MICROCONTROLLERS: Hardware – Memory map in Intel 80196 family MCU system – IO ports – Programmable Timers and High-speed outputs and input captures – Interrupts – instructions.
ARM 32 Bit MCUs: Introduction to 16/32 Bit processors – ARM architecture and organization – ARM / Thumb programming model – ARM / Thumb instruction set – Development tools.

TEXT BOOKS:
1. Raj Kamal, "Microcontrollers Architecture, Programming, Interfacing and System Design" – Pearson Education, 2005.
2. Mazidi and Mazidi, "The 8051 Microcontroller and Embedded Systems" – PHI, 2000.

REFERENCES:
1. A.V. Deshmuk, "Microcontrollers (Theory & Applications)" – WTMH, 2005.
2. John B. Peatman, "Design with PIC Microcontrollers" – Pearson Education, 2005.
3. Microcontroller Programming, Julio Sanchez, Maria P. Canton, CRC Press.
4. The 8051 Microcontroller, Ayala, Cengage Learning.
5. Microprocessors and Microcontrollers, Architecture, Programming and System Design, Krishna Kant, PHI Learning PVT. Ltd.
6. Microprocessors, Nilesh B. Bahadure, PHI Learning PVT. Ltd.

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ELECTIVE – 4.2: EMBEDDED SYSTEMS

Prerequisite: Microprocessors and Interfacing Devices

Course Objectives:

- To emphasize the general embedded system concepts, design of embedded hardware and software development tools
- To explain the basics of real time operating and embedded systems
- To describe key issues such as CPU scheduling, memory management, task synchronization, and file system in the context of real-time embedded systems.

Course Outcomes:

Upon the completion of this course, the student will be able to

- To analyze and design embedded systems and real-time systems
- Define the unique design problems and challenges of real-time systems
- Identify the unique characteristics of real-time operating systems and evaluate the need for real-time operating system
- Explain the general structure of a real-time system and Understand and use RTOS to build an embedded real-time system
- Gain knowledge and skills necessary to design and develop embedded applications based on real-time operating systems.

UNIT- I: OVERVIEW OF EMBEDDED SYSTEM

Embedded System, types of Embedded System, Requirements of Embedded System, and Issues in Embedded software development, Applications.

UNIT-II: PROCESSOR & MEMORY ORGANIZATION

Structural units in a processor, Processor selection, Memory devices, Memory selection, Memory Allocation & Map, Interfacing.

UNIT-III: DEVICES, DEVICE DRIVERS & BUSES FOR DEVICE NETWORKS

I/O devices, Timer & Counter devices, Serial Communication, Communication between devices using different buses. Device drives, Parallel and serial port device drives in a system, Interrupt servicing mechanism, context and periods for context switching, Deadline and Interrupt Latency.

UNIT-IV: PROGRAMMING & MODELING CONCEPTS

Program elements, Modeling Processes for Software Analysis, Programming Models, Modeling of Multiprocessor Systems, Software algorithm Concepts, design, implementation, testing, validating, debugging, Management and maintenance, Necessity of RTOS.

UNIT-V: HARDWARE AND SOFTWARE CO-DESIGN

Embedded system design and co-design issues in software development, design cycle in development phase for Embedded System, Use of ICE & Software tools for development of ES, Issues in embedded system design.

TEXTBOOKS:

1. Embedded systems: Architecture, programming and design by Rajkamal, TMH
2. Embedded system design by Arnold S Burger, CMP

REFERENCES:

1. An embedded software primer by David Simon, PEA
2. Embedded systems design:Real world design be Steve Heath; Butterworth Heinenann, Newton mass USA 2002
3. Data communication by Hayt.

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ELECTIVE – 4.3: RELIABILITY ENGINEERING

Prerequisite: None

Course Objectives:

- To comprehend the concept of Reliability and Unreliability
- Derive the expressions for probability of failure, Expected value and standard deviation of Binominal distribution, Poisson distribution, normal distribution and weibull distributions.
- Formulating expressions for Reliability analysis of series-parallel and Non-series parallel systems
- Deriving expressions for Time dependent and Limiting State Probabilities using Markov models.

Course Outcomes:

Upon the completion of this course, the student will be able to

- Apply fundamental knowledge of Reliability to modeling and analysis of series-parallel and Non-series parallel systems.
- Solve some practical problems related with Generation, Transmission and Utilization of Electrical Energy.
- Understand or become aware of various failures, causes of failures and remedies for failures in practical systems.

Unit I:

Rules for combining probabilities of events, Definition of Reliability. Significance of the terms appearing in the definition. Probability distributions: Random variables, probability density and distribution functions. Mathematical expectation, Binominal distribution, Poisson distribution, normal distribution, weibull distribution.

Unit II:

Hazard rate, derivation of the reliability function in terms of the hazard rate. Failures: Causes of failures, types of failures (early failures, chance failures and wear-out failures). Bath tub curve - Preventive and corrective maintenance - Modes of failure. Measures of reliability: mean time to failure and mean time between failures.

Unit III:

Classification of engineering systems: series, parallel and series-parallel systems- Expressions for the reliability of the basic configurations. Reliability evaluation of Non-series-parallel configurations: Decomposition, Path based and cutest based methods, Deduction of the Paths and cut sets from Event tree.

Unit IV:

Discrete Markov Chains: General modeling concepts, stochastic transitional probability matrix, time dependent probability evaluation and limiting state probability evaluation of one component repairable model. Absorbing states: Continuous Markov Processes: Modeling concepts, State space diagrams, Stochastic Transitional Probability Matrix, Evaluating time dependent and limiting state Probabilities of one component repairable model. Evaluation of limiting state probabilities of two component repairable model.

UNIT-V:
Approximate system Reliability analysis of Series systems, parallel systems with two and more than two components, Network reduction techniques. Minimal cutest/failure mode approach.

TEXT BOOKS:

1. "Reliability evaluation of Engineering systems", Roy Billinton and Ronald N Allan, BS Publications.
2. "Reliability Engineering", Elsayed A. Elsayed, Prentice Hall Publications.

REFERENCE BOOKS:

1. "Reliability Engineering: Theory and Practice", By Alessandro Birolini, Springer Publications.
2. "An Introduction to Reliability and Maintainability Engineering", Charles Ebeling, TMH Publications.
3. "Reliability Engineering", E. Balaguruswamy, TMH Publications.

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ELECTIVE-4.4: OPTIMIZATION TECHNIQUES

Prerequisite: None

Course Objectives:
- To understand the theory of optimization methods and algorithms developed for solving various types of optimization problems.
- To develop an interest in applying optimization techniques in problems of Engineering and Technology
- To apply the mathematical results and numerical techniques of optimization theory to concrete Engineering problems.

Course Outcomes:
Upon the completion of this course, the student will be able to
- Know basic theoretical principles in optimization
- formulate optimization models and obtain solutions for optimization;
- apply methods of sensitivity analysis and analyze post processing of results

UNIT – I
Introduction and Classical Optimization Techniques:
Statement of an Optimization problem – design vector – design constraints – constraint surface – objective function – objective function surfaces – classification of Optimization problems.
Classical Optimization Techniques
Single variable Optimization – multi variable Optimization without constraints – necessary and sufficient conditions for minimum/maximum – multivariable Optimization with equality constraints.
Solution by method of Lagrange multipliers – multivariable Optimization with inequality constraints – Kuhn – Tucker conditions.

UNIT – II
Linear Programming
Standard form of a linear programming problem – geometry of linear programming problems – definitions and theorems – solution of a system of linear simultaneous equations – pivotal reduction of a general system of equations – motivation to the simplex method – simplex algorithm.

UNIT – III
Transportation Problem
Finding initial basic feasible solution by north – west corner rule, least cost method and Vogel's approximation method – testing for optimality of balanced transportation problems.
Unconstrained Nonlinear Programming:
One – dimensional minimization methods: Classification, Fibonacci method and Quadratic interpolation method

U**NIT – IV**
Unconstrained Optimization Techniques
Univariate method, Powell's method and steepest descent method.
Constrained Nonlinear Programming:
Characteristics of a constrained problem, Classification, Basic approach of Penalty Function method; Basic approach of Penalty Function method; Basic approaches of Interior and Exterior penalty function methods. Introduction to convex Programming Problem.

UNIT – V

Dynamic Programming:

Dynamic programming multistage decision processes – types – concept of sub optimization and the principle of optimality – computational procedure in dynamic programming – examples illustrating the calculus method of solution - examples illustrating the tabular method of solution.

TEXT BOOKS:

1. "Engineering optimization: Theory and practice"-by S. S.Rao, New Age International (P) Limited, 3rd edition, 1998.
2. "Introductory Operations Research" by H.S. Kasene& K.D. Kumar, Springer(India), Pvt. LTd.

REFERENCES:

1. "Optimization Methods in Operations Research and systems Analysis" – by K.V. Mital and C. Mohan, New Age International (P) Limited, Publishers, 3rd edition, 1996.
2. Operations Research – by Dr. S.D.Sharma.
3. "Operations Research: An Introduction" by H.A. Taha, PHI Pvt. Ltd., 6th edition
4. Linear Programming by G. Hadley

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ELECTIVE-4.5: ENERGY GENERATION FROM WASTE

Prerequisite: NCPG

Course Objectives:
- To understand the theory of Nonconventional energy sources.
- To develop an interest in applying energy generation from waste and solve problems of Engineering and Technology .

Course Outcomes:
Upon the completion of this course, the student will be able to
- Apply fundamental knowledge of NCPG to Generate Energy from Waste .
- Solve some practical problems related **.**
- Understand or become aware of various failures, causes of failures and remedies for failures in practical systems

UNIT-I:
Solid Waste Sources Solid Waste Sources, types, composition, Properties, Global warming, Municipal Solid Waste: Physical, chemical and biological properties , Waste Collection and, Transfer stations, Waste minimization and recycling of municipal waste, Segregation of waste, Size Reduction , Managing Waste.Status of technologies for generation of Energy from Waste Treatment and Disposal Aerobic composting, incineration, Furnace type and design, Medical waste /Pharmaceutical waste treatment Technologies, incineration, Environmental impacts, Measures to mitigate environmental effects due to incineration .

UNIT-II:
Land Fill method of Solid waste disposal Land fill classification, Types, methods and Sitting consideration, Layout and preliminary design of landfills: Composition, characteristics, generation, Movement and control of landfill leach ate and gases, Environmental monitoring system for land fill gases.

UNIT-III:
Energy Generation from Waste Bio-chemical Conversion: Sources of energy generation, anaerobic digestion of sewage and municipal wastes, direct combustion of MSW-refuse derived solid fuel, Industrial waste, agro residues, Anaerobic Digestion.

UNIT-IV:
Biogas production, Land fill gas generation and utilization, Thermo-chemical conversion: Sources of energy generation, Gasification of waste using Gasifiers, Briquetting, Utilization and advantages of briquetting, Environmental benefits of Bio-chemical and Thermo-chemical conversion.

UNIT–V:
E-waste: e-waste in the global context – Growth of Electrical and Electronics Industry in India – Environmental concerns and health hazards – Recycling e-waste: a thriving economy of the unorganized sector – Global trade in hazardous waste – impact of hazardous e-waste in India. Management of e-waste: e-waste legislation, Government regulations on e-waste management – International experience – need for stringent health safeguards and environmental protection laws of India.

TEXT BOOKS:

1. Nicholas P. Cheremisinoff. Handbook of Solid Waste Management and Waste Minimization Technologies. An Imprint of Elsevier, New Delhi (2003).
2. P. AarneVesilind, William A. Worrell and Debra R. Reinhart. Solid Waste Engineering. Thomson Asia Pte Ltd. Singapore (2002)
3. M. Dutta , B. P. Parida, B. K. Guha and T. R. Surkrishnan. Industrial Solid Waste Management and Landfilling practice. Narosa Publishing House, New Delhi (1999).
4. "E-waste in India: Research unit, RajyaSabha Secretariat, New Delhi, June 2011"
5. AmalenduBagchi. Design, construction and Monitoring of Landfills. John Wiley and Sons. New York. (1994)
6. M. L. Davis and D. A. Cornwell. Introduction to environmental engineering. McGraw Hill International Edition, Singapore (2008)
7. C. S. Rao. Environmental Pollution Control Engineering. Wiley Eastern Ltd. New Delhi (1995)
8. S. K. Agarwal. Industrial Environment Assessment and Strategy. APH Publishing Corporation. New Delhi (!996)
9. Sofer, Samir S. (ed.), Zaborsky, R. (ed.), "Biomass Conversion Processes for Energy and Fuels", New York, Plenum Press, 1981
10. Hagerty, D.Joseph; Pavoni, Joseph L; Heer, John E., "Solid Waste Management", New York, Van Nostrand, 1973
11. George Tchobanoglous, Hilary Theisen and Samuel Vigil Prsl: Tchobanoglous, George Theisen, Hillary Vigil, Samuel, "Integrated Solid Waste management: Engineering Principles and Management issues", New York, McGraw Hill, 1993.

REFERENCES:

1. C Parker and T Roberts (Ed), Energy from Waste - An Evaluation of Conversion Technologies, Elsevier Applied Science, London, 1985
2. KL Shah, Basics of Solid and Hazardous Waste Management Technology, Prentice Hall, 2000 3. M Datta, Waste Disposal in Engineered Landfills, Narosa Publishing House, 1997
3. G Rich et.al, Hazardous Waste Management Technology, Podvan Publishers, 1987
4. AD Bhide, BB Sundaresan, Solid Waste Management in Developing Countries, INSDOC, New Delhi,1983 FUEL CELL AND
5. **Google books:**
   (i) e-waste Management: From waste to ResourceKlaus Hieronymi, RamzyKahnat, Eric williams Tech. & Engg.-2013(Publisher: Earthscan 2013).
   (ii) What is the impact of E-waste: Tamara Thompson
   (iii) E-waste poses a Health Hazard: SairudeenPattazhy
6. **Weblinks :**
   www.unep.org
   www.routledge.com
   www.amazon.com
   www.bookdepository.com
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ELECTIVE-4.6: INTEGRATION OF ENERGY SOURCES

Prerequisite: Power Generation
Power Electronics
Power system Stability
Non-conventional energy sources

Preamble:
A comprehensive discussion of renewable energy resources, the associated conversion technologies for electric power generation and challenges in renewable energy integration to the grid are provided in this course. The course also introduces the importance hybrid systems and isolated systems.

Course Objectives:
Upon successful completion of the course the students will be familiar with:
- To introduce the characteristics of various types of renewable energy sources and converters.
- To explain the importance of storage and sizing of hybrid systems.
- To introduce the control issues of isolated systems.
- To explain the harmonics, power quality, voltage imperfections, power injection issues on the grid by integrating renewable energy sources.

Course Outcomes:
At the end of the course, the student should be able to:
- Identify the characteristics of renewable energy sources and converters.
- Analyze the importance of storage and sizing of hybrid systems.
- Realize the problems related to isolated systems.
- Analyze the challenges faced by the grid by integrating renewable energy sources.

UNIT- I:
Review of characteristics of power sources: Basic review of power generation from wind - Solar PV - Thermal - Small hydro - Biomass power strategies in each of these energy conversion systems - Review of maximum power point tracking techniques in solar PV and wind (perturb & observe, hill climbs, incremental conductance).

UNIT-II:
Converter Topologies: DC/DC converter (buck, boost, buck boost) - DC/AC inverters (sine, triangular, PWM techniques) - Phase locked loop for inverters.

UNIT-III:
Hybrid Systems: Advantages of hybrid power systems - Importance of storage in hybrid power systems - Design of hybrid power system based on load curve - Sizing of hybrid power systems.

UNIT-IV:
Isolated Systems: Control issues in isolated systems for voltage and frequency - Small signal stability in isolated power systems - Importance of storage and dump load in isolated systems.

UNIT-V:

Issues in integration of renewable energy sources: Overview of challenges in integrating renewable sources to the grid - Impact of harmonics on power quality - Need to maintain voltage within a band and fluctuations in voltage because of renewable integration - Power inverter and converter technologies - Mechanism to synchronize power from renewable sources to the grid - Overview of challenges faced in designing power injection from offshore generation sources - Challenges in modeling intermittent nature of renewable power in a power system.

TEXT BOOKS:

1. Power Electronics, Converters, Applications and Design" by N. Mohan; T.M. Undeland; W.P. Robbins. 1995, John Wiley and Sons.
2. Renewable Energy IntegrationChallenges and SolutionsSeries: Green Energy and Technology**Hossain**, Jahangir, **Mahmud**, Apel (Eds.)
3. Integration of Alternative Sources of EnergyFelix A. Farret**,** M. Godoy Simões, December 2005, Wiley-IEEE Press.

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POWER CONVERTERS SIMULATION LAB

Course Objectives:
Upon successful completion of the lab students will be familiar with:
- Simulation of various AC-AC, AC-DC, DC-DC, DC-AC converter topologies
- Modeling and simulation of industrial drives

Course Outcomes:
At the end of the course, the student should be able to:
- Simulate AC-AC Converters
- Simulate AC-DC Converters
- Simulate DC-DC Converters
- Simulate DC-AC Converters
- Model and Simulate DC drives fed by power electronics converters
- Model and Simulate AC drives fed by power electronics converters

1. Single phase full converter using RL and E loads.
2. Single phase semi converter using RL and E loads.
3. Three phase full converter using RL and E loads.
4. Three phase semi converter using RL and E loads.
5. Single phase AC Voltage controller using RL load.
6. Single phase Cyclo-converter Voltage controller using RL load.
7. Three-phase inverter with PWM controller.
8. DC-DC Converters.
9. Modeling of Separately Excited DC Motor.
10. Modeling of Three Phase Induction Motor.

Note: Use any two suitable software’s for each simulation.

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ADVANCED POWER ELECTRONIC CONVERTERS
(Core Theory – 3)

Prerequisite: Power Electronics

Course Objectives:
- To understand various advanced power electronics devices.
- To describe the operation of multi level inverters with switching strategies for high power
applications.
- To comprehend the design of resonant converters and switched mode power supplies.

Course Outcomes:
After taking this course, student will be able to:
- Develop and analyze various converter topologies.
- Design AC or DC switched mode power supplies.

UNIT I: MODERN POWER SEMICONDUCTOR DEVICES
Modern power semiconductor devices – Insulated Gate Bipolar Transistor (IGBT) – MOSFET-MOS Turn off Thyristor (MTO) – Emitter Turn Off Thyristor (ETO) – Integrated Gate-Commutated Thyristor (IGCTs) – MOS-controlled thyristors(MCTs)– Power integrated circuits (PICs) – symbol, structure and equivalent circuit – comparison of their features.

UNIT II: RESONANT PULSE INVERTERS
Resonant pulse inverters – series resonant inverters – series resonant inverters with unidirectional switches – series resonant inverters with bidirectional switches – analysis of half bridge resonant inverter – evaluation of currents and voltages of a simple resonant inverter – analysis of half bridge and full bridge resonant inverter with bidirectional switches – Frequency response of series resonant inverters – for series loaded inverter – for parallel loaded inverter – For series and parallel loaded inverters – parallel resonant inverters – Voltage control of resonant inverters – class E resonant inverter – class E resonant rectifier – evaluation of values of *C*'s and *L's* for class E inverter and Class E rectifier – numerical problems.

UNIT III: RESONANT CONVERTERS
Resonant converters – zero current switching resonant converters – L type ZCS resonant converter – M type ZCS resonant converter – zero voltage switching resonant converters – comparison between ZCS and ZVS resonant converters – Two quadrant ZVS resonant converters – resonant dc-link inverters – evaluation of L and C for a zero current switching inverter – Numerical problems.

UNIT IV: MULTILEVEL INVERTERS
Multilevel concept – Classification of multilevel inverters – Diode clamped Multilevel inverter – principle of operation – main features – improved diode Clamped inverter – principle of operation – Flying capacitors multilevel inverter-principle of operation – main features – cascaded multilevel inverter – principle of operation – main features – Multilevel inverter applications – reactive power compensation – back to back intertie system – adjustable

drives -Switching device currents – dc link capacitor voltage balancing – features of Multilevel inverters – comparisons of multilevel converters.

UNIT V: D.C & A.C POWER SUPPLIES

DC power supplies – classification - switched mode dc power supplies – fly back Converter – forward converter – push-pull converter – half bridge converter – Full bridge converter – Resonant d c power supplies – bidirectional power supplies – Applications.

AC power supplies – classification – switched mode ac power supplies – Resonant AC power supplies – bidirectional ac power supplies – multistage conversions – control circuits – applications. Introduction – power line disturbances – power conditioners – Uninterruptible Power supplies – applications.

TEXT BOOKS:

1. Mohammed H. Rashid –"Power Electronics"– Pearson Education- Third Edition – first Indian reprint -2004.
2. Ned Mohan, Tore M. Undeland and William P. Robbins- "Power Electronics"– John Wiley & Sons – Second Edition.

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POWER ELECTRONIC CONTROL OF AC DRIVES
(Core Theory – 4)

Prerequisite: Power Electronic Devices and Circuits

Course Objectives:
- To understand principle operation of scalar control of ac motor and corresponding speed-torque characteristics
- To comprehend the vector control for ac motor drive (IM and SM)
- To explain the static resistance control and Slip power recovery drive
- To explain synchronous motor drive characteristics and its control strategies
- To comprehend the brushless dc motor principle of operation.

Course Outcomes:
After taking this course, student will be able to:
- Develop induction motor for variable speed operations using scalar and vector control techniques.
- Identify the difference between the rotor resistance control and static rotor resistance control method and significance of slip power recovery drives.
- Develop controllers for synchronous motor and variable reluctance motor.

UNIT-I:
INTRODUCTION: Introduction to motor drives – Torque production – Equivalent circuit analysis – Speed – Torque Characteristics with variable voltage operation Variable frequency operation constant v/t operation – Variable stator current operation – Induction motor characteristics in constant torque and field weakening regions.
STATOR SIDE CONTROL OF INDUCTION MOTOR DRIVES
Scalar control – Voltage fed inverter control – Open loop volts/Hz control – speed control slip regulation – speed control with torque and flux control – current controlled voltage fed inverter drive – current – fed inverter control – Independent current and frequency control – Speed and flux control in Current –Fed inverter drive – Volts/Hz control of Current –fed inverter drive – Efficiency optimization control by flux program – closed loop operation.

UNIT–II: ROTOR SIDE CONTROL OF INDUCTION MOTOR DRIVES
Slip power recovery drives – Static Kramer Drive – Phasor diagram – Torque expression – speed control of Kramer Drive – Static Scheribus Drive – modes of operation.

UNIT–III:
CONTROL OF SYNCHRONOUS MOTOR DRIVES: Synchronous motor and its characteristics – Control strategies – Constant torque angle control – Unity power factor control – Constant mutual flux linkage control – closed loop operation.
Controllers: Flux weakening operation – Maximum speed – Direct flux weakening algorithm – Constant Torque mode controller – Flux Weakening controller – indirect flux weakening – Maximum permissible torque – speed control scheme – Implementation strategy speed controller design.

UNIT–IV:

VARIABLE RELUCTANCE MOTOR DRIVE: Variable Reluctance motor drive – Torque production in the variable reluctance motor Drive characteristics and control principles – Current control variable reluctance motor service drive.

PMSM &BRUSHLESS DC MOTOR DRIVES: Three phase full wave Brushless dc motor – Sinusoidal type of Brushless dc motor- current controlled Brushless dc motor Servo drive.

UNIT–V:

VECTOR CONTROL OF INDUCTION MOTOR DRIVES: Principles of Vector control – Vector control methods – Direct methods of vector control – Indirect methods of vector control – Adaptive control principles – Self tuning regulator Model referencing control – Direct torque control of AC motors.

TEXT BOOKS:

1. Electric Motor Drives Pearson Modeling, Analysis and control – R. Krishnan – Publications – 1st edition – 2002.
2. Modern Power Electronics and AC Drives B K Bose – Pearson Publications 1st edition
3. Power Electronics and Control of AC Motors – MD Murthy and FG Turn Bull Pergman Press 1st edition

REFERENCE BOOKS:

1. Power Electronics and AC Drives – BK Bose – Prentice Hall Eagle wood diffs New Jersey - 1st edition
2. Power Electronic circuits Deices and Applications – M H Rashid – PHI – 1995.
3. Fundamentals of Electrical Drives – G. K. Dubey – Narosa publications – 1995.

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ELECTIVE – 5.1: DYNAMICS OF ELECTRICAL MACHINES

Prerequisite: Machine Modeling and Analysis

Course Objectives:
- To introduce generalized modeling electrical machines
- To analyze different electrical machines with dynamic modeling

Course Outcomes:
After taking this course, the student will be able to:
- Understand the basic mathematical analysis of electrical machines and its characteristics.
- Understand behavior of electrical machines under steady state and transient state.
- Understand dynamic modeling of electrical machines.

UNIT-I: BASIC MACHINE THEORY
Electromechanical Analogy – Magnetic Saturation – Rotating field theory – Operation of Inductor motor – equivalent circuit – Steady state equations of DC machines – operations of synchronous motor – Power angle characteristics

UNIT-II: ELECTRODYNAMICAL EQUATION & THEIR SOLUTIONS
Spring and Plunger system - Rotational motion – mutually coupled coils – Lagrange's equation – Application of Lagrange's equation solution of Electro dynamical equations.

UNIT-III: DYNAMICS OF DC MACHINES
Separately excited d.c. generations – stead state analysis – transient analysis – Separately excited d. c. motors – stead state analysis – transient analysis – interconnection of machines – Ward Leonard system of speed control.

UNIT-IV: INDUCTION MACHINE DYNAMICS
Induction machine dynamics during starting and braking – accelerating time – induction machine dynamic during normal operation – Equation for dynamical response of the induction motor.

UNIT-V: SYNCHRONOUS MACHINE DYNAMICS
Electromechanical equation – motor operation – generator operation – small oscillations – general equations for small oscillations – representation of the oscillation equations in state variable form.

TEXT BOOKS:
1. Sen GuptaD.P. and J.W" Electrical Machine Dynamics"Macmillan Press Ltd 1980.
2. Bimbhra P.S. "Generalized Theory of Electrical Machines " Khanna Publishers 2002.

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ELECTIVE – 5.2: SPECIAL MACHINES

Prerequisite: Electrical Machines

Course Objectives:

- To learn the constructional features, principle of operation, methods of control and applications of stepper motors.
- To understand the constructional features, principle of operation, methods of control and applications of Switched reluctance motors.
- To have an insight into the constructional features, principle of operation, methods of control and applications of PMBLDC motors.
- To know about the types, the constructional features, principle of operation, methods of control and applications of PMSM.
- To gain knowledge in the types, the constructional features, principle of operation, methods of control and applications of Synchronous machine.

Course Outcomes:

At the end of the course, the student is able to:

- Realize the need for stepper motors and the various applications in industries.
- Draw the operational characteristics and the applications of SRM.
- Know the various types of PMBLDC motors, rotor position sensors, methods of control and their applications.
- Know features, control and the applications of various special machines.

UNIT–I: STEPPER MOTORS

Introduction-synchronous inductor (or hybrid stepper motor), Hybrid stepping motor, construction, principles of operation, energization with two phase at a time- essential conditions for the satisfactory operation of a 2-phase hybrid step motor - very slow - speed synchronous motor for servo control-different configurations for switching the phase windings-control circuits for stepping motors-an open-loop controller for a 2-phase stepping motor.

UNIT-II: VARIABLE RELUCTANCE STEPPING MOTORS

Variable reluctance (VR) Stepping motors, single-stack VR step motors, Multiple stack VR motors-Open-loop control of 3-phase VR step motor-closed-Loop control of step motor, discriminator (or rotor position sensor) transilator, major loop-characteristics of step motor in open-loop drive – comparison between open-loop position control with step motor and a position control servo using a conventional (dc or ac) servo motor- Suitability and areas of application of stepping motors-5- phase hybrid stepping motor - single phase - stepping motor, the construction, operating principle torque developed in the motor.

SWITCHED RELUCTANCE MOTOR: Introduction – improvements in the design of conventional reluctance motors- Some distinctive differences between SR and conventional reluctance motors - principle of operation of SRM- Some design aspects of stator and rotor pole arcs, design of stator and rotor and pole arcs in SR motor-determination of L(θ)**-**θ profile **-** power converter for SR motor - A numerical example – Rotor sensing mechanism and logic control, drive and power circuits, position sensing of rotor with Hall problems-derivation of torque expression, general linear case.

UNIT–III: PERMANENT MAGNET MATERIALS AND PMDC MACHINES

Introduction, Hysteresis loops and recoil line- stator frames (pole and yoke **-** part) of conventional PM dc Motors, Equivalent circuit of PM Generator and Motor-Development of Electronically commutated dc motor from conventional dc motor.

BRUSHLESS DC MOTOR: Types of construction – principle of operation of BLDM- sensing and switching logic scheme, sensing logic controller, lockout pulses –drive and power circuits, Base drive circuits, power converter circuit-Theoretical analysis and performance prediction, modeling and magnet circuit d-q analysis of BLDM -transient analysis formulation in terms of flux linkages as state variables-Approximate solution for current and torque under steady state –Theory of BLDM as variable speed synchronous motor (assuming sinusoidal flux distribution)- Methods or reducing Torque Pulsations, 180 degrees pole arc and 120 degree current sheet.

UNIT-IV: LINEAR INDUCTION MOTOR

Development of a double sided LIM from rotary type IM- A schematic of LIM drive for electric traction development of one sided LIM with back iron-field analysis of a DSLIM fundamental assumptions.

UNIT-V: PERMANENT MAGNET AXIAL FLUX (PMAF) MACHINES

Construction, Armature windings – Toroidal Stator and Trapezoidal Stator Windings, Torque and EMF equations, Phasor diagram and output equation.

TEXT BOOKS:

1. Special electrical machines, K. Venkataratnam, - University press.
2. Special electrical machines, E. G. Janardanan, - PHI.

REFERENCE BOOKS:

1. R. K. Rajput, “Electrical machines” – 5^{th} edition.
2. V. V. Athani, “Stepper motor: Fundamentals, Applications and Design”, New age International publishers.
3. Switched Reluctance Motor Drives by R. Krishnan, CRC Press,

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ELECTIVE – 5.3: SMART GRID TECHNOLOGIES

Prerequisite: None

Course Objectives:
- To group various aspects of the smart grid,
- To defend smart grid design to meet the needs of a utility
- To select issues and challenges that remain to be solved
- To analyze basics of electricity, electricity generation, economics of supply and demand, and the various aspects of electricity market operations in both regulated and deregulated environment.

Course Outcomes:
Upon the completion of this course, the student will be able to
- Analyze the structure of an electricity market in either regulated or deregulated market conditions.
- Know the advantages of DC distribution and developing technologies in distribution
- Discriminate the trade-off between economics and reliability of an electric power system.
- Differentiate various investment options (e.g. generation capacities, transmission, renewable, demand-side resources, etc) in electricity markets.
- Analyze the development of smart and intelligent domestic systems.

UNIT–I: INTRODUCTION
Introduction to smart grid - Electricity network - Local energy networks- Electric transportation - Low carbon central generation - Attributes of the smart grid - Alternate views of a smart grid.
SMART GRID TO EVOLVE A PERFECT POWER SYSTEM: Introduction- Overview of the perfect power system configurations- Device level power system- Building integrated power systems- Distributed power systems- Fully integrated power system-Nodes of innovation.

UNIT–II: DC DISTRIBUTION AND SMART GRID
AC Vs DC sources-Benefits of and drives of DC power delivery systems - Powering equipment and appliances with DC-Data centers and information technology loads - Future neighborhood-Potential future work and research.
INTELLIGRID ARCHITECTURE FOR THE SMARTGRID: Introduction- Launching intelligent grid –Intelligent grid today - Smart grid vision based on the intelligent grid architecture-Barriers and enabling technologies.

UNIT–III: DYNAMIC ENERGY SYSTEMS CONCEPT
Smart energy efficient end use devices-Smart distributed energy resources - Advanced whole building control systems- Integrated communications architecture - Energy management-Role of technology in demand response- Current limitations to dynamic energy management-Distributed energy resources-Overview of a dynamic energy management-Key characteristics of smart devices- Key characteristics of advanced whole building control systems-Key characteristics of dynamic energy management system.

UNIT–IV: ENERGY PORT AS PART OF THE SMART GRID:
Concept of energy - Port, generic features of the energy port.
POLICIES AND PROGRAMS TO ENCOURAGE END – USE ENERGY EFFICIENCY: Policies and programs in action - multinational - national-state-city and corporate levels.
MARKET IMPLEMENTATION: Framework-factors influencing customer acceptance and response - program planning - monitoring and evaluation.

UNIT–V: EFFICIENT ELECTRIC END–USE TECHNOLOGY ALTERNATIVES
Existing technologies – lighting - Space conditioning - Indoor air quality - Domestic water heating - hyper efficient appliances - Ductless residential heat pumps and air conditioners - Variable refrigerant flow air conditioning-Heat pump water heating - Hyper efficient residential appliances - Data center energy efficiency- LED street and area lighting - Industrial motors and drives - Equipment retrofit and replacement - Process heating - Cogeneration, Thermal energy storage - Industrial energy management programs - Manufacturing process-Electro-technologies, Residential, Commercial and industrial sectors.

TEXT BOOKS:
1. Clark W Gellings, “The Smart Grid, Enabling Energy Efficiency and Demand Side Response”- CRC Press, 2009.
2. Jean Claude Sabonnadière, NouredineHadjsaïd, “Smart Grids”, Wiley-ISTE, IEEE Press, May 2012

REFERENCES:
1. JanakaEkanayake, KithsiriLiyanage, Jianzhong.Wu, Akihiko Yokoyama, Nick Jenkins, “Smart Grid: Technology and Applications”- Wiley, 2012.
2. James Momoh, “Smart Grid: Fundamentals of Design and Analysis” - Wiley, IEEE Press, 2012.

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ELECTIVE – 6.1: FLEXIBLE AC TRANSMISSION SYSTEMS

Prerequisite: Power Electronics and Power Systems

Course Objectives:

- To develop the understanding of uncompensated lines and their behavior under heavy loading conditions.
- To understand the concept and importance controllable parameters of FACTS controllers.
- To emphasize the objectives of Shunt compensation, and basic operation of SVC and STATCOM.
- To analyze the functioning of series controllers like GCSC, TSSC and TCSC

Course Outcomes:

Upon the completion of this course, the student will be able to

- Choose proper controller for the specific application based on system requirements
- Understand various systems thoroughly and their requirements
- Interpret the control circuits of Shunt Controllers SVC & STATCOM for various functions viz. Transient stability Enhancement, voltage instability prevention and power oscillation damping
- Detect the Power and control circuits of Series Controllers GCSC, TSSC and TCSC

UNIT-I: FACTS CONCEPTS

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

UNIT-II: VOLTAGE SOURCE CONVERTERS

Single phase three phase full wave bridge converters transformer connections for 12 pulse 24 and 48 pulse operation. Three level voltage source converter, pulse width modulation converter, basic concept of current source Converters, and comparison of current source converters with voltage source converters.

UNIT-III: STATIC SHUNT COMPENSATION

Objectives of shunt compensation, mid-point voltage regulation voltage instability prevention, improvement of transient stability, Power oscillation damping, Methods of controllable VAR generation, variable impedance type static VAR generators switching converter type VAR generators hybrid VAR generators.

UNIT-IV: SVC AND STATCOM

The regulation and slope transfer function and dynamic performance, transient stability enhancement and power oscillation damping operating point control and summary of compensator control.

UNIT-V: STATIC SERIES COMPENSATORS
Concept of series capacitive compensation, improvement of transient stability, power oscillation damping, and functional requirements of GTO thyristor controlled series capacitor (GSC), thyristor switched series capacitor (TSSC), and thyristor controlled series capacitor (TCSC)
Control schemes for GSC TSSC and TCSC.

TEXT BOOKS:

1. Hingorani H G and Gyugyi. L " Understanding FACTS-Concepts and Technology of Flexible AC Transmission Systems" New York, IEEE Press, 2000.
2. Padiyar.K.R, " FACTS Controllers in Power Transmission and Distribution" New Age Int. Publishers, 2007

REFERENCES:

1. Zhang, Xiao-Ping, Rehtanz, Christian, Pal, Bikash "Flexible AC Transmission Systems: Modeling and Control", Springer, 2012
2. Yong-Hua Song, Allan Johns, "Flexible AC Transmission Systems", IET, 1999.

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ELECTIVE – 6.2: SWITCHED MODE POWER SUPPLIES

Prerequisite: Power Electronic Devices and circuits

Course Objectives:
- To apply the basic concepts of power electronics for designing converters.
- Design and implement practical circuits for UPS, SMPS etc.

Course Outcomes: After taking this course, student will be able to:
- Design converter system for electrical applications
- Understand and design SMPS.

UNIT – I
BASIC CONVERTER CIRCUITS:
Buck Regulator, Buck- Boost Regulator, Boost Regulator, Cuk Converters and Resonant Converters. Choice of switching frequency.

UNIT – II
ISOLATED SMPS:
Fly back Converter, Forward Converter, Half-Bridge and Full Bridge Converters, Push-Pull Converter and SMPS with multiple outputs. Choice of switching frequency.

UNIT – III
CONTROL ASPECTS
PWM Controllers, Isolation in feedback loop, Power Supplies with multiple output.
Stability analysis using Bode Diagrams.

UNIT – IV
DESIGN CONSIDERATIONS
Selection of output filter capacitor, Selection of energy storage inductor, Design of High Frequency Inductor and High frequency Transformer, Selection of switches. Snubber circuit design, Design of driver circuits.

UNIT – V
ELECTRO MAGNETIC INTERFERENCE (EMI)
EMI Filter Components, Conducted EMI suppression, Radiated EMI suppression, Measurement.

PROTECTION
Over current protection, Over voltage protection, Inrush current protection.

THERMAL MODEL
Thermal Resistance, Cooling Considerations, Selection of Heat sinks, Simple Heat sink calculations.

TEXT BOOKS:

1. Switched Mode Power Supplies, Design and Construction, H. W. Whittington, B. W. Flynn and D. E. MacPherson, Universities Press, 2009 Edition.
2. Mohan N. Undeland . T & Robbins W, Power Electronics Converters, Application and Design. John Wiley, 3rd edition, 2002
3. Umanand L., Bhat S.R., Design of magnetic components for switched Mode Power Converters. , Wiley Eastern Ltd.,1992
4. Robert. W. Erickson, D. Maksimovic .Fundamentals of Power Electronics., Springer International Edition, 2005
5. Course Material on Switched Mode Power Conversion, V. Ramanarayanan.

REFERENCES:

1. Krein P.T .Elements of Power Electronics., Oxford University Press
2. M.H.Rashid, Power Electronics. Prentice-Hall of India

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ELECTIVE – 6.3: DIGITAL CONTROL SYSTEMS

Prerequisite: None

Course Objectives:

- To explain basic and digital control system for the real time analysis and design of control systems.
- To apply the knowledge state variable analysis in the design of discrete systems.
- To explain the concept of stability analysis and design of discrete time systems.

Course Outcomes:

Upon the completion of this course, the student will be able to

- Apply the concepts of Digital control systems.
- Analyze and design of discrete systems in state variable analysis.
- To relate the concepts of stability analysis and design of discrete time systems.

UNIT – I: Concept & Representation of Discrete time Systems

Block Diagram of typical control system- advantages of sampling in control systems – examples of discrete data and digital systems – data conversion and quantization – sample and hold devices – D/A and A/D conversion – sampling theorem – reconstruction of sampled signals.

Z-transform: Definition of Z-transforms – mapping between s-plane and z-plane – inverse z-transform – properties of z-transforms - ROC of z-transforms –pulse transfer function –relation between G(s) and G(z) – signal flow graph method applied to digital control systems.

UNIT- II:STATE SPACE ANALYSIS:

State space modeling of discrete time systems – state transition equation of discrete time invariant systems – solution of time invariant discrete state equations: recursive method and the Z-Transformation method – conversion of pulse transfer function to the state model & vice-versa – Eigen values – Eigen vectors of discrete time system-matrix (A) – Realization of pulse transformation in state space form, discretization of continuous time systems, Computation of state transition matrix and its properties. Response of sample data system between sampling instants.

UNIT – III: Controllability, Observability& Stability tests

Concept of controllability, stabilizability, observability and reachability - Controllability and observability tests, Transformation of discrete time systems into controllable and observable forms.

Stability: Definition of stability – stability tests – The second method of Liapunov.

UNIT- IV: Design of discrete time Controllers and observers

Design of discrete time controller with bilinear transformation – Realizatiion of digital PID controller-Design of deadbeat controller; Pole placement through state feedback.

UNIT-V: STATE OBSERVERS:

Design of - Full order and reduced order observers. Study of observer based control design

TEXT BOOKS:

1. K. Ogata , Discrete-Time Control systems, Pearson Education/PHI, 2nd Edition.
2. V. I. George, C. P. Kurian, Digital Control Systems, Cengage Learning.
3. M.Gopal, Digital Control Engineering, New Age Int. Pvt. Ltd., 2014

REFERENCES:

1. Kuo, Digital Control Systems, Oxford University Press, 2nd Edition, 2003.
2. M.Gopal , Digital Control and State Variable Methods, TMH.
3. M. Sami Fadali Antonio Visioli, Digital Control Engineering Analysis and Design, Academic Press

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ELECTIVE – 7.1: POWER QUALITY

Prerequisite: Power Systems

Course Objectives:

- To Study the basics of power quality , power quality problems and power quality standards,
- To Study about the characteristics of non-linear loads
- To Study Voltage, Current, Power and Energy measurements and analysis methods of Laplace's, Fourier and Hartley and Wavelet Transforms
- To Study the analysis and conventional mitigation methods
- To Study about various devices used to enhance power quality.

Course Outcomes:
After taking this course, the student will be able to:

- Know the different characteristics of electric power quality in power systems,
- Learn about the applications of non-linear loads ,
- Know the applications of Hartley and Wavelet Transforms ,
- Learn how to mitigate the power quality problems
- Learn about the application of FACTS device on DG side.

UNIT-I:
INTRODUCTION
Introduction of the Power Quality (PQ) problem, Terms used in PQ: Voltage, Sag, Swell, Surges, Harmonics, over voltages, spikes, Voltage fluctuations, Transients, Interruption, overview of power quality phenomenon, Remedies to improve power quality, power quality monitoring.

UNIT-II:
LONG & SHORT INTERRUPTIONS
Interruptions – Definition – Difference between failures, outage, Interruptions – causes of Long Interruptions – Origin of Interruptions – Limits for the Interruption frequency – Limits for the interruption duration – costs of Interruption – Overview of Reliability evaluation to power quality, comparison of observations and reliability evaluation.
Short interruptions: definition, origin of short interruptions, basic principle, fuse saving, voltage magnitude events due to re-closing, voltage during the interruption, monitoring of short interruptions, difference between medium and low voltage systems. Multiple events, single phase tripping – voltage and current during fault period, voltage and current at post fault period, stochastic prediction of short interruptions.

UNIT III:
SINGLE AND THREE-PHASE VOLTAGE Sag CHARACTERIZATION
Voltage sag – definition, causes of voltage sag, voltage sag magnitude, and monitoring, theoretical calculation of voltage sag magnitude, voltage sag calculation in non-radial systems, meshed systems, and voltage sag duration.
Three phase faults, phase angle jumps, magnitude and phase angle jumps for three phase unbalanced sags, load influence on voltage sags.

UNIT-IV:

POWER QUALITY CONSIDERATIONS IN INDUSTRIAL POWER SYSTEMS

Voltage sag – equipment behavior of Power electronic loads, induction motors, synchronous motors, computers, consumer electronics, adjustable speed AC drives and its operation. Mitigation of AC Drives, adjustable speed DC drives and its operation, mitigation methods of DC drives.

UNIT-V:

MITIGATION OF INTERRUPTIONS & VOLTAGE SAGS

Overview of mitigation methods – from fault to trip, reducing the number of faults, reducing the fault clearing time changing the power system, installing mitigation equipment, improving equipment immunity, different events and mitigation methods. System equipment interface – voltage source converter, series voltage controller, shunt controller, combined shunt and series controller.

Power Quality and EMC Standards:

Introduction to standardization, IEC Electromagnetic compatibility standards, European voltage characteristics standards, PQ surveys.

TEXT BOOKS:

1. “Understanding Power Quality Problems” by Math H J Bollen. IEEE Press.
2. “Power Quality VAR Compensation in Power Systems”, R. SastryVedamMulukutla S. Sarma,CRC Press.

REFERENCES:

1. Power Quality, C. Sankaran, CRC Presss.
2. Electrical Power Systems Quality, Roger C. Dugan , Mark F. McGranaghan, Surya Santoso, H. Wayne Beaty, Tata McGraw Hill Education Private Ltd.

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ELECTIVE – 7.2: SOLAR PHOTO VOLTAIC SYSTEMS

Pre-requisite: None

Course Objectives:
Objectives of this course are
- To introduce photovoltaic systems
- To deal with various technologies of solar PV cells
- To understand details about manufacture, sizing and operating techniques
- To have knowledge of design considerations.

Course Outcomes:
After this course, the student will be able to
- Identify photovoltaic system components and system types
- Calculate electrical energy and power
- Correctly size system components, design considerations of solar equipment
- Design a basic grid-tie PV system.

UNIT – I
SOLAR ENERGY: Sun and Earth, Solar Spectrum, Solar Geometry, Solar radiation on horizontal and inclined planes, Instruments for measurement of solar radiation ,Solar cell, Equivalent circuit, V-I characteristics, Performance improvement.

UNIT – II
SOLAR CELLS: Manufacture of Solar Cells-Technologies, Design of Solar cells, Photovoltaic modules, Design requirements, encapsulation systems, manufacture, power rating, hotspot effect, Design qualifications.

UNIT – III
PROTECTION AND MEASUREMENTS: Flat plate arrays, support structures, module interconnection and cabling, lightning protection, Performance measurement – using natural sun light and simulator, determination of temperature coefficients, internal series resistance, curve correction factor.

UNIT - IV
PHOTOVOLTAIC SYSTEMS: Photovoltaic systems- types- general design considerations-system sizing-battery sizing- inverter sizing-design examples – Balance of PV systems.

UNIT – V
MAXIMUM POWER POINT TRACKERS: Maximum power point trackers-algorithms-perturb and observe-incremental conductance method, hill climbing method, , hybrid and complex methods, data based and other approximate methods, instrument design, other MPP techniques-Grid interactive PV system.

TEXT BOOKS:
1. Generating electricity from Sun, F.C.Treble, Pergamon Press
2. Photvolatic systems: Analysis and design, A.K.Mukherjee, Nivedita Thakur, PHI 2011
3. Solar Photovoltaics: Fundamentals, Technologies and applications, C.S.Solanki, PHI, 2009

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ELECTIVE – 7.3: HYBRID AND ELECTRIC VEHICLES

Pre-requisites:
1. Control Systems Engineering – I.
2. Electrical Machines-I.
3. Electrical Machines-II.
4. Power Electronics

Course Objectives:
Objectives of this course are to:
- Introduce the fundamental concepts, principles, analysis and design of hybrid and electric vehicles
- Introduce the various aspects of hybrid and electric drive train such as their configuration, types of electric machines that can be used, energy storage devices, etc.

Course Outcomes:
After this course, the student will be able to
- Get knowledge on hybrid electric vehicles
- Compare the advantages and disadvantages of hybrid electric vehicles over conventional vehicles
- Compare the merits and demerits of hybrid electric trains over electrical trains
- Know the different energy storage techniques
- Discuss the electric population, motor drive technologies
- Analyze the different types of energy management strategies

UNIT-I:
Introduction to Hybrid Electric Vehicles: History of hybrid and electric vehicles, social and environmental importance of hybrid and electric vehicles, impact of modern drive-trains on energy supplies.

Conventional Vehicles: Basics of vehicle performance, vehicle power source characterization, transmission characteristics, and mathematical models to describe vehicle performance.

UNIT-II:
Hybrid Electric Drive-trains: Basic concept of hybrid traction, introduction to various hybrid drive-train topologies, power flow control in hybrid drive-train topologies, fuel efficiency analysis.

Electric Drive-trains: Basic concept of electric traction, introduction to various electric drive-train topologies, power flow control in electric drive-train topologies, fuel efficiency analysis.

UNIT-III:
Electric Propulsion unit: Introduction to electric components used in hybrid and electric vehicles, Configuration and control of DC Motor drives, Configuration and control of Induction Motor drives, configuration and control of Permanent Magnet Motor drives, Configuration and control of Switch Reluctance Motor drives, drive system efficiency.

UNIT-IV:

Energy Storage: Introduction to Energy Storage Requirements in Hybrid and Electric Vehicles, Battery based energy storage and its analysis, Fuel Cell based energy storage and its analysis, Super Capacitor based energy storage and its analysis, Flywheel based energy storage and its analysis, Hybridization of different energy storage devices.

Sizing the drive system: Matching the electric machine and the internal combustion engine (ICE), Sizing the propulsion motor, sizing the power electronics, selecting the energy storage technology, Communications, supporting subsystems

UNIT-V:

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

REFERENCES:

1. Iqbal Hussein, Electric and Hybrid Vehicles: Design fundamentals, CRC Press, 2003.
2. MehrdadEhsani, YimiGao, Sebastian E. Gay, Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press, 2004.
3. James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley, 2003.
4. Design of a Hybrid Electric Vehicle (HEV), Design of a Battery Electric Vehicle (BEV).

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ELECTIVE – 8.1: PROGRAMMABLE LOGIC CONTROLLERS AND APPLICATIONS

Prerequisite: None

Course Objectives:

- To provide and ensure a comprehensive understanding of using advanced controllers in measurement and control instrumentation.
- To illustrate about data acquisition - process of collecting information from field instruments.
- To analyze Programmable Logic Controller (PLC), IO Modules and internal features.
- To Comprehend Programming in Ladder Logic, addressing of I/O.
- To apply PID and its Tuning.

Course Outcomes:

Upon the completion of this course, the student will be able to

- Describe the main functional units in a PLC and be able to explain how they interact.
- They should know different bus types used in automation industries.
- Development of ladder logic programming for simple process.

UNIT-I:

PLC Basics PLC system, I/O modules and interfacing CPU processor programming equipment programming formats, construction of PLC ladder diagrams, devices connected to I/O modules.

UNIT-II:

PLC Programming input instructions, outputs, operational procedures, programming examples using contacts and coils. Drill-press operation.

Digital logic gates programming in the Boolean algebra system, conversion examples Ladder diagrams for process control Ladder diagrams and sequence listings, ladder diagram construction and flow chart for spray process system.

UNIT-III:

PLC Registers: Characteristics of Registers module addressing holding registers input registers, output registers. PLC Functions Timer functions and industrial applications counters counter function industrial applications, Architecture functions, Number comparison functions, number conversion functions.

UNIT-IV:

Data handling functions: SKIP, Master control Relay Jump Move FIFO, FAL, ONS, CLR and Sweep functions and their applications. Bit Pattern and changing a bit shift register, sequence functions and applications, controlling of two axes and three axis Robots with PLC, Matrix functions.

UNIT-V:

Analog PLC operation: Analog modules and systems Analog signal processing multi bit data processing , analog output application examples, PID principles position indicator with PID control, PID modules, PID tuning, PID functions

TEXT BOOKS:

1. Programmable Logic Controllers – Principle and Applications by John W. Webb & Ronald A. Reiss, Fifth Edition, PHI
2. Digital Design by Morris Mano, PHI, 3rd Edition 2006.

REFERENCES:

1. Programmable logic Controllers, Frank D. Petruzella, 4th Edition, McGraw Hill Publishers.
2. Programmable Logic Controllers – Programming Method and Applications by JR. Hackworth & F.D Hackworth Jr. – Pearson, 2004.
3. Programmable logic controllers and their Engineering Applications, 2nd Edition, Alan J. Crispin.

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ELECTIVE – 8.2: AI TECHNIQUES IN ELECTRICAL ENGINEERING

Prerequisite: None

Course Objectives:
- To locate soft commanding methodologies, such as artificial neural networks, Fuzzy logic and genetic Algorithms.
- To observe the concepts of feed forward neural networks and about feedback neural networks.
- To practice the concept of fuzziness involved in various systems and comprehensive knowledge of fuzzy logic control and to design the fuzzy control
- To analyze genetic algorithm, genetic operations and genetic mutations.

Course Outcomes:
Upon the completion of this course, the student will be able to
- Understand feed forward neural networks, feedback neural networks and learning techniques.
- Understand fuzziness involved in various systems and fuzzy set theory.
- Develop fuzzy logic control for applications in electrical engineering
- Develop genetic algorithm for applications in electrical engineering.

UNIT – I: ARTIFICIAL NEURAL NETWORKS
Introduction-Models of Neural Network - Architectures – Knowledge representation – Artificial Intelligence and Neural networks – Learning process – Error correction learning – Hebbian learning – Competitive learning – Boltzman learning – Supervised learning – Unsupervised learning – Reinforcement learning - learning tasks.

UNIT- II: ANN PARADIGMS
Multi – layer perceptron using Back propagation Algorithm-Self – organizing Map – Radial Basis Function Network – Functional link, network – Hopfield Network.

UNIT – III: FUZZY LOGIC
Introduction – Fuzzy versus crisp – Fuzzy sets - Membership function – Basic Fuzzy set operations – Properties of Fuzzy sets – Fuzzy cartesian Product – Operations on Fuzzy relations – Fuzzy logic – Fuzzy Quantifiers - Fuzzy Inference - Fuzzy Rule based system - Defuzzification methods.

UNIT – IV: GENETIC ALGORITHMS
Introduction-Encoding – Fitness Function-Reproduction operators - Genetic Modeling – Genetic operators - Crossover - Single–site crossover – Two-point crossover – Multi point crossover-Uniform crossover – Matrix crossover - Crossover Rate - Inversion & Deletion – Mutation operator –Mutation – Mutation Rate-Bit-wise operators-Generational cycle-convergence of Genetic Algorithm.

UNIT–V: APPLICATIONS OF AI TECHNIQUES
Load forecasting – Load flow studies – Economic load dispatch – Load frequency control – Single area system and two area system – Small Signal Stability (Dynamic stability) Reactive power control – speed control of DC and AC Motors.

TEXT BOOKS:

1. S.Rajasekaran and G.A.V.Pai, "Neural Networks, Fuzzy Logic & Genetic Algorithms"- PHI, New Delhi, 2003.

REFERENCES:

1. P.D.Wasserman,VanNostrandReinhold,'"Neural Computing Theory & Practice", New York,1989.
2. Bart Kosko, "Neural Network & Fuzzy System", Prentice Hall, 1992.
3. G.J.Klir and T.A.Folger, "Fuzzy sets,Uncertainty and Information", PHI, Pvt.Ltd,1994.
4. D.E.Goldberg, "Genetic Algorithms", Addison Wesley 1999.

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ELECTIVE – 8.3.ENERGY EFFICIENT SYSTEMS

Prerequisite: Power Systems

Course Objectives:

- To have basic concepts of Electrical systems, motors, generating systems.
- To illustrate the application of Electrical systems in PF improvement scheme
- To illustrate the application of pumps and pumping system.

Course Outcomes:

Upon the completion of this course, the student will be able to

- Understand the advantages of Electrical system and its basic components.
- Understand the implementation of Energy Efficient Technologies in Electrical Systems

UNIT-I:
Electrical System: Electricity billing, Electrical Load Management and maximum demand control, Power factor improvement and its benefit, Selection and location of capacitors, Performance assessment of PF capacitors, Distribution and Transformer losses.

UNIT-II:
Electric Motors: Types, Losses in Electric Motors, motor efficiency, factors affecting motor performance, rewinding and motor replacement issues, energy saving opportunities with energy efficient motors **Lighting System:** Light source, choice of lighting, luminance requirements, and energy conservation avenues. Energy efficient lightning controls, comparison of sodium vapor, halogen, CFL and LED lamps.

UNIT-III:
Compressed Air System: Types of air compressors, compressor efficiency, efficient compressor operation, compressed air system components, capacity assessment, leakage test, factors affecting the performance and savings opportunities. **HVAC and Refrigeration system:** vapor compression refrigeration cycle, refrigerants, coefficient of performance, capacity, factors affecting refrigeration and air-conditioning system performance and saving opportunities, vapor absorption refrigeration system - working principle, types and comparison with vapour compression system, saving potential Fans and Blowers: Types, performance evaluation, efficient system operation, flow control strategies and energy conservation opportunities.

UNIT-IV:
Pumps and Pumping System: Types, performance evaluation, efficient system operation, flow control strategies and energy conservation opportunities. **Cooling Tower:** Types and performance evaluation, efficient system operation, flow control strategies, energy saving opportunities, Assessment of cooling tower.

UNIT-V:

Diesel generating system: Factors affecting selection, energy performance assessment of diesel conservation avenues. **Energy Efficient Technologies in Electrical Systems:** Maximum Demand Controllers, automatic power factor controllers, energy efficient motors, soft starters with energy saver, variable speed drives, energy efficient transformers, electronic ballast, occupancy sensors, energy saving potential of each technology. Calculation of energy frequency ratio in the performance of star ratings.

TEXT BOOKS:

1. Eastop T.D & Croft D.R, Energy Efficiency for Engineers and Technologists,.Logman Scientific & Technical, ISBN-0-582-03184, 1990.
2. Reay D.A, Industrial Energy Conservation, 1stedition, Pergamon Press, 1977.

REFERENCE:

1. Larry C Whitetal, Industrial Energy Management & Utilization.
2. Power System Engineering 2nd Ed. D P Kothari, I J Nagrath, Tata McGraw-Hill Co 2008
3. Bureau of Energy Efficiency (BEE) : www.bee-india.nic.in
4. The Energy and Resource Institute (TERI): http://www.teriin.org/
5. Energy Efficiency for Engineers and Technologists, First Edition, 1990, by TD Eastop and DR Croft, Longman Group UK Ltd.
6. Industrial Energy Management and Utilization, 1988, by LC Wittie, P S Schmidt and D R Brown, Hemisphere Publishing Company. 3. Energy Management Hand Book, Third Edition, 1997, by W C Turner, the Fairmont Press Inc.
7. www.bee-india.nic.in (Guide on Energy Efficient room Air conditioners)

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ELECTIVE – 8.4: SOFTWARE ENGINEERING

Prerequisites

1. A course on "Computer Programming and Data Structures"
2. A course on "Object Oriented Programming Through Java"

Course Objectives:

1. The aim of the course is to provide an understanding of the working knowledge of the techniques for estimation, design, testing and quality management of large software development projects.
2. Topics include process models, software requirements, software design, software testing, software process/product metrics, risk management, quality management and UML diagrams

Course Outcomes:

1. Ability to translate end-user requirements into system and software requirements, using e.g. UML, and structure the requirements in a Software Requirements Document (SRD).
2. Identify and apply appropriate software architectures and patterns to carry out high level design of a system and be able to critically compare alternative choices.
3. Will have experience and/or awareness of testing problems and will be able to develop a simple testing report

UNIT-I:

Introduction to Software Engineering: The evolving role of software, changing nature of software, software myths.

A Generic view of process: Software engineering- a layered technology, a process framework, the capability maturity model integration (CMMI), process patterns, process assessment, personal and team process models.

Process models: The waterfall model, incremental process models, evolutionary process models, the unified process.

UNIT-II:

Software Requirements: Functional and non-functional requirements, user requirements, system requirements, interface specification, the software requirements document.

Requirements engineering process: Feasibility studies, requirements elicitation and analysis, requirements validation, requirements management.

System models: Context models, behavioral models, data models, object models, structured methods.

UNIT-III:

Design Engineering: Design process and design quality, design concepts, the design model.

Creating an architectural design: software architecture, data design, architectural styles and patterns, architectural design, conceptual model of UML, basic structural modeling, class diagrams, sequence diagrams, collaboration diagrams, use case diagrams, component diagrams.

UNIT-IV:

Testing Strategies: A strategic approach to software testing, test strategies for conventional software, black-box and white-box testing, validation testing, system testing, the art of debugging.

Product metrics: Software quality, metrics for analysis model, metrics for design model, metrics for source code, metrics for testing, metrics for maintenance.

UNIT-V:

Metrics for Process and Products: Software measurement, metrics for software quality.

Risk management: Reactive Vs proactive risk strategies, software risks, risk identification, risk projection, risk refinement, RMMM, RMMM plan.

Quality Management: Quality concepts, software quality assurance, software reviews, formal technical reviews, statistical software quality assurance, software reliability, the ISO 9000 quality standards.

TEXT BOOKS:

1. Software Engineering, A practitioner's Approach- Roger S. Pressman, 6th edition, McGraw Hill International Edition.
2. Software Engineering- Sommerville, 7th edition, Pearson Education.
3. The unified modeling language user guide Grady Booch, James Rambaugh, Ivar Jacobson, Pearson Education.

REFERENCES:

1. Software Engineering, an Engineering approach- James F. Peters, WitoldPedrycz, John Wiely.
2. Software Engineering principles and practice- Waman S Jawadekar, The McGraw-Hill Companies.
3. Fundamentals of object oriented design using UML Meiler page-Jones: Pearson Education.

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ELECTIVE – 8.5: ENERGY STORAGE TECHNOLOGIES

Prerequisite: Power Systems

Course Objectives:

- To know about the Demand for Energy Storage.
- To study the roles of electrical energy storage technologies in electricity.
- To analyze the features of energy storage systems.

Course Outcomes:

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

- Evaluate various techniques for storing electrical energy.
- Understand the features of storage systema and apply them for conventional power generation, grid operation & service.

UNIT-I: The roles of electrical energy storage technologies in electricity use: Characteristics of electricity, Electricity and the roles of EES, High generation cost during peak-demand periods,Need for continuous and flexible supply,Long distance between generation and consumption, Congestion in power grids,Transmission by cable, Emerging needs for EES, More renewable energy, less fossil fuel, Smart Grid uses,The roles of electrical energy storage technologies,The roles from the viewpoint of a utility,The roles from the viewpoint of consumers, The roles from the viewpoint of generators of renewable energy.

UNIT-II: Types and features of energy storage systems: Classifi cation of EES systems,Mechanical storage systems, Pumped hydro storage (PHS), Compressed air energy storage (CAES), Flywheel energy storage (FES), Electrochemical storage systems, Secondary batteries, Lead-Acid Batteries, Lithium-Ion Batteries, Flow batteries, Other Batteries in Development, Chemical energy storage, Hydrogen (H2), Synthetic natural gas (SNG), Electrical storage systems,Double-layer capacitors (DLC), Superconducting magnetic energy storage (SMES),Thermal storage systems, Standards for EES,Technical comparison of EES technologies.

UNIT-III: Applications of EES: Present status of applications, Utility use (conventional power generation, grid operation & service), Consumer use (uninterruptable power supply for large consumers), EES installed capacity worldwide, New trends in applications, Renewable energy generation, Smart Grid, Smart Microgrid, Smart House, Electric vehicles,

UNIT-IV: Management and control hierarchy of EES: Internal configuration of battery storage systems, External connection of EES systems, Aggregating EES systems and distributed generation (Virtual Power Plant),“Battery SCADA” – aggregation of many dispersed batteries.

Demand for Energy Storage: Growth in Variable Energy Resources, Relationship between balancing services and variable energy resources, Energy Storage Alternatives, Variable Generator Control, Demand Management, Market Mechanisms, Longer Term Outlook.

Valuation Techniques: Overview, Energy Storage Operational Optimization, Market Price Method, Power System Dispatch Model Method, Ancillary Service Representation, Energy Storage Representation, Survey of Valuation Results.

UNIT-V: Forecast of EES market potential by 2030: EES market potential for overall applications, EES market estimation by Sandia National Laboratory (SNL), EES market estimation by the Boston Consulting Group (BCG), EES market estimation for Li-ion batteries by the Panasonic Group, EES market potential estimation for broad introduction of renewable energies, EES market potential estimation for Germany by Fraunhofer, Storage of large amounts of energy in gas grids, EES market potential estimation for Europe by Siemens, EES market potential estimation by the IEA, Vehicle to grid concept, EES market potential in the future

TEXT BOOKS:

1. Techno-Economic Analysis of Different Energy Storage Technologies, Hussein Ibrahim and Adrian Ilinca
2. Energy Storage 2010th Edition, by Robert A. Huggins (Author), Springer
3. Energy Storage, Yves Brunet (Editor), May 2013, Wiley-ISTE
4. Energy Storage in Electric Power Grids ,by Benoît Robyns, Bruno François, Wiley

REFERENCES:

1. andreasoberhofer@gmx.de
2. www.ecofys.com/com/publications
3. www.iec.ch

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ELECTIVE – 8.6. ELECTRICAL ENGINEERING MATERIALS

Prerequisite: EMF

Course Objectives:
- To know the properties, characteristics of dielectric materials.
- To study the properties, characteristics of dielectric materials.
- To analyze the properties, characteristics of semiconductor materials.
- To discuss the different kind of materials for electric applications.
- To have a glance on the properties, characteristics of special materials.

Course Outcomes:
At the end of the course the student will be able to:
- Evaluate insulating, conducting and magnetic materials used in electrical machines.
- Understand the properties of liquid, gaseous and solid insulating materials.
- Evaluate transformer oil by testing

UNIT-I:
DIELECTRIC MATERIALS
Dielectric as Electric Field Medium,leakage currents, dielectric loss,dielectric strength, breakdown voltage,breakdown in solid dielectrics, flashover,liquiddielectrics,electric conductivity in solid,liquid and gaseous dielectrics, Ferromagnetic materials, properties of ferromagnetic materials in static fields,spontaneous, Polarization, Curie point, anti-ferromagnetic materials, piezoelectric materials, pyroelectric materials.

UNIT-II:
MAGNETIC MATERIALS
Classification of magnetic materials, spontaneous magnetization in ferromagnetic materials,magneticAnisotropy,Magnetostriction,diamagnetism, magnetically soft and hard materials,special purpose materials, feebly magnetic materials, Ferrites, cast and cermet permanent magnets,ageing of magnets.factors effecting permiablity and hystersis.

UNIT-III:
SEMICONDUCTOR MATERIALS
Properties of semiconductors, Silicon wafers, integration techniques, Large and very large scale integration techniques (VLSI).

UNIT-IV:
MATERIALS FOR ELECTRICAL APPLICATIONS
Materials used for Resistors, rheostats, heaters, transmission line structures, stranded conductors, bimetals fuses, soft and hard solders,electric contact materials, electric carbon materials, thermocouple materials.Solid Liquid and Gaseous insulating materials. Effect of moisture on insulation.

UNIT-V:

SPECIAL PURPOSE MATERIALS

Refractory Materials, Structural Materilas, Radioactive Materials, Galvonization and Impregnation of materials, Processing of electronic materials, Insulating varnishes and coolants, Properties and applications of mineral oils, Testing of Transformer oil as per ISI.

TEXT BOOKS:

1. R K Rajput: A course in Electrical Engineering Materials, Laxmi Publications. 2009
2. T K BasaK: A course in Electrical Engineering Materials:, New Age Science Publications 2009

REFRENCE:

1. TTTI Madras: Electrical Engineering Materials
2. AdrianusJ.Dekker: Electrical Engineering Materials , THM Publication

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POWER CONVERTERS LAB

Course Objectives:
Upon successful completion of the lab students will be familiar with:
- Speed control techniques of DC and AC drives
- Gate drive circuit configurations for converter circuits
- Advanced converter topologies
- Open loop and closed loop speed control analysis of AC and DC drives

Course Outcomes:
At the end of the course, the student should be able to:
- Know the speed control strategies of AC and DC drives
- Design speed, current controllers for AC and DC drives
- Get the knowledge on multi-level inverter/converter topologies
- Perform the open loop and closed loop speed control analysis of AC and DC drives
- Design the gate driver circuits for converter topologies
- Know the complete study of advanced converter technologies.

1. Speed control of separately excited DC Motor Drive with 1 quadrant chopper
2. Speed control of separately excited DC Motor Drive with 4 quadrant chopper.
3. Speed control of BLDC Motor Drive.
4. Multi-level inverter based AC Induction Motor Drive control equipment.
5. Speed control of 3-phase wound rotor Induction Motor Drive.
6. Speed control of 3-phase doubly fed Induction Motor Drive.
7. Speed control of 5-phase Induction Motor Drive.
8. Speed control of 3-phase Induction Motor Drive using V/F control.
9. Speed control of 3-phase Induction Motor Drive using Vector Control technique.
10. Speed Measurement and closed loop control using PMDC Motor Drive.
11. Speed measurement and closed loop control of PMDC Motor Drive with thyristor circuit.
12. Matrix Converter
13. Speed measurement and closed loop control of IGBT used single 4 quadrant chopper for PMDC Motor Drive.
14. Isolated Gate Drive circuits for MOSFET / IGBT based circuits.

Note: Any ten experiments can be conducted.

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SOFT SKILLS LAB
(Activity-based)

Course Objectives

- To improve the fluency of students in English
- To facilitate learning through interaction
- To illustrate the role of skills in real-life situations with case studies, role plays etc.
- To train students in group dynamics, body language and various other activities which boost their confidence levels and help in their overall personality development
- To encourage students develop behavioral skills and personal management skills
- To impart training for empowerment, thereby preparing students to become successful professionals

Learning Outcomes

- Developed critical acumen and creative ability besides making them industry- ready.
- Appropriate use of English language while clearly articulating ideas.
- Developing insights into Language and enrich the professional competence of the students.
- Enable students to meet challenges in job and career advancement.

INTRODUCTION

Definition and Introduction to Soft Skills – Hard Skills vs Soft Skills – Significance of Soft/Life/Self Skills – Self and SWOT Analysis ***and***

1. **Exercises on Productivity Development**
   - Effective/ Assertive Communication Skills (Activity based)
   - Time Management (Case Study)
   - Creativity & Critical Thinking (Case Study)
   - Decision Making and Problem Solving (Case Study)
   - Stress Management (Case Study)
2. **Exercises on Personality Development Skills**
   - Self-esteem (Case Study)
   - Positive Thinking (Case Study)
   - Emotional Intelligence (Case Study)
   - Team building and Leadership Skills (Case Study)
   - Conflict Management (Case Study)
3. **Exercises on Presentation Skills**
   - Netiquette
   - Importance of Oral Presentation – Defining Purpose- Analyzing the audience- Planning Outline and Preparing the Presentation- Individual & Group Presentation- Graphical Organizers- Tools and Multi-media Visuals
   - One Minute Presentations (Warming up)
   - PPT on Project Work- Understanding the Nuances of Delivery- Body Language – Closing and Handling Questions – Rubrics for Individual Evaluation (Practice Sessions)
4. **Exercises on Professional Etiquette and Communication**
   - Role-Play and Simulation- Introducing oneself and others, Greetings, Apologies, Requests, Agreement & Disagreement….etc.

- Telephone Etiquette
- Active Listening
- Group Discussions (Case study)- Group Discussion as a part of Selection Procedure- Checklist of GDs
- Analysis of Selected Interviews (Objectives of Interview)
- Mock-Interviews (Practice Sessions)
- Job Application and Preparing Resume
- Process Writing (Technical Vocabulary) – Writing a Project Report- Assignments

5. **Exercises on Ethics and Values**

Introduction — Types of Values - Personal, Social and Cultural Values - Importance of Values in Various Contexts

- Significance of Modern and Professional Etiquette – Etiquette (Formal and Informal Situations with Examples)
- Attitude, Good Manners and Work Culture (Live Examples)
- Social Skills - Dealing with the Challenged (Live Examples)
- Professional Responsibility – Adaptability (Live Examples)
- Corporate Expectations

☞ Note: Hand-outs are to be prepared and given to students.

☞ Training plan will be integrated in the syllabus.

☞ Topics mentioned in the syllabus are activity-based.

SUGGESTED SOFTWARE:

☞ The following software from **'train2success.com'**

- o Preparing for being Interviewed
- o Positive Thinking
- o Interviewing Skills
- o Telephone Skills
- o Time Management
- o Team Building
- o Decision making

SUGGESTED READING:

1. Alex, K. 2012. *Soft Skills.* S. Chand Publishers
2. *Management Shapers*. 2011. Collection of 28 Books by different Authors. Universities Press.
3. Sherfield, Robert M. *2005. et al Cornerstone: Developing Soft Skills*. Pearson
4. Suresh Kumar,E; Sreehari, P. & Savithri, J. 2011. *Communication Skills and Soft Skills- An Integrated Approach.* New Delhi: Pearson
5. The ACE of Soft Skills by Gopalaswamy Ramesh & Mahadevan Ramesh. 2013. Pearson Publishers. New Delhi.
6. Patnaik, P. 2011. *Group Discussion and Interview Skills.* New Delhi: Foundation
7. Sudhir Andrews. 2009. *How to Succeed at Interviews.* New Delhi: Tata McGraw Hill
8. **Sasikumar, V & Dhamija, P.V. 1993. *Spoken English - A Self-Learning Guide to Conversation Practice.* New Delhi: Tata McGraw-Hill**
9. *Dixson, Richard J. Everyday Dialogues in English. Prentice Hall India Pvt Ltd*
10. Mukhopadhyay. L *et al. 2012. Polyskills. New Delhi: CUP India Pvt Ltd*
11. Rizvi, M. A. 2005. *Effective Technical Communication.* New Delhi: Tata McGraw Hill
12. *The Hindu Speaks on Education* by the Hindu Newspaper
13. Naterop, B. Jean and Revell, Rod. 2004. *Telephoning in English*. Cambridge: CUP