

## EE001 POWER GENERATION SYSTEMS

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**Course Objectives:** To understand the working of different types of power generation systems and to realize the necessity for interconnected operation of different power stations.

**Prerequisites:** Basic knowledge about working of alternators and electric power systems

Hydro-electric power plants – selection of site, elements of power plant, classification, water turbines, governor action, hydro-electric generator, plant layout, pumped storage plants.

Thermal Steam power plants – selection of site, elements and operational circuits of the power plant, turbo-alternators, plant layout, steam turbines, controls and auxiliaries.

Nuclear power plants – selection of site, nuclear reaction – fission process and chain reaction, constituents of power plant and layout, nuclear reactor – working, classification, control, shielding and waste disposal.

Renewable power plants – Solar power generation – Photo-voltaic and solar thermal generation – solar concentrators, Wind power generation – types of wind mills, wind generators, tidal, biomass, geothermal and magneto-hydro dynamic power generation, micro-hydel power plants, fuel cells and diesel and gas power plants.

Combined operation of power plants – plant selection, choice of size and number of generator units, interconnected systems, real and reactive power exchange among interconnected systems. Major electrical equipment in power plants, DC systems in power plants, station control - switch yard and control room. Economic considerations – types of costs, tariff and consumers.

### Text Books:

1. Chakrabarti A., Soni M.L., Gupta P.V., and Bhatnagar U.S., 'A text book on Power Systems Engg.', Dhanpat Rai and Sons, New Delhi, 2<sup>nd</sup> revised edition, 2010.
2. J.B.Gupta, 'A course in Power Systems', S.K.Kataria and sons, reprint 2010-2011.

### Reference Books:

1. Wadhwa, C.L., 'Generation Distribution and Utilisation of Electrical Energy', New Age International publishers, 3<sup>rd</sup> edition, 2010.
2. Deshpande M.V, 'Elements of Electrical Power systems Design', Pitman, New Delhi, PHI Learning Private Limited, 1<sup>st</sup> edition, 2009.

### COURSE OUTCOMES:

Upon completion of the course the students would be able to:-

1. Appreciate the different types of tariff, consumers and different types of power generation plants
2. Determine the significance of various components of the power generation plants
3. Correlate the importance of interconnected operation of different power generation systems
4. Plan an appropriate scheduling of electric power to satisfy the demand constraint

## EE002 DESIGN OF ELECTRICAL APPARATUS

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**Course Objectives:** This course offers the preliminary instructions and techniques to design the main dimensions and other major part of the transformer and DC and AC rotating machines. The course also provides the students with an ability to understand the step by step procedure for the complete design of electrical machines.

**Prerequisites:** DC Machines and Transformers , AC Machines

General concepts in the design of rotating machines-output equation-Magnetic and electric loadings-Common design features of all rotating machines-Conducting, insulating and magnetic materials used in electrical apparatus-mmf calculation for the magnetic circuit of rotating machines-Leakage reactance calculation.

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

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

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

Constructional features of synchronous machines-SCR-Output equation-specific loadings-Main dimensions-Stator design-Design of salient pole field coil.

### Text Books:

1. Sawhney, A.K., 'A course in Electrical Machines Design', Dhanpat Rai and sons Publications, 4<sup>th</sup> edition, 2010.

### References:

1. Sen, S.K., 'Principles of Electrical Machine Design with computer Programmes', Oxford and I.B.H Publishing Co.Pvt.Ltd, 2<sup>nd</sup> edition, 2006.
2. Rai, H.M., 'Principles of Electrical Machines Design', Sathya Prakash Publications, 3<sup>d</sup> edition, 1994.

### COURSE OUTCOMES:

Upon completion of this course,

1. The student will be able to understand the design of main dimensions and other major part of the transformer and DC and AC rotating machines.
2. The student will be capable of evaluating the procedure for the design of main dimensions and other major part of the transformer and DC and AC rotating machines.
3. The student will be equipped to apply in-depth knowledge related to the design of electrical machines.

## EE003 STATIC RELAYS

<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
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**Course Objectives:** To emphasize on various type and implementation of relays using solid-state circuits and microprocessors.

**Prerequisites:** Fundamentals on Power system protection, Analog electronics, Digital electronics and Microprocessor

Power system protection and its requirements – conventional Vs static relays - steady state and transient performance of signal deriving elements, signal mixing techniques and measuring techniques.

Over current protection - instantaneous over current relay – directional over current relay – applications – differential relays - generator and transmission line protection.

Static relay circuits for generator loss of field, under frequency, distance, impedance, reactance, mho and special characteristics - reverse power relays

Static relay circuits for carrier protection and testing of relays - Static relay circuits - tripping circuits using thyristor.

Microprocessor/Microcontroller based Relays-Hardware and software for the measurements of voltage, current, frequency and phase angle- implementation of over current, directional, impedance and mho relays.

### Text Books:

1. Madhava Rao T.S., 'Power System Protection - Static Relays', McGraw Hill, New Delhi, 2<sup>nd</sup> Edition, 21<sup>st</sup> reprinted, 2008.

### Reference Books:

1. Ram.B. 'Fundamentals of Microprocessors and Microcomputers', M/s. Dhanpat Rai & sons, New Delhi, 2011.
2. Van.C.Warrington, 'Protective Relays - Their Theory and Practice', Vols. I & II, Chapman & Hall Ltd. London, 2<sup>nd</sup> Edition, 1994.

### COURSE OUTCOMES:

Upon completion of the course the students would be able to

1. Distinguish between the conventional electro-mechanical relays and static relays
2. Design various electronic circuits to implement various relaying functions
3. Implement microprocessor based relays

## EE004 EHV AC AND DC TRANSMISSION

<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
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- Course Objectives:**
- To understand and analyze the HVAC and HVDC transmission systems.
  - To plan an appropriate transmission system between two destinations based on the load requirement and anticipated technical performance of power transmission
- Prerequisites:** As a pre-requisite to this course the students should have completed a fundamental course on Transmission and Distribution and Power Electronics.

Design aspects of HVAC – conductor, tower, insulator and substation structure design, mechanical design - sag-tension calculations, design of EHVAC lines based on steady state limits and transient over voltages - design of extra HV cables - XLPE cables and gas insulated cables.

Real and reactive power flows in HVAC systems – reactive power compensation, FACTS devices in EHV Transmission, short circuit level & real power transfer capacity. Stability- voltage stability and control. Theory of travelling and stationary waves, radio interference, television interference, audible noise and corona.

Introduction to HVDC transmission - Bridge converters – rectifier and inverter operation, equivalent circuit representation, power reversal, desired features of control and actual control characteristics.

Basic HVDC controllers, converter faults, commutation failure, bypass action in bridges, protection issues in HVDC - DC reactors, voltage and current oscillations, DC circuit breakers and over voltage protection, HVDC cables

Harmonics in HVDC - characteristics and uncharacteristic harmonics, troubles due to harmonics, harmonic filters – active and passive filters, active and reactive power exchange in converters and recent trend in HVDC transmission – Hybrid HVDC and Off-shore wind power evacuation through HVDC, introduction to Wide Area Monitoring Systems.

### Text Books:

1. S.Rao, 'EHV-AC, HVDC Transmission and Distribution Engineering', Khanna publishers, 3<sup>rd</sup> edition, 2012.
2. Rakosh Das Begamudre, 'Extra High Voltage AC Transmission Engineering', New Age International publishers, 3<sup>rd</sup> edition, 2009.

### Reference Books:

1. Padiyar K.R., 'HVDC transmission systems', New Age International publishers, 2<sup>nd</sup> revised edition, 2012.

### Useful web links:

1. <http://nptel.iitm.ac.in/courses/108104013>

### COURSE OUTCOMES:

Upon completion of the course the students would be able to

1. Distinguish between the usage of EHVAC and HVDC transmission systems.
2. Judge when and where to use EHAV / HVDC transmission systems in practice.
3. Design implementation circuitry for various controllers used in HVDC transmission systems
4. Plan an appropriate electric power transmission system between two destinations to satisfy the pre-defined load requirement without compromising the technical performance.

## EE005 FUNDAMENTALS OF FACTS

<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
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**Course Objectives:** To familiarize the students with the basic concepts, different types, scope and applications of FACTS controllers in power transmission.

**Prerequisites:** Power Electronics, Electrical Machines and Power systems.

Fundamentals of ac power transmission, transmission problems and needs, emergence of FACTS-FACTS control considerations, FACTS controllers.

Principles of shunt compensation – Variable Impedance type & switching converter type- Static Synchronous Compensator (STATCOM) configuration, characteristics and control.

Principles of static series compensation using GCSC, TCSC and TSSC, applications, Static Synchronous Series Compensator (SSSC), TJE.

Principles of operation-Steady state model and characteristics of a static voltage regulators and phase shifters-power circuit configurations.

UPFC-Principles of operation and characteristics, independent active and reactive power flow control, comparison of UPFC with the controlled series compensators and phase shifters.

### Text Books:

1. Hingorani, L. Gyugyi, 'Concepts and Technology of flexible AC transmission system', Standard Publishers Distributors, 1<sup>st</sup> Edition, 2011.
2. R.M. Mathur and R.K. Varma, 'Thyristor-Based FACTS Controllers for Electrical Transmission Systems', Wiley India Pvt. Limited Publications, 1<sup>st</sup> Edition, 2011.

### References:

1. K. R. Padiyar, 'FACTS Controllers in Power Transmission and Distribution', New Age International Publications, 1<sup>st</sup> Edition, 2009.

### COURSE OUTCOMES:

Upon completion of the course, the students shall be able to

1. Understand various control issues, for the purpose of identifying the scope and for selection of specific FACTS controllers.
2. Apply the concepts in solving problems of simple power systems with FACTS controllers.
3. Design simple FACTS controllers

**EE006 UTILIZATION OF ELECTRICAL ENERGY**

<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
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**Course Objectives:** To design illumination systems, choose appropriate motors for any drive application, to debug a domestic refrigerator circuit and to design battery charging circuitry for specific applications.

**Prerequisites:** Basics of circuit theory, operational characteristics of various dc and ac motors.

Illumination – Terminology, Laws of illumination, Photometry, lighting calculations. Electric lamps – Different types of lamps, LED lighting and Energy efficient lamps. Design of lighting schemes - factory lighting - flood lighting – street lighting.

Refrigeration- Domestic refrigerator and water coolers. Air-Conditioning - Various types of air conditioning system and their applications, smart air conditioning units. Energy Efficient motors: Standard motor efficiency, need for more efficient motors, Motor life cycle, Direct Savings and payback analysis, efficiency evaluation factor.

Domestic utilization of electrical energy – House wiring. Induction based appliances, Online and OFF line UPS, Batteries. Power quality aspects – nonlinear and domestic loads. Earthing – domestic, industrial and sub-station.

Electric Heating- Types of heating and applications, Electric furnaces - Resistance, inductance and Arc Furnaces, Electric welding and sources of welding, Electrolytic processes – electro-metallurgy and electro-plating.

Traction system – power supply, traction drives, electric braking, tractive effort calculations and speed-time characteristics. Locomotives and train - recent trend in electric traction.

**Text Books:**

1. Dr. Uppal S.L. and Prof. S. Rao, 'Electrical Power Systems', Khanna publishers, New Delhi, 2009.
2. Gupta, J.B., 'Utilisation of Electrical Energy and Electric Traction', S.K.Kataria and sons, 10<sup>th</sup> Edition, 1990.
3. Rajput R.K., 'Utilisation of Electrical Power', Laxmi publications, 1st Edition, 2007.

**Reference Books:**

1. N.V.Suryanarayana, 'Utilisation of Electrical Power', New Age International publishers, Reprinted 2005.
2. C.L.Wadhwa, 'Generation Distribution and Utilization of Electrical Energy', New Age International publishers, 4<sup>th</sup> edition, 2011.
3. Energy Efficiency in Electrical Utilities, BEE guide book, 2010.

**COURSE OUTCOMES:**

Upon completion of the course the students would be able to

1. Develop a clear idea on various Illumination techniques and hence design lighting scheme for specific applications
2. Identify an appropriate method of heating for any particular industrial application
3. Evaluate domestic wiring connection and debug any faults occurred
4. Construct an electric connection for any domestic appliance like refrigerator as well as to design a battery charging circuit for a specific household application.
5. Realize the appropriate type of electric supply system as well as to evaluate the performance of a traction unit.

## EE007 SPECIAL ELECTRICAL MACHINES

<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
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**Course** To expose the students to the construction, principle of operation and performance of special electrical machines as an extension to the study of basic electrical machines.

**Prerequisites:** Fundamentals of DC and AC machines

Constructional features – Types – Axial and Radial flux motors – Operating principles – Variable Reluctance and Hybrid Motors – SYNREL Motors – Voltage and Torque Equations - Phasor diagram - Characteristics.

Constructional features – Principle of operation – Variable reluctance motor – Hybrid motor – Single and multi-stack configurations – Torque equations – Modes of excitations – Characteristics – Drive circuits – Microprocessor control of stepping motors – Closed loop control.

Constructional features – Rotary and Linear SRMs - Principle of operation – Torque production – Steady state performance prediction- Analytical method -Power Converters and their controllers – Methods of Rotor position sensing – Sensor less operation – Closed loop control of SRM - Characteristics.

Permanent Magnet materials – Magnetic Characteristics – Permeance coefficient -Principle of operation – Types – Magnetic circuit analysis – EMF and torque equations –Commutation - Power controllers – Motor characteristics and control.

Principle of operation – Ideal PMSM – EMF and Torque equations – Armature reaction MMF – Synchronous Reactance – Sine wave motor with practical windings - Phasor diagram – Torque/speed characteristics - Power controllers - Converter Volt-ampere requirements.

### Text Books:

1. T.J.E. Miller, 'Brushless Permanent Magnet and Reluctance Motor Drives', Clarendon Press, Oxford, 1993.
2. T. Kenjo, 'Stepping Motors and Their Microprocessor Controls', Clarendon Press London, 1995.

### Reference Books:

1. R.Krishnan, 'Switched Reluctance Motor Drives – Modeling, Simulation, Analysis, Design and Application', CRC Press, New York, 2001.
2. P.P. Aearnley, 'Stepping Motors – A Guide to Motor Theory and Practice', Peter Perengrinus London, 2002.
3. T. Kenjo and S. Nagamori, 'Permanent Magnet and Brushless DC Motors', Clarendon Press, London, 1988.

### COURSE OUTCOMES:

Upon completion of the course the students would be able to understand the construction, principle of operation and performance of

1. Synchronous reluctance motors
2. Stepping motors
3. Switched reluctance motors
4. Permanent magnet brushless D.C. motors
5. Permanent magnet synchronous motors.

**EE008 ELECTRICAL SAFETY**

<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
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**Course Objectives:** To provide a comprehensive exposure to electrical hazards, various grounding techniques, safety procedures and various electrical maintenance techniques.

**Prerequisites:** Basic science and electrical engineering

Primary and secondary hazards- arc, blast, shocks-causes and effects-safety equipment- flash and thermal protection, head and eye protection-rubber insulating equipment, hot sticks, insulated tools, barriers and signs, safety tags, locking devices- voltage measuring instruments- proximity and contact testers-safety electrical one line diagram- electrician's safety kit.

General requirements for grounding and bonding- definitions- grounding of electrical equipment- bonding of electrically conducting materials and other equipment- connection of grounding and bonding equipment- system grounding- purpose of system grounding- grounding electrode system- grounding conductor connection to electrodes-use of grounded circuit conductor for grounding equipment- grounding of low voltage and high voltage systems.

The six step safety methods- pre job briefings- hot -work decision tree-safe switching of power system- lockout-tag out- flash hazard calculation and approach distances- calculating the required level of arc protection-safety equipment , procedure for low, medium and high voltage systems- the one minute safety audit

Electrical safety programme structure, development- company safety team- safety policy- programme implementation- employee electrical safety teams- safety meetings- safety audit- accident prevention- first aid- rescue techniques-accident investigation

Safety related case for electrical maintenance- reliability centered maintenance (RCM) - eight step maintenance programme- frequency of maintenance- maintenance requirement for specific equipment and location- regulatory bodies- national electrical safety code- standard for electrical safety in work place- occupational safety and health administration standards.

**Text Books:**

1. Dennis Neitzel, Al Winfield, 'Electrical Safety Handbook', McGraw-Hill Education , 4<sup>th</sup> Edition, 2012.

**Reference Books:**

1. John Cadick, 'Electrical Safety Handbook', McGraw-Hill School Education Group, 1994.
2. Maxwell Adams.J, "Electrical safety- a guide to the causes and prevention of electric hazards", The Institution of Electric Engineers, 1994.
3. Ray A. Jones, Jane G. Jones, 'Electrical safety in the workplace', Jones & Bartlett Learning, 2000.

**COURSE OUTCOMES:**

Upon completion of the course the students would be able to:-

1. Describe electrical hazards and safety equipment.
2. Analyze and apply various grounding and bonding techniques.
3. Select appropriate safety method for low, medium and high voltage equipment.
4. Participate in a safety team.
5. carry out proper maintenance of electrical equipment by understanding various standards



<b>EE009 COMPUTER RELAYING AND PHASOR MEASUREMENT UNIT</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
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- Course Objectives:**
- To understand and analyze the basic architecture of Digital Relay
  - Understand the basics of Phasor Measurement unit (PMU)
  - Applications of PMUs in power system

**Prerequisites:** Fourier series, Fourier Transform, Phasors , ADC

Mathematical background to protection algorithms-Finite difference technique-Numerical differentiation-Least Squares Method-Fourier analysis-Fourier analysis of analogue signals- Fourier analysis of discrete signals-Walsh function analysis.

Basic elements of digital protection-Signal conditioning subsystem-Transducers-Surge protection circuits-Analogue filtering-Analog multiplexers-Conversion subsystem-Sampling theorem-Signal aliasing error-Sample and hold circuit-Digital multiplexing-Digital to Analogue Conversion-Analogue to Digital Conversion-Processor-Data and Program memory-Digital relay hardware unit.

Phasor Measurement Unit– Introduction- Phasor representation of sinusoids- Phasor Estimation of Nominal Frequency Signals- Formulas for updating phasors - Nonrecursive updates-Recursive updates- Frequency Estimation.

Phasor Measurement Applications-State Estimation-History- Operator’s load flow- weighted least square least square- Linear weighted least squares; Nonlinear weighted least squares- Static state estimation- State estimation with Phasors measurements- linear state estimation.

Adaptive protection- Differential and distance protection of transmission lines- Adaptive out-of-step protection.

**Text Books:**

1. Arun G. Phadke, James S. Thorp, ‘Computer Relaying for Power Systems’, A John Wiley and Sons Ltd., Research Studies Press Limited, 2009.
2. A.G. Phadke • J.S. Thorp, ‘Synchronized Phasor Measurements and Their Applications’, Springer,2008.

**Reference Books:**

1. A.T.Johns and S.K.Salman, ‘Digital Protection For Power Systems’, Peter Peregrinus Ltd, 1997.

**COURSE OUTCOMES:**

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

1. Understand the operation of computer relay.
2. Understand the basics of phasor measurement unit.
3. Understand the different applications of PMUs on power system.

**EE081 SOLID STATE DRIVES**

<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
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**Course**

- To understand the basic concept of DC and AC Drives.

**Objectives:**

- To understand the various control techniques involved with both DC and AC Drives.
- To brief about the working principle of Special Electrical Drives.

**Prerequisites:**

Electrical machines, Power Electronics.

Introduction to solid state drives, various components-power converters, motors, loads, coupling mechanisms, Stability of drive.

Modeling of d.c.motor drives. Transfer function and state-space models. Experimental determination of drive parameters. Speed control using ac to dc converters, Input performance parameters, Speed reversal schemes.

Chopper fed d.c.motor drives. Four quadrant operation. Input filters design. Dynamic braking with dc chopper. Type-c chopper fed regenerative braking. Operation with non- receptive lines.

Power converters for induction motor speed control. Harmonic behavior of induction motors-harmonic currents and harmonic torques using per phase equivalent circuit. Stator voltage control schemes.

State-space modeling of induction motors. Voltage source-Inverter fed operation. Field oriented control schemes. Current source – inverter drives. Principle of vector control.

**Text Books:**

1. P.C.Sen, 'Thyristor DC Drives' John Wiley& Sons Publishers, New York, 2008.
2. R.Krishnan, 'Electric Motor Drives-Modeling, Analysis, and Control', Pearson Education Publishers, 1<sup>st</sup> edition, 2003.
3. B.K.Bose, 'Modern Power Electronics and AC drives', Pearson Education Publications, 2<sup>nd</sup> edition, 2005.

**Reference Books:**

1. G.K. Dubey, 'Fundamentals of Electrical Drives', Narosa Publishing house, 2<sup>nd</sup> edition, 2008.
2. T. Wildi, 'Electrical Machines Drives and Power Systems', Pearson Education Publications, 6<sup>th</sup> edition, 2004.

**COURSE OUTCOMES:**

Upon completion of this course,

1. The student learns the fundamental concepts of power electronic converter fed DC and AC machines.
2. The student can analyze the converter fed motor under different torque/speed conditions.
3. The student will be able to design converter fed drives with existing/new control techniques.

## EE082 POWER SYSTEM DYNAMICS

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- Course Objectives:**
- To explain the power system stability problem
  - To understand the behavior of synchronous and induction machines during disturbance
  - To employ mathematical tools for power system stability analysis
- Prerequisites:** Mathematical Transformations, Fundamentals of Synchronous and asynchronous machines, Principle of load flow and short circuit analysis

Stability considerations – Dynamic modeling requirements- angle stability – equal area criterion- Critical fault clearing time and angle-numerical integration techniques.

Synchronous machines - Park's transformation – flux linkage equations – formulation of normalized equations – state space current model – simplified models of the synchronous machine – turbine, Generator – steady state equations and phasor diagrams.

Dynamics of Synchronous machines - Mechanical relationships – electrical transient relationships – adjustment of machine models – Park's equation in the operational form.

Induction motor equivalent circuits and parameters - free acceleration characteristics – dynamic performance – effect of three phase short circuit and unbalanced faults.

Transient and dynamic stability distinction – linear model of unregulated synchronous machine and its oscillation modes – distribution of power impacts – effects of excitation on stability – supplementary stabilization signals.

### Text Books:

1. Krause P.C., 'Analysis of Electric Machinery', McGraw-Hill, 3rd revised Editions, 2013.
2. Ramanujam R, 'Power System Dynamics', PHI Learning Pvt. Ltd., New Delhi, 2009.

### Reference Books:

1. Kundur P, 'Power System Stability and Control', McGraw-Hill, New York, 1st Edition, 2006.

### COURSE OUTCOMES:

Upon completion of the course, the students will have acquired

1. Understanding of the dynamic phenomena of the power system operation
2. Knowledge to employ modeling techniques for investigating the response of system during disturbance.
3. Ability to interpret results coming from the simulation of differential -algebraic systems

**EE083 POWER SYSTEM RESTRUCTURING**

<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
3	0	0	3

**Course** To understand the electricity power business and technical issues in a restructured

**Objectives:** power system in both Indian and world scenario.

**Prerequisites:** Knowledge in power system analysis & Power system generation, transmission and distribution.

Introduction – Market Models – Entities – Key issues in regulated and deregulated power markets; Market equilibrium- Market clearing price- Electricity markets around the world

Operational and planning activities of a Genco - Electricity Pricing and Forecasting -Price Based Unit Commitment Design - Security Constrained Unit Commitment design. – Ancillary Services - Automatic Generation Control (AGC).

Introduction-Components of restructured system-Transmission pricing in Open- access system - Open transmission system operation; Congestion management in Open-access transmission systems-FACTS in congestion management - Open-access Coordination Strategies; Power Wheeling-Transmission Cost Allocation Methods

Open Access Distribution - Changes in Distribution Operations- The Development of Competition – Maintaining Distribution Planning

Power Market Development – Electricity Act, 2003 - Key issues and solution; Developing power exchanges suited to the Indian market - Challenges and synergies in the use of IT in power-Competition- Indian power market- Indian energy exchange- Indian power exchange- Infrastructure model for power exchanges- Congestion Management-Day Ahead Market- Online power trading.

**Text Books:**

1. *Loi Lei Lai, 'Power System Restructuring and Deregulation', John Wiley & son LTD, New York, HRD Edition, 2001.*
2. *Mohammad Shahidehpour, Hatim Yamin,' Market operations in Electric power systems', John Wiley & son LTD, Publication, 2002.*
3. *Lorrin Philipson, H. Lee Willis, 'Understanding Electric Utilities and Deregulation', Taylor & Francis, New York, 2nd Edition, 2006.*

**Reference Books:**

1. *Mohammad S hahidehpour, Muwaffaq Alomoush, 'Restructured Electrical Power Systems', Marce Dekker, INC., New York, 1st Edition, 2001.*

**Useful web links**

1. Indian energy exchange: <http://www.ixindia.com/>
2. Indian power India limited: <http://www.powerexindia.com/>
3. Indian Electricity Regulations: <http://www.cercind.gov.in/>

**COURSE OUTCOMES:**

Upon completion of the course the students would be able to

1. Explain and differentiate the key issues involved in the regulator and de-regulated power markets.
2. Describe the operational activities in Generation, Transmission and Distribution system in the restructured environment.
3. Illustrate and Solve problems in the de-regulated power System.
4. Explain and analyze the restructuring activities in Indian Power System.

## EE084 POWER SWITCHING CONVERTERS

<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
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**Course** This course aims at modelling, analysis and control of various power converter circuits.

### **Objectives:**

**Prerequisites:** Fundamentals of power electronics, Basic Electrical Engineering, Control systems

Basic converter topologies: Buck, Boost, Buck-Boost converter; steady state converter analysis - Equivalent circuit modelling

State space averaging of converters- Transfer function of converters- Design of feedback compensators-voltage and current loop

Design constraints of reactive elements in Power Electronic Systems: Design of inductor, transformer and capacitors for power electronic applications, Input filter requirement.

Isolated converters: forward converter, push-pull converter, fly back converter, half bridge and full bridge converter-operating principles

Soft-switching DC - DC Converters: zero-voltage-switching converters, zero-current switching converters, Multi-resonant converters and Load resonant converters-operating principles

### **Text Books:**

1. Simon Ang, Alejandro Oliva, 'Power Switching Converters', Taylor & Francis, 3<sup>rd</sup> Edition, 2010.
2. Robert W. Erickson, Dragan Maksimovic,, 'Fundamentals of Power Electronics', springer,2<sup>nd</sup> edition, 2001

### **Reference Books:**

1. N. Mohan, T. Undeland, and W. Robbins, 'Power Electronics: Converters, Applications, and Design', 2<sup>nd</sup> edition, John Wiley & Sons, 1995.
2. M. Rashid, 'Power Electronics: Circuits, Devices, and Applications', , Prentice Hall, 2<sup>nd</sup> edition 1993

### **COURSE OUTCOMES:**

Upon completion of this course the students will be able to

1. Understand the classification and operation of different types of DC-DC converters.
2. Analyze the Steady-state operation of DC-DC converter circuits
3. Develop the transfer function of DC-DC converter circuits
4. Design the compensator and reactive elements of DC-DC converter circuits
5. Illustrate different soft switching techniques in DC-DC converter circuits

<b>EE085 MODERN OPTIMIZATION TECHNIQUES FOR ELECTRIC POWER SYSTEMS</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
	3	0	0	3

**Course Objectives:** To learn the concepts and techniques of evolutionary and optimization techniques in power system applications.

**Prerequisites:** Fundamentals of electrical power system

Definition-Classification of optimization problems-Unconstrained and Constrained optimization-Optimality conditions-Classical Optimization techniques (Linear and nonlinear programming, Quadratic programming, Mixed integer programming)-Intelligent Search methods (Optimization neural network, Evolutionary algorithms, Tabu search, Particle swarm optimization, Application of fuzzy set theory).

Evolution in nature-Fundamentals of Evolutionary algorithms-Working Principles of Genetic Algorithm-Evolutionary Strategy and Evolutionary Programming-Genetic Operators-Selection, Crossover and Mutation-Issues in GA implementation- GA based Economic Dispatch solution-Fuzzy Economic Dispatch including losses- Tabu search algorithm for unit commitment problem-GA for unit commitment-GA based Optimal power flow- GA based state estimation.

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

Simulated annealing algorithm-Tabu search algorithm-SA and TS for unit commitment-Ant colony optimization- Bacteria Foraging optimization.

Concept of pareto optimality-Conventional approaches for MOOP-Multi objective GA-Fitness assignment-Sharing function-Economic Emission dispatch using MOGA-Multiobjective PSO (Dynamic neighbourhood PSO, Vector evaluated PSO) –Multiobjective OPF problem.

**Text Books:**

1. SolimanAbdel Hady,Abdel Aal Hassan Mantawy, “Modern optimization techniques with applications in Electric Power Systems”, Springer,2012.

**Reference Books:**

1. D.P.Kothari and J.S.Dhillon, “Power System Optimization”, 2nd Edition, PHI learning private limited, 2010.
2. Kalyanmoy Deb, “Multi objective optimization using Evolutionary Algorithms”, John Wiley and Sons, 2008.
3. Kalyanmoy Deb, “Optimization for Engineering Design”,Prentice hall of India first edition, 1988.

**COURSE OUTCOMES:**

Upon completion of this course the students will be able to

1. Understand the concept of optimization techniques.
2. Apply evolutionary algorithms for unit commitment and economic dispatch problems.
3. Interpret hybrid approach for power system reliability and security.

## EE086 VEHICULAR ELECTRIC POWER SYSTEM

L	T	P	C
3	0	0	3

**Course Objectives:** This course introduces the fundamental concepts, principles and analysis of hybrid and electric vehicles.

**Prerequisites:** Power Conversion Techniques, Electrical Machines

History of hybrid and electric vehicles, social and environmental importance of hybrid and electric vehicles, impact of modern drive-trains on energy supplies. Basics of vehicle performance, vehicle power source characterization, transmission characteristics

Introduction to electric components used in hybrid and electric vehicles- Configuration and control of DC Motor drives Induction Motor drives, Permanent Magnet Motor drives, and Switched Reluctance Motor drives- drive system efficiency.

Energy storage technologies in hybrid vehicles-flywheel, hydraulic, fuel cell and hybrid fuel cell energy storage system-ultra capacitors- comparison- - battery charging control

Introduction to energy management strategies used in hybrid and electric vehicle, classification of different energy management strategies, comparison of different energy management strategies, implementation issues of energy strategies.

Electrical power system in air craft, sea and undersea vehicles, space vehicles-hybrid vehicle control strategies-supporting subsystem

### Text Books:

1. Ali Emadi, Mehrdad Ehsani, John M. Miller 'Vehicular Electric Power Systems: Land, Sea, Air, and Space Vehicles',

### Reference Books:

1. Ion Boldea and S.A Nasar, 'Electric drives', CRC Press, 2005
2. Sandeep Dhameja, 'Electric Vehicle Battery Systems',
3. Chris Mi, M. Abul Masrur, David Wenzhong Gao,
4. Iqbal Husain, *Electric and Hybrid Vehicles: Design Fundamentals, Second Edition*

### COURSE OUTCOMES:

On completion of the course, the student would be able to

1. Understand the various aspects of hybrid and electric vehicles
2. Plan the selection of electrical machines for hybrid and electric vehicles
3. Select various energy storage technologies for hybrid and electric vehicles
4. Implement energy management techniques for hybrid and electric vehicles
5. Demonstrate the power system of various vehicular system

**EE087 DISTRIBUTION SYSTEM AUTOMATION**

<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
3	0	0	3

**Course Objectives:** To understand and appreciate the basic control techniques involved in distribution automation and also get introduced to the various communication systems involved in distribution automation. Also the objective of the course is to enable the students capable of analyzing the economics behind the automation of distribution system automation.

**Prerequisites:** Basic knowledge on control systems, communication systems and electric power distribution systems

Introduction to Distribution Automation, Control System Interfaces, Control and Data requirements, Centralized (Vs) Decentralized Control, Distribution Automation System, DAS Hardware, DAS Software, DA Capabilities, Automation system computer facilities.

Layout of substations and feeders, design considerations. Distribution system load flow, optimal siting and sizing of substations, optimal capacitor placement. Distribution system monitoring and control: SCADA, Remote metering and load control strategies, Optimum feeder switching for loss minimization and load control. Distribution system restoration. Distribution system protection and switchgear. Power quality issues. System Reliability Management, Voltage Management and Load Management.

DA Communication Requirements, Communication Reliability, Cost Effectiveness, Data Rate Requirements, Two Way Capability, Ability to communicate during outages and faults, Ease of operation and maintenance, Conforming to the architecture of data flow. Communication Systems used - Distribution line carrier (Power line carrier), Telephone, Cable TV, Radio, AM Broadcast, FM SCA, VHF Radio, UHF Radio, Microwave, Satellite, Fibre Optics, Hybrid Communication Systems.

DA Benefit Categories, Capital Deferred Savings, Operation and Maintenance Savings, Interruption Related Savings, Customer-related Savings, Operational savings, Improved operation, Function Benefits, Potential Benefits for Functions, Function-shared Benefits, Guidelines for Formulation of Estimating Equations.

Economic impacts and Benefit impacts of Automation on Distribution Systems, Integration of benefits into economic evaluation. Development and Evaluation of Alternate plans, Operation and Maintenance Cost Evaluation, Evaluation of Alternatives. Economic Comparison of Alternate Plans, Classification of Expenses and Capital Expenditures, Comparison of revenue requirements of alternative plans, Sensitivity Analysis, Computational Aids. Distribution system restoration. Distribution system protection and switchgear. Power quality issues.

**Text Books:**

1. Momoh A. Momoh, James A. Momoh., 'Electric Power Distribution, Automation, Protection, and Control', CRC Press, 2007
2. Gonen., 'Electric Power Distribution System Engineering', BSP Books, Pvt. Ltd, 2007

**Reference Books:**

1. D. Bassett, K. Clinard, J. Grainger, S. Purucker, and D. Ward, 'Tutorial Course: Distribution Automation', IEEE Tutorial Publication 88EH0280-8-PWR, 1988.
2. IEEE Working Group on 'Distribution Automation'

**COURSE OUTCOMES:**

Upon completion of the course the students would be able to

1. Understand the Distribution Automation Systems and the Control techniques involved.
2. Develop a clear idea on the layout of the substations and feeders and also on the various management techniques viz., load management and voltage management.
3. Identify an appropriate method of communication for any particular distribution system with a view of automation
4. Evaluate the economic aspects of any distribution system with automation



## EE021 COMPUTER ARCHITECTURE

<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>

**Course Objectives:** This Course will render the basic structure of computers their control design, memory organizations and an introduction to parallel processing

**Prerequisites:** Fundamental of digital systems , Basic programming skills

Computer – Functional units, Addressing modes, Instruction formats, Stacks and Subroutines. Processing Unit - Execution of instructions - Control step sequence.

Control Design - Hardwired control- design - multiplier control unit - CPU control unit and Micro programmed control - micro instructions - Sequencing - prefetching.

Arithmetic and Logic Unit-Fixed point and floatingpoint numbers and operations. Design of arithmetic units.

Memories - cache memories - virtual memories. Input-Output Organization - Data transfer-synchronization- Interrupt handling-I/O interfaces.

Introduction to parallel processing- Generation of computer systems – Parallelism in uniprocessor system – Parallel computer structures- architectural classification schemes.

### Text Books:

1. David A. Patterson and John L. Hennessy, 'Computer Organization and Design: The Hardware/Software interface', 4<sup>th</sup> Edition, Elsevier, 2009.
2. Morris Mano.M., 'Computer system Architecture', PHI, New Delhi, 3<sup>rd</sup> Edition 1993.
3. William Stallings, 'Computer Organization and Architecture – Designing for Performance', 8<sup>th</sup> Edition, Pearson Education, 2010.

### Reference Books:

1. Behrooz Parhami, 'Computer Architecture from up to super computer', Oxford press, reprinted 2014
2. John P. Hayes, 'Computer Architecture and Organization', Tata McGraw Hill, 3<sup>rd</sup> Edition, 1998.
3. Carl Hamachar, Zvonko Uranesic, Safwat zaky, ' Computer Organization', Tata McGraw Hill, 6<sup>th</sup> revised Edition ,2011

### COURSE OUTCOMES:

Upon completion of this course , students will

1. Describe the general architecture of computers.
2. Be familiar with the history and development of modern computers, the Von Neumann architecture and functional units of the processor such as the register file and arithmetic- logical unit,
3. Understand the major components of a computer including CPU, memory, I/O and storage, how computer hardware has evolved to meet the needs of multi-processing systems, the uses for cache memory, parallelism both in terms of a single processor and multiple processors.
4. Design principles in instruction set design including RISC architectures.
5. Analyze and design computer hardware components.

## EE022 COMPUTER NETWORKS

<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>

**Course Objectives:** To know about different network architectures and network protocols, data communications and different IEEE standards.

**Prerequisites:** Basics of Programming, Digital Electronics

Introduction - Architecture, Network hardware and software. Physical layer - Guided transmission media - Cable television.

Data Link Layer - Design issues – Channel allocation problem - Multiple access protocols - Ethernet - Wireless LAN - 802.11 architecture.

Network Layer - Design issues – Routing algorithms - Congestion control algorithms -Quality of Service - Internetworking.

Transport Layer - Transport service - Elements of transport protocols - User Datagram Protocol - Transmission Control Protocol.

Application Layer - DNS - Electronic mail - World Wide Web - Multimedia - Network security.

### Text Books:

1. A. S. Tanenbaum, 'Computer Networks', Pearson Education, 4<sup>th</sup> Edition, 2003
2. W. Stallings, 'Data and Computer Communication', Pearson Education, 8<sup>th</sup> Edition, 2007
3. James F.Kurose, Keith W.Ross,'Computer Networking', Pearson Education, 6<sup>th</sup> Edition, 2012.

### Reference Books:

1. Douglas E.Comer, 'Computer Networks and Internet', Pearson education, 4<sup>th</sup> Edition, 2008.
2. Behrouz A. Foruzan, 'Data Communication and Networking', Tata McGraw Hill, 5<sup>th</sup> Edition, 2013.
3. Larry L. Peterson and Bruce S. Davie, 'Computer Networks - A systems Approach', Harcourt Asia/Morgan Kaufmann, 5<sup>th</sup> Edition, 2011.

### COURSE OUTCOMES:

Upon completion of this course , students will be able to

1. Understand of the fundamental network issues
2. Analyze the significance of the network layers and their functions.
3. Gain knowledge about the basic network protocols.
4. Have a basic understanding of TCP / IP

## EE023 DESIGN WITH PIC MICROCONTROLLERS

<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
3	0	0	3

**Course Objectives:** To understand the internal structure and operation of PIC16F876 microcontroller, assembly language programming with MPLAB and PICSTART plus and design methodology for software and hardware applications.

**Prerequisites:** Knowledge on any microprocessor and power electronics may be desirable.

Introduction to PIC microcontrollers-PIC 16F876 microcontroller –device overview-pin diagrams-memory organisation.

Special Function Registers-I/O ports-Timers –Capture/Compare/PWM modules (CCP)-Analog to digital converter module-selection –reset–interrupts-watchdog timer.

Instruction set-instruction description–PIC16F876 assembly language programming –simple programs.

Introduction to MPLABIDE and PICSTART plus–Device Programming using MPLAB and PICSTART plus.

Assembly language programming for –Zero crossing detectors-square wave generation–firing pulse generation for typical single-phase converters and inverters- ADC program –hardware demonstration.

### Text Books:

1. PIC16F87X datasheet, 28/40- pin 8 bit CMOS flash Microcontrollers, Microchip Technology Inc, 2001.
2. Myke Predko, 'Programming and Customizing the PIC Microcontroller', Tata McGraw Hill Publications, 1<sup>st</sup> Edition, 2007.
3. John B. Peatman, 'Design with PIC Microcontrollers', Pearson Education Publications, 1<sup>st</sup> Edition, 2008.

### References:

1. MPLABIDE Quick start guide Microchip technology Inc., 2007.
2. M. D. Singh and K. B. Khanchandani, 'Power Electronics', Tata McGraw Hills Publishing Company Limited, 2<sup>nd</sup> Edition, 2006.

### COURSE OUTCOMES:

Upon completion of this course, students will

1. Understand the architecture of PIC 16F876 microcontroller and its instruction set.
2. Be able to develop assembly language program.
3. Be able to develop the program using MPLAB and download it to the microcontroller chip using suitable developer.
4. Be able to design and generate the firing pulses for typical power electronic circuits

## EE024 EMBEDDED SYSTEM DESIGN

<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>

**Course** To enable the learner to design a system with combination of hardware and Software

**Objectives:** for specific application.

**Prerequisites:** Basics of processors and controllers

Embedded System Architectures – ARM processor and SHARC processor - architectural design - memory organization - data operation - bus configurations. System on-chip, scalable bus architectures, Design example: Alarm clock, hybrid architectures.

Sensor and Actuator I/O – ADC, DAC, timers, Servos, Relays, stepper motors, H-Bridge, CODECs, FPGA, ASIC, diagnostic port.

Real time operating systems (RTOS) – real time kernel – OS tasks – task states – task scheduling – interrupt processing – clocking communication and synchronization – control blocks – memory requirements and control – kernel services.

Embedded Networks – Distributed Embedded Architecture – Hardware and Software Architectures, Networks for embedded systems– I2C, CAN Bus, Ethernet, Internet, Network–Based design– Communication Analysis, system performance Analysis, Hardware platform design, Allocation and scheduling, Design Example: Elevator Controller.

System Design – Specification, Requirements and Architectural design of PBX systems, Set-top box, Ink-jet printer, Laser printer, Personal digital Assistants.

### Text Books:

1. Wayne Wolf, 'Computers as Components: Principles of Embedded Computing System Design', Morgan Kaufman Publishers, 2<sup>nd</sup> Edition, 2010.
2. C.M Krishna, Kang G. Shin, 'Real time systems', Mc-Graw Hill, 1<sup>st</sup> Edition, 2010.
3. Galski D. Vahid F., Narayan S., 'Specification and Design of Embedded Systems', Prentice Hall, 1<sup>st</sup> impression, 2007

### Reference Books:

1. Herma K., 'Real Time Systems: Design for Distributed Embedded Applications', Springer, 2<sup>nd</sup> Edition, 2011.
2. WilliamHohl, 'ARM Assembly Language, Fundamentals and Techniques', CRC Press, 2009.

### COURSE OUTCOMES:

Upon completion of this course , students will be able to

1. Remember the concepts of process and controllers
2. Apply the concepts for real time applications
3. Create a real time system for particular applications

## EE025 DIGITAL SIGNAL PROCESSING

<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
3	0	0	3

**Course** To explore the basic concepts of digital signal processing in a simple and easy-to-understand manner.

**Objectives:**

**Prerequisites:** Signals and systems

Linearity shift - invariance - Unit sample response characterization – Convolution summation, causality, linear difference equations with constant coefficients and their solution using Z-transform – System function concept.

Discrete Fourier Transform and its properties – Circular convolution – Linear convolution of two finite length sequences through circular convolution, Sectioned convolutions – Relationship between Z- Transform, Fourier Transform and the Discrete Fourier Transform, Digital filter sampling, Introduction to radix-2 FFT – decimation in time and decimation in frequency radix2 algorithm – FFT Fortran program.

Amplitude and phase response of FIR filters – Linear phase filters – Windowing technique for the design of linear phase FIR filters – Rectangular – Hamming and Kaiser windows – Frequency sampling technique – Introduction to optimal filters.

Properties of IIR digital filters – Design of IIR filters from continuous time filters – Impulse invariance and Bilinear transformation technique – Finite Word Length Effects – Elementary ideas of finite word length effects in digital filters.

Architecture and features of signal processor and motion controller.

**Text Books:**

1. Oppenheim and Schaffer, 'Discrete time Signal processing', Pearson Education Publications, 3rd edition, 2010.
2. Ludemann L. C., 'Fundamentals of Digital Signal Processing', Harper and Row Publications, 1<sup>st</sup> edition, 1992.

**Reference Books:**

1. Rabiner & Gold, 'Theory and applications of Digital signal processing', PHI Learning Publications, 1<sup>st</sup> edition, 2009.
2. Hamid A. Toliyat and Steven G. Campbell, 'DSP Based Electro Mechanical Motion Control', CRC Press, 1<sup>st</sup> edition, 2004.

**COURSE OUTCOMES:**

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

1. Understand the operations on digital signals.
2. Analyze the signal processing concepts.
3. Design the systems required for digital signal processing

**EE026 DIGITAL SYSTEM DESIGN AND HDLS**

<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
3	0	0	3

**Course** To impart the concepts of Digital systems and hardware description languages.

**Objectives:**

**Prerequisites:** Essentials of Digital Electronics

Finite State machines - Mealy and Moore, state assignments, design and examples – Asynchronous finite state machines – design and examples – multi-input system controller design.

*Programmable Devices:* Simple and Complex Programmable logic devices (SPLD and CPLDs) , Field Programmable Gate Arrays (FPGAs), Internal components of FPGA, Case study: A CPLD and a 10 million gates type of FPGA.

VHDL- Modeling styles – structural – Behavioral – Dataflow - Design of simple/ complex combinational and sequential circuits using VHDL – Data types – Test bench and simulation. Case study on system design.

Verilog HDL - Modeling styles – structural – Behavioral – Dataflow - Design of simple/ complex combinational and sequential circuits using Verilog – Test bench and simulation – case study on system design.

Fault classes and models – Stuck at faults, Bridging faults - Transition and Intermittent faults. Fault Diagnosis of combination circuits by conventional methods - Path sensitization technique - Boolean different method and Kohavi algorithm

**Text Books:**

1. William I. Fletcher, 'An Engineering Approach to Digital Design', Prentice Hall, 2009.
2. Donald D.Givone, 'Digital principles and design', TMH, 2002.
3. Morris Mano, 'Digital Design', PHI, 3<sup>rd</sup> Edition, 2005.
4. J. Bhaskar, 'Verilog HDL Primer', BPB publications, 2000.

**Reference Books:**

1. Samuel C.Lee, 'Digital circuits and logic design', PHI, 2001.

**COURSE OUTCOMES:**

On completion of the course the students would be able to:-

1. To understand the insights of the finite state machines.
2. To appreciate and classify the programmable logic devices and FPGA.
3. To design the logic circuits using VHDL.
4. To develop the systems using Verilog HDL.
5. To test the circuits for different faults.

## EE027 LOW POWER MICROCONTROLLER

<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
3	0	0	3

**Course Objectives:** To enrich the student with the concepts of low power microcontroller, its architecture, peripherals and applications.

**Prerequisites:** Essentials of Electronic devices, circuits, Digital systems, Microprocessor basics.

Introduction - Motivation for MSP430 microcontrollers – Low Power embedded systems, Main characteristics of a MSP430 microcontroller, Main features of the MSP430X RISC CPU architecture, Address space, Interrupt vector table, Flash/ROM, Information memory (Flash devices only), Boot memory (Flash devices only), RAM, Peripheral Modules, Special Function Registers (SFRs), Central Processing Unit (MSP430 CPU), Arithmetic Logic Unit (ALU), MSP430, CPU registers, Central Processing Unit (MSP430X CPU), MSP430X CPU registers.

Addressing modes & Instruction set- Double operand instructions, Single operand instructions, Program flow control – Jumps, Emulated instructions and programming.

Device Systems and Operating Modes- system reset, system clock, interrupt management, WDT, WDT+, Basic Timer, Capture/Compare blocks, Timer\_A Interrupts, Timer\_B special features, Real Time Clock (RTC).

On-Chip Peripherals and General Purpose I/O- Hardware multiplier, ADC, DAC, SD16, LCD, DMA, Registers, Interruptible ports, Flashing LED, Blinking the LED, toggle the LED state by pressing the push button, Enable / disable LED blinking by push button.

Communications: Communications system model, Transmission mode, Synchronous and asynchronous serial communications, Serial Peripheral Interface (SPI) communication protocol, MSP430 communications interfaces, Case Studies of applications of MSP430.

### Text Books:

1. John H Davies, "MSP430 Microcontroller Basics", Newnes Publications, 2008
2. Chris Nagy, "Embedded systems Design using TI MSP430 Series", Newnes, 2003.

### Reference Books:

*Teaching MSP430, Manual from Texas Instruments.*

### COURSE OUTCOMES:

Upon completion of the course the students would be able to

1. Understand the architecture of MSP 430 Microcontroller.
2. Appreciate the different Addressing modes and Instruction set.
3. Identify the device systems and operating modes of MSP 430.
4. Utilize the on-chip peripherals and I/O pins of MSP 430.
5. Construct the applications of MSP 430 and understand the communication interfaces.

## EE088 AIRCRAFT ELECTRONIC SYSTEMS

<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
3	0	0	3

**Course** To inculcate the habit of applying theory in practical electronic systems.

**Objectives:**

**Prerequisites:** Essentials of Digital Electronics and system design

Basic flight instruments – Electronic flight instrument systems – primary flight display – navigation display – Display processor unit - Electronic attitude and direction indicator (EADI) – Electronic Horizontal situation indicator (EHSI) – Multi-function processor unit.

Electronic centralized aircraft Monitor - Engine indicating and crew alerting system - Flight management system – cockpit layouts.

Electrostatic sensitive devices (ESD) – Different devices and its features - tribo-electric series – handling and transporting ESDs - Electromagnetic compatibility – EMI generation – EMC and avionics equipment – spectrum analysis.

Airframe control and indicating systems - Landing gear - Trailing edge flaps - Control surfaces - Electronic indicating systems – Terrain awareness warning systems

Flight data and cockpit voice recorders - Health and usage monitoring system (HUMS) - Aircraft Communication Addressing and Reporting System - Fly-by-wire (FBW).

**Text Books:**

1. Mike Tooley, 'Aircraft Digital Electronic and Computer Systems: Principles, Operation and Maintenance', 1<sup>st</sup> Edition, Elsevier, 2007.
2. Mike Tooley and David Wyatt, 'Aircraft Electrical and Electronic Systems: Principles, operation and maintenance', Elsevier, 2009.

**Reference Books:**

*IEEE Guide for Aircraft Electric systems, 1976.*

**COURSE OUTCOMES:**

On completion of the course the students would be able to:-

1. To understand the insights of the flight instruments.
2. To appreciate and classify the monitoring and management systems.
3. To differentiate electrostatic and electromagnetic effects.
4. To list the control and indicating systems in aircraft.
5. To enrich about recording and reporting systems in aircraft.



**EE089 APPLIED SIGNAL PROCESSING**

<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
3	0	0	3

**Course** To inculcate the habit of applying theory in practical signal processing in real time systems.

**Objectives:**

**Prerequisites:** Essentials of signals and systems, signal processing

Speech processing in a cell phone conversation - Linear predictive processing of speech – LP model of speech - LP estimation algorithm - LP processing in practice - Linear predictive coders.

Bits played back in an Audio CD - Delta–sigma modulation - Uniform quantization: Bits vs. SNR - Conventional DACs - Oversampling DACs – Noise shaping - Delta–sigma DACs.

Sound processed in a MP3 player - Sub-band and transform coding - Perfect reconstruction filters- Filter banks and lapped transforms - masking properties of the human ear - Audio coders.

Compression of Digital TV programs for broadcasting - Motion estimation - Motion estimation: The block matching algorithm - specificities of video coding standards.

Acoustic echo cancellation - internet phone – guidance and navigation systems – case studies on other real time systems.

**Text Books:**

1. *Thierry Dutoit · Ferran Marqués, 'Applied Signal Processing: A MATLAB-Based Proof of Concept', Springer, 2009.*

**Reference Books:**

1. *Dimitris G. Manolakis and Vinay K. Ingle, 'Applied Digital Signal Processing', Cambridge University press, 2011.*
2. *V. Udayashankara, 'Real time Digital Signal Processing', PHI, 2010.*

**COURSE OUTCOMES:**

Upon completion of the course, the students will be able to

1. To appreciate the speech processing technique in cell phones.
2. To understand the bits processed in audio CD.
3. To identify the concepts of sound processed in MP3 player.
4. To determine the compression technique used in Digital TV programs.
5. To enrich about different real time signal processing systems.

## EE041 ARTIFICIAL NEURAL NETWORKS

<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
3	0	0	3

**Course** To learn the fundamentals of ANN and its application to electrical system.

### Objectives:

**Prerequisites:** Engineering Mathematics, Introduction to EEE.

Objectives-History-Biological Inspiration- Neuron Model- Single-Input Neuron-Multi- Input Neuron-Network Architectures- A Layer of Neurons-Multiple Layers of Neurons.

Perceptron Architecture- Single-Neuron Perceptron- Multi-Neuron Perceptron- Perceptron Learning Rule- Constructing Learning Rules-Training Multiple-Neuron Perceptron.

Simple Associative Networks-Unsupervised Hebb Rule- Hebb Rule with Decay-Instar Rule- Outstar Rule-Kohonen Rule.

Adaline Network – Madaline Network – Mean Square Error- LMS Algorithm- Back Propagational Neural networks–Hopfield Networks.

Adaptive Filtering-Adaptive Noise Cancellation-Forecasting–Neural control applications–Character recognition.

### Text Books:

1. Hagan, Demuth, Beale, 'Neural Network Design', PWS Publishing Company, 1<sup>st</sup> Edition, 2002.
2. Freeman, J.A and Skapura, D.M., 'Neural networks - Algorithms, applications and programming techniques', Addison Wesley Publications, Digitized Reprint(2007), 1991.

### Reference books:

1. Satish Kumar, 'Neural Networks–A classroom approach', Tata McGraw-Hill Publishing Company Limited, 2013

### COURSE OUTCOMES:

Upon completion of the course students will be able to

1. Describe the development of artificial neural networks (ANN) and classify various ANN models.
2. Solve and design various ANN models.
3. Apply and construct ANN models to various applications of electrical systems.

## EE042 FUZZY SYSTEMS AND GENETIC ALGORITHMS

<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
3	0	0	3

### Course

### Objectives:

- This course is designed to expose students to fuzzy methods of analyzing problems which involve incomplete or vague criteria rather than crisp values. The course investigates requirements analysis, logical design, and technical design of components for fuzzy systems development.
- The subject is primarily concerned with the definitions and concepts associated with a fuzzy set, Fuzzy reasoning, Fuzzy design and Fuzzy logic applications. The course also introduces Neuro-Fuzzy systems, Fuzzy Genetic Algorithms.

### Prerequisites:

Fundamentals of control systems.

Different faces of imprecision – inexactness, ambiguity, undecidability, Fuzziness and certainty, Fuzzy sets and crisp sets.

Intersections of Fuzzy sets, Union of Fuzzy sets the complement of Fuzzy sets-Fuzzy reasoning..

Linguistic variables, Fuzzy propositions, Fuzzy compositional rules of inference- Methods of decompositions and defuzzification.

Methodology of fuzzy design - Direct & Indirect methods with single and multiple experts, Applications -Fuzzy controllers – Control and Estimation.

Genetic Algorithms- basic structure-coding steps of GA, convergence characteristics, applications.

### Text Books:

1. *Zimmermann H.J., 'Fuzzy set theory and its applications', Springer Pvt Limited, 4<sup>th</sup> edition, 2012.*
2. *Timothy J. Ross, 'Fuzzy Logic with Engineering Applications', John Wiley & Sons Ltd Publications, 3<sup>rd</sup> edition, 2010.*
3. *M. Mitchell, 'Introduction to Genetic Algorithms', Indian reprint, MIT press Cambridge, 2<sup>nd</sup> edition, 2002.*

### References:

1. *John Yen, Reza Langari, 'Fuzzy Logic, Intelligence, Control & Information', Pearson Education Inc., 1<sup>st</sup> edition, 2002.*
2. *Zdenko Kovacic, Stjepan Bogdan, 'Fuzzy Controller Design Theory and Applications', CRC Press, 1<sup>st</sup> edition, 2006.*
3. *Riza C. Berkaan, Sheldon L. Trubatch, 'Fuzzy Systems Design Principles – Building Fuzzy IF THEN Rule Based', IEEE Press, 1<sup>st</sup> edition, 1997.*

### COURSE OUTCOMES:

Upon the completion of the course, the students will be able to

1. Understand the fundamentals of Fuzzy logic theory.
2. Apply and analyse the concept to existing systems.
3. Design Fuzzy logic Systems for engineering applications

## EE043 INDUSTRIAL AUTOMATION

L	T	P	C
3	0	0	3

**Course Objectives:** The contents aim to develop the knowledge of the student in the field of automation in industries. This will be comprising knowledge of PLC, DCS and SCADA Systems. They will also get familiar with different industrial standard protocols.

**Prerequisites:** Basic knowledge of Control systems and Electrical and electronics measurement

Introduction to process control: Process Control block Diagram, Control System Evaluation, and Digital Control: Supervisory Control, Direct Digital Control, Networked Control Systems, and Distributed Digital Control. Smart Sensor. Definitions of the terms used to describe process control. Data Acquisition Systems: DAS Hardware, DAS Software. Data Logger.

Controller Principles: Process Characteristics: Process Equation, Process Load, Process Lag, Self-Regulation. Control System parameters: Error, Variable Range, Control parameter Range, Control Lag, Dead Time, Cycling, Controller Modes. Discontinuous Controller Mode: Two Position Mode, Multiposition Mode, Floating Control Mode. Continuous Control Mode: Proportional Control Mode, Integral Control Mode, Derivative Control Mode. Composite Control Modes: PI Control, PD Control, PID Control

Analog Controllers: Introduction, Electronic Controllers: Error Detector, Single Controller Modes, Composite Controller Modes. Pneumatic Controllers: General features, Mode Implementation.

Programmable Logic Controller: Evaluation of PLC, PLC Architecture, Basic Structure. PLC Programming: Ladder Diagram – Ladder diagram symbols, Ladder diagram circuits. PLC Communications and Networking, PLC Selection: I/O quantity and Type, Memory size and type, Programmer Units. PLC Installation, Advantages of using PLCs.

Distributed Control System: Introduction, Overview of Distributed Control System, DCS Software configuration, DCS Communication, DCS Supervisory Computer Tasks, DCS Integration with PLCs and Computers, Features of DCS, Advantages of DCS.

### Text Books:

1. C.D. Johnson, 'Process Control Instrumentation Technology', PHI, 8<sup>th</sup> edition, 2013
2. S.K. Singh, 'Computer Aided Process Control', PHI, 2004

### Reference books:

1. Noel M. Morris., 'Control Engg', McGraw-Hill, 4<sup>th</sup> edition, 1992
2. Thomas E. Kissell, 'Industrial Electronics', PHI, 3<sup>rd</sup> edition, 2003
3. Lukcas M.P., 'Distributed control systems', Van Nostrand Reinhold co, illustrated.
4. Huges T, 'Programmable Controllers', ISA press, 4<sup>th</sup> edition, 1994.
5. A.K. Ghosh, 'Introduction to Instrumentation & Control', Eastern Economy Edition
6. George C. Barney, 'Intelligent Instrumentation', Prentice Hall India

### COURSE OUTCOMES:

Upon completion of the subject, students will be able to:

1. Implement low cost automation systems using pneumatic and electrical means.
2. Learn about the modern techniques and devices used for the monitoring and control of manufacturing systems including programming of programmable logic controllers and their interfacing with various sensors and actuators.
3. Design automated assembly system for industrial applications.

**EE044 OPERATION RESEARCH**

<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
3	0	0	3

**Course Objectives:** To equip students to identify and formulate real life problems using mathematical modeling; devise a solution procedure; analyze and interpret the results; revise for the process based on the actual results

**Prerequisites:** Knowledge of differential and integral calculus, matrix analysis, differential equations and algebraic system of equations

Linear Programming: Basic concepts – Mathematical formulation of L.P.P – Graphical solution – simplex method – Charnes' Big-M method – Two-phase method – Dual simplex method

Dual Theory Transportation and Assignment problems: Dual formulation of primal L.P.P and its solution – Transportation problem – Assignment problem – Travelling salesman problem

Integer programming and CPM-PERT: Gomory's method – Branch and bound technique – Critical path in networks – CPM – Time and Cost aspects in networks - PERT

Queueing Theory and Inventory models: Classification of queues – Poisson arrivals – Exponential service time – M/M/1 and M/M/c models – Inventory control – E.O.Q. with uniform demand, with finite rate of replenishment and with shortage – Buffer stock – Inventory with price breaks – Basic probabilistic models

Dynamic programming: Recursive equation approach – applications to shortest path network, Inventory and production control – solution of LPP by dynamic programming

**Text Books:**

1. Hamdy A. Taha, 'Operation Research – An Introduction', Person Education, 9<sup>th</sup> Edition, 2014

**References:**

1. Gass, S.I., 'Linear Programming: methods and applications', McGraw Hill Ltd, 1975.
2. Hillier, F.S., and Lieberman, G.J., 'Operation Research', McGraw Hill Ltd, 9<sup>th</sup> edition, 2009.
3. Wagner, 'Principles Of Operations Research, With Applications To Managerial Decisions', Prentice Hall, 2<sup>nd</sup> Edition, 2009.
4. Gillet, M.N., 'Introduction to Operation Research', Tata McGraw Hill Education Pvt Ltd, 1<sup>st</sup> edition, 2010

**COURSE OUTCOMES:**

Upon completing the course, the student will be able to

1. Increase the analytical skill of identifying and solving engineering problems.
2. Optimizing the resources and input-output process.
3. Devising new techniques for the better understanding of real life situation.

## EE090 MODERN CONTROL SYSTEMS

<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
3	0	0	3

**Course Objectives:** Apply modern control techniques to electrical systems.

**Prerequisites:** Basic control systems, Linear algebra

Review of state space analysis - state variable systems - controllability and observability - State variable feedback and its effect on controllability and observability-elements of observer theory.

Common types of non- linear phenomena – linearization -singular points- phase plane method - construction of phase trajectories- describing functions.

Basic concepts-derivation of describing functions-stability of non- linear systems by describing function method- Liapunov's method of stability studies- Popov's criterion.

Pole placement technique by state feedback for linear SISO time invariant system–Design of state observers and servo system.

Optimal control, adaptive control, robust control and intelligent control methods-Introduction to distributed control systems.

### Text Books:

1. Chi-Tsong Chen, 'Linear System Theory and Design', Oxford University Press, 4<sup>th</sup> Edition, 2012.
2. Khalil H.D., 'Nonlinear Systems', Prentice Hall Publications, 3<sup>rd</sup> Edition, 2003.

### Reference books:

1. Stanley M. Shiner, 'Modern Control System theory and Design', John Wiley and Sons Publications, 2<sup>nd</sup> Edition, 1998.
2. Ogata K. 'Modern Control Engineering', Prentice Hall Publications, 5<sup>th</sup> Edition, 2010.

### COURSE OUTCOMES:

Upon completion of the course, the students will be able to

1. Understand the concepts of modern control theory using state- space approach.
2. Compare and analyse the classical control system with modern control system.
3. Develop advanced controllers to the existing system using modern control design techniques.

**EE091 DIGITAL CONTROL SYSTEMS**

L	T	P	C
3	0	0	3

**Course** To learn the digital control design techniques.

**Objectives:**

**Prerequisites:** Classical Control Systems, Modern Control systems

Introduction- Comparison between analog and digital control-Importance of digital control- Structure of digital control- Examples of digital control system- Difference equations- Z-transform- MATLAB examples. Frequency response of discrete time systems- Properties of frequency response of discrete time systems-Sampling theorem.

ADC model- DAC model- Transfer function of zero order hold- DAC, Analog Subsystem, and ADC Combination Transfer Function-Closed loop transfer function- Steady state error and its constants (MATLAB commands).

Definitions of stability (Asymptotic stability, exponential stability etc)-stable z-domain pole placement locations- stability conditions-Stability determination (Routh array)-Nyquist criterion.

Root locus- root locus design (p-control, Pi-control, pd)- Z-domain root locus- z-domain root locus design-digital implementation of analog controller design (differencing methods forward and backward)- bilinear transformation-direct z-domain controller design-frequency response design-Finite time response settling time.

Concept of state space method-state space representations of discrete time systems- solving discrete time state space equations- Pulse transfer function matrix- Discretization of continuous state space equations- Liapunov stability analysis( discrete time) Controllability-observability-design Via pole placement-state observers.

**Text Books:**

1. Kannan M. Moudgalya, 'Digital Control', Wiley Publishers, 1<sup>st</sup> illustrated edition, 2007.
2. M.Gopal, 'Digital Control engineering', New Age International (ltd) Publishers, 1<sup>st</sup> edition reprint(2003), 1998.

**Reference books:**

1. M. Sam Fadalli, 'Digital Control Engineering Analysis And Design', Elsevier publication, 1<sup>st</sup> edition, 2012.
2. Katsuhiko Ogata, 'Discrete Time Control Systems', Pearson Education Publications, 2<sup>nd</sup> edition, 2005.

**COURSE OUTCOMES:**

Upon completion of this course, the students can

1. Understand the fundamental differences between continuous time control and digital control.
2. Analyse the advantages of digital control over the continuous time control.
3. Develop digital controllers explicitly compared to continuous time controller.

## EE092 NON-LINEAR CONTROL SYSTEMS

<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
3	0	0	3

**Course Objectives:** The aim of this course is to introduce the concept of non-linear controller design to the undergraduate student.

**Prerequisites:** Linear Electrical Control systems

Open and closed sets, compact set, dense set, Continuity of functions, Lipschitz condition, smooth functions, Vector space, norm of a vector, normed linear space, inner product space.

Mathematical modeling of simple mechanical and electrical systems, concept of equilibrium points, isolated equilibrium points and limit cycles.

Stability analysis of nonlinear systems – Lyapunov stability, asymptotic stability, relative stability, finite-time stability and exponential stability. Lasalles invariance principle

Feedback linearization- dynamic feedback linearization, flatness and back stepping controllers design

Sliding mode controller design, Lyapunov redesign and energy based controller design

### Text Books:

1. Khalil H.K., 'Nonlinear Systems', Prentice Hall, 3<sup>rd</sup> edition, 2001.
2. Vidyasagar M., 'Nonlinear System Analysis', Prentice Hall, 2<sup>nd</sup> edition, 2002.

### Reference Books:

1. J.-J. E. Slotine and W. Li, 'Applied Nonlinear Control', Prentice Hall, Englewood Cliffs, NJ, 1991.
2. Zhihua Qu, 'Robust Control of Nonlinear Uncertain Systems', John Wiley & Sons, Interscience Division, New York, NY, 1998.
3. A.Isidori, 'Nonlinear Control Systems', Communications and Control Engineering, Springer-Verlag, Third Edition, 1995.
4. H. Nijmeijer and A. J. van der Schaft, 'Nonlinear Dynamical Control Systems', Springer-Verlag, New York, 1990.

### COURSE OUTCOMES:

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

1. Understand the concept of non-linear control system
2. Analyze the stability of non-linear system
3. Design non-linear controller for electrical system