# Electrical Engineering

**Semester -VII**

**Branch: Electrical Engineering**

| S.N. | Code | Course Title | Lecture | Tutorial | Practical | Credits |
|---|---|---|---|---|---|---|
| 1 | ELC701 | Protection of Power Apparatus Sy | 3 | 0 | 0 | 3 |
| 2 | PEC-III | **Professional Elective-III** | 3 | 0 | 0 | 3 |
| 3 | PEC-IV | **Professional Elective-IV** | 3 | 0 | 0 | 3 |
| 4 | OEC III | **Open Elective-III** | 3 | 0 | 0 | 3 |
| 5 | OEC VI | **Open Elective-IV** | 3 | 0 | 0 | 3 |
| 6 | EL701P | Power System Protection | 0 | 0 | 2 | 1 |
| 7 | EL702D | Project Part - I | 0 | 0 | 4 | 2 |
| 8 | EL703I | Internship Assessment | 0 | 0 | 2 | 2 |
| **Total credits** | | | | | | 20 |

| Code | Professional Elective-III (Any one) | Code | Professional Elective-IV (Any one) |
|---|---|---|---|
| ELP702 | Electrical Drives and Control | ELP706 | High Power Converters |
| ELP703 | Utilization of Electrical Power | ELP707 | HVDC Transmission and FACTS |
| ELP704 | Power System Dynamics and Control | ELP708 | Smart Grid Technology |
| ELP705 | Power Quality | ELP709 | Electrical and Hybrid Vehicles |

| Code | Open Elective-III (Any one) | Code | Open Elective-IV(Any one) |
|---|---|---|---|
| ELO710 | Soft Optimization Techniques | ELO713 | Digital Signal Processing |
| ELO711 | Illumination Technology | ELO714 | Energy Storage Systems |
| ELO712 | Process Instrumentation and Control | ELO715 | Electrical machine and Power Systems* |

* Not for EE Students

**Semester -VIII**

**Branch: Electrical Engineering**

| S.N. | Code | Course Title | L | T | P | Credits |
|---|---|---|---|---|---|---|
| 1 | EL801D | Project-II | | | 16 | 08 |
| | | | | | **Total Credits** | 08 |

**NOTE- A Student can be allowed to do project outside after the permission of departmental Academic Committee. Those students doing project outside has present their project progress every month. Those students doing project outside can be permitted to present progress every fortnight though video conferencing. Students doing project in house has present their project progress every week.**

**ELECTRICAL ENGINEERIG**

| Electrical Engineering | | | |
|---|---|---|---|
| **ELC701** | **Protection of Power Apparatus and System** | **L** | **T** |
| | | **3** | **0** |

**Course Outcomes:**

After successful completion of the course students will be able to:

| |
|---|
| CO1: **Analyze** the need of power system protection and **classify** the different types of relay and their operating principle. |
| CO2: **Distinguish** the difference between the distribution line protection and transmission line protection. |
| CO3: **Explain** the protection of generator, busbar and transformer and its limitations. |
| CO4**: Select** the different kind of circuit breaker based on their application. |
| CO5: **Choose** different type of protective devices against overvoltage as well as for earthing purpose. |

**CO-PO Mapping Matrix:**

Enter correlation levels 1, 2 or 3 as defined below-

1. Slight (low) 2. Moderate (Medium) 3. Substantial (High)

| COs/POs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | | 2 | | | | | | | | 1 |
| CO2 | 3 | 2 | | 2 | | | | | | | | 1 |
| CO3 | 2 | 1 | | 2 | | | | | | | | 1 |
| CO4 | 3 | 3 | | 3 | | | | | | | | 1 |
| CO5 | 3 | 3 | | 2 | 3 | | | | | | | 1 |
| Avg. | **2.8** | **2.4** | | **2.2** | **3** | | | | | | | **1** |

## DETAILED SYLLABUS

**Module – I** **(5 Lectures)**

Basic concept & components of power system protection, types of relays-their operating principles, characteristics and their uses, Introduction to static relays and its advantages over electromagnetic relays.

**Module – II** **(8 Lectures)**

Protection of Alternators: Protection of generators against Stator faults, Rotor faults, and abnormal Conditions. Restricted earth fault and Inter-turn fault Protection. Numerical problems on % winding unprotected.

**Module-- III** **(8 Lectures)**

Protection of transformers: Percentage Differential Protection, Numerical Problem on Design of CT's Ratio, Buchholz relay Protection.

**Module – IV** **(8 Lectures)**

Protection of Lines: Over Current, Carrier Current and Three - zone distance relay protection using Impedance relays. Translay relay. Protection of Bus bars –differential Protection.

**Module – V** **(8 Lectures)**

Theory of arc interruption, types of circuit breakers – air, air-blast, minimum oil, vacuum & SF6, resistance switching, current chopping, auto-reclosing, circuit breaker ratings.

Protection against lightning over voltages - valve type and zinc - oxide lighting arresters,

**Module – VI** **(5 Lectures)**

Grounded and ungrounded neutral systems, methods of neutral grounding: solid, resistance, reactance, resonant grounding.

**Text Books**

[1]. Badri Ram, D. Vishwakarma, “Power System Protection and Switchgear”, McGraw Hill, 2nd Edition.
[2]. Y.G. Paithankar, S.R. Bhide, “Fundamentals of Power System Protection”, PHI, 2nd Edition
[3]. BhuvaneshOza, Nirmal-Kumar Nair, Rashesh Mehta, Vijay Makwana, “Power System Protection & Switchgear, McGraw Hill, 1st Edition.

**Reference Books**

[1]. Stanley H. Horowitz, Arun G. Phadke, James K. Niemira, “Power System Relaying”, Wiley, 4th Edition.
[2]. R. van C. Warrington, “Protective Relays Their Theory and Practice”, Springer, 1st Edition.

| Electrical Engineering | | | |
|---|---|---|---|
| **ELP702** | **Electrical Drives and Control** | **L** | **T** |
| | | **3** | **0** |

**Course Outcomes:** After successful completion of the course students will be able to:

**COs-POs Mapping:**
Enter correlation levels1, 2 or 3 as defined below-

1. Slight (low) 2. Moderate (Medium) 3. Substantial (High)

| COs/POs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 3 | 3 | | 1 | | | | | | | | 1 |
| **CO2** | 3 | 3 | 1 | 1 | | | | | | | | 1 |
| **CO3** | 3 | 3 | 2 | 1 | | | | | | | | 1 |
| **CO4** | 3 | 3 | 3 | 1 | | | | | | | | 1 |
| **CO5** | 3 | 3 | 3 | 1 | | | | | | | | 1 |
| **Avg.** | **3** | **3** | **2.25** | **1** | | | | | | | | **1** |

## DETAILED SYLLABUS

**Module – I: Introduction to Electrical Drives (9 Lectures)**
Concept, classification, parts and advantages of electrical dives. Types of Loads, Components of load toques, Fundamental torque equations, Equivalent value of drive parameters for loads with rotational and translational motion. Determination of moment of inertia, Multi quadrant operation of drives. Load equalization.

**Module – II: Starting and Braking of Electrical Drives (9 Lectures)**
Effect of starting on Power supply, motor and load. Methods of stating of electric motors. Acceleration time Energy relation during stating, methods to reduce the Energy loss during starting. Types of braking, braking of DC motor, Induction motor and Synchronous motor, Energy loss during braking.

**Module – III: Solid State Speed Control of DC Motor (7 Lectures)**
Single phase, three phases fully controlled and half controlled DC drives. Dual converter control of DC drives. DC chopper drives.

**Module – IV: Solid State Speed Control of Induction Motor (7 Lectures)**

Speed control of three phase induction motor – Voltage control, voltage / frequency control, slip power recovery scheme – Using inverters and AC voltage regulators – applications, Static Scherbius drive, Static Kramer drive.

**Module-V: Synchronous Motor Drive (10 Lectures)**

Synchronous motor V/f control, Cycloconverter control, self-controlled synchronous motor drive. Drive consideration for Textile mills, Steel rolling mills, Cement mills, Paper mills, Machine tools. Cranes & hoist drives.

**Text Books**


[1]. Fundamental of Electrical Drives, G.K. Dubey, New Age International Publication.

[2]. Electric Drives, Vedam Subrahmanyam, TMH

[3]. A first course on Electrical Drives, S.K. Pillai, New Age International Publication.


**Reference Books**


[1]. Electric motor drives, R. Krishnan, PHI

[2]. Modern Power Electronics & Ac drives, B.K. Bose, Pearson Education.

[3]. Electric Motor & Drives. Austin Hughes, Newnes.

| Electrical Engineering | | | |
|---|---|---|---|
| **ELP703** | **Utilization of Electrical Power** | **L** | **T** |
| | | **3** | **0** |

**Course Outcomes:**
After successful completion of the course students will be able to:

| CO's | CO Description |
|---|---|
| CO1 | **Classify electric** drives and their specific application in industry. |
| CO2 | **Explain** the operation of electric traction, energy consumption and it's advantages. |
| CO3 | **Make use of** electric heating based on induction principle. |
| CO4 | **List** different light sources and illumination parameters. |
| CO5 | **Demonstrate** electrolytic process and **design** motor control circuit. |

**CO's-PO's Mapping Matrix:**
Enter correlation levels 1, 2 or 3 as defined below

1. Slight (low) 2. Moderate (Medium) 3. Substantial (High)

| COs/ POs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 3 | 2 | 2 | 2 | 3 | | | | | | | 1 |
| **CO2** | 3 | 2 | 2 | | | | 2 | | | | | 1 |
| **CO3** | 3 | 2 | 2 | | 2 | | | | | | | 1 |
| **CO4** | 3 | 2 | 2 | | | | | | | | | 1 |
| **CO5** | 3 | 2 | 2 | 2 | 2 | | | | | | | 1 |
| **Avg.** | **3** | **2** | **2** | **2** | **2.33** | | **2** | | | | | **1** |

## DETAILED SYLLABUS

**Module I: Industrial Drives** **(12 Lectures)**

Characteristics of electrical motors and their particular application for industrial drives. Motor enclosures, bearing, transmission of drives, choice of motor, motor used for lifts, cranes and general purpose machines, typical application in sugar, textile, paper and steel industries. Motors used in mining operations, rating of electric motors, calculation of size load equation of flywheels electric breaking; plugging, dynamic and regenerative breaking, breaking current, torque, speed time curves (number of revolutions made before stop)

**Module II: Electrical Traction** **(10 Lectures)**

General features and systems of track electrification, Tractive effort calculation of traction motors, traction motor control (series-parallel control).

Track equipment and collection gear, train movement, speed-time curve, Specific Energy Consumption (SEC) and factors affecting it.

**Module III: Electric Heating** **(5 Lectures)**

Introduction – Classification of methods of electric heating – Requirements of a good heating material – Design of heating element – Temperature control of resistance furnace – Electric arc furnace – Induction heating.

**Module IV: Welding and Illumination** **(13 Lectures)**

Dielectric heating – Electric welding – Resistance welding – Electric arc welding. Sources of light, incandescent and fluorescent lamps, Lighting Fittings, reflection factor illumination, calculation, solid angle, candle power, units of light and illumination, power curves, M. H. C. P and M. S. C. P. Illumination level and its measurement coefficient of utilization, waste light factor, illumination calculations for building and playgrounds, flood lighting, industrial lighting, Street lighting.

**Module V** **(2 Lectures**)

Electrolytic process and motor control circuit

**Text Books:**

[1]. "A first course on Electric Drives", S.K.Pillai, Wiley Eastern Ltd.
[2]. "Utilization of Electrical Energy", (S.I. Units), E.Open Shaw Taylor and V.V.L.Rao, Orient Long man.
[3]. "Generation, Distribution and Utilization of Electrical Energy", C.L. Wadhwa; Wiley Eastern Ltd.

| Electrical Engineering | | | |
|---|---|---|---|
| **ELP704** | **Power System Dynamics and Control** | **L** | **T** |
| | | **3** | **0** |

**Course Outcomes:**

After successful completion of the course student will be able to:

| COs | CO Description |
|---|---|
| CO1 | **Outline** basic concepts of synchronous machine and its modeling |
| CO2 | **Model** excitation systems, prime-mover, transmission line and load |
| CO3 | **Apply** the concept of equal area criteria and critical clearing angle to transient stability of the machine. |
| CO4 | **Explain** various methods for transient stability improvement |
| CO5 | **Classify** voltage stability and outline its modeling requirements |

**CO's-PO's Mapping Matrix:**

Enter correlation levels1, 2 or 3 as defined below-

1. Slight (low) 2. Moderate (Medium) 3. Substantial (High)

| COs/POs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 2 | 1 | | | | | | | | | | 1 |
| **CO2** | 2 | 2 | | | | | | | | | | 1 |
| **CO3** | 2 | 2 | 2 | | | | | | | | | 1 |
| **CO4** | 2 | 1 | 1 | | | | | | | | | 1 |
| **CO5** | 2 | 2 | | | | | | | | | | 1 |
| **Avg.** | **2** | **1.6** | **1.5** | | | | | | | | | 1 |

## DETAILED SYLLABUS

**Module I** **(12 Lectures)**

A review of synchronous machine (cylindrical rotor and salient pole), Equations, Phasor diagrams under steady state and transient condition.

Meaning of stability in power system, explanation of steady state and transient stability, development of swing equations for a multi machine system; assumptions generally made for solution of swing equation**.**

**Module II** **(10 Lectures)**

Synchronous machine modeling: sub- transient model , two axis model , one axis (flux decay) model , classical model .

Excitation systems modeling: DC excitation, AC excitation and static excitation. Prime mover and energy supply systems modeling. Transmission line modeling, load modeling.

**Module III** **(10 Lectures)**

Equal area criterion for a two machine system without and including transmission losses; pre-determined swing curves; application of equal area criteria to understand the effect of various factors on transient stability limit. equal area criterion, critical clearing angle, application of critical clearing angle to transient stability of synchronous machine.

**Module IV** **(5 Lectures)**

Methods of improving transient stability: reducing fault clearance time, automatic reclosing, single phase reclosing, electric braking, voltage regulators, fast governor action, high speed excitation system.

**Module V** **(5 Lectures)**

Classification of voltage stability, modeling requirement s of voltage stability analysis: static and dynamic, sensitivity analysis, modal analysis, voltage collapse, prevention of voltage collapse.

**Text Books:**

[1]. P. Kundur, 'Power System Stability and Control', McGraw Hill Inc, New York, 1995.
[2]. Edward Wilson Kimbark, "Power System Stability, Volumes I, II, III," Wiley-IEEE Press, 1995.

**Reference Books:**

[1]. K.R.Padiyar, "Power System Dynamics, Stability & Control", 2nd Edition, B.S. Publications, Hyderabad, 2002.
[2]. P.Sauer&M.A.Pai, "Power System Dynamics & Stability", Prentice Hall, 1997.

| Electrical Engineering | | | |
|---|---|---|---|
| **ELP705** | **Power Quality** | **L** | **T** |
| | | **3** | **0** |

**Course Outcomes:**
After successful completion of the course students will be able to:

| COs | CO Description |
|---|---|
| CO1 | To understand the various power quality issues. |
| CO2 | Evaluate the power quality indices used in industrial power system. |
| CO3 | Understand various mitigation techniques for compensating devices to improve the power quality. |
| CO4 | Simulate the compensating devices to improve the power quality |

**CO's-PO's Mapping Matrix:**

Enter correlation levels1, 2 or 3 as defined below-

1. Slight (low) 2. Moderate (Medium) 3. Substantial (High)

| COs/POs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 2 | - | - | - | - | - | 2 | 1 | - | 1 | - | 2 |
| **CO2** | 2 | - | 3 | 2 | - | 2 | - | - | - | - | - | - |
| **CO3** | 2 | 3 | - | 2 | 3 | 2 | 2 | - | - | - | - | - |
| **CO4** | - | 3 | - | 3 | 3 | 2 | | - | 2 | - | - | 2 |
| **Avg.** | **2** | **3** | **3** | **2.33** | **3** | **2** | **2** | **1** | **2** | **1** | **-** | **2** |

## DETAILED SYLLABUS

**Module - I: Overview of Power Quality** **(10 Lectures )**
Classification of power quality issues, characterization of electric power quality, power acceptability curves – power quality problems: poor load power factor, non linear and unbalanced loads, dc offset in loads, notching in load voltage, disturbance in supply voltage, flicker, transient phenomenon, voltage fluctuations, sags/swells, voltage unbalance, power quality indices, distortion index, C-message index, IT product, IEEE guides and recommended practices.

**Module- II: Measurement and Analysis Methods** **(8 Lectures)**
Voltage, current, power and energy measurements, power factor measurement and definitions, time domain methods, Instantaneous Reactive Power Theory, Synchronous Frame Theory, Synchronous Detection Method, instantaneous symmetrical components, Instantaneous real and reactive powers

**Module- III: Harmonics & Voltage Fluctuations** **(8 Lectures)**
Sources and effect of harmonics and inter harmonics, voltage fluctuations, flicker and impulses, flicker calculations, effect of voltage fluctuations and impulses, occurrence and causes of voltage unbalance, standardization, decomposition into symmetrical components.

**Module IV: Power Quality Improvement-I** **(8 Lectures)**

**U**tility- Customer interface, harmonic filter: passive, active and hybrid filter, compensation using shunt devices-DSTATCOM, voltage regulation using DSTATCOM, principle, working and construction, algorithms for control of DSTATCOM, some case study examples.

**Module V: Power Quality Improvement-II** **(8 Lectures)**

Series compensation, protecting sensitive loads using DVR, principle, working construction and control schemes for DVR, hybrid devices –UPQC, principle, working and construction, some case study examples.

**Text /reference Books:**


[1]. Power Quality Enhancement Using Custom Power Devices, Arindam Ghosh, Gerard Ledwich, Springer, 2009

[2]. Power Quality: VAR Compensation in Power Systems R. Sastry Vedam, Mulukutla S. Sarma, CRC Press, 2008

[3]. Understanding Power Quality Problems: Voltage Sags and Interruptions, Math H.J. Bollen, Wiley India Pvt Ltd, 2011.

[4]. Power Quality: Mitigation Technologies in a Distributed Environment,A Moreno Munoz, Springer India Private Limited 2007.

[5]. Power System Quality Assessment J.Arrillaga, N.R.Watson, S.Chen, Wiley India Pvt Ltd, 2011.

| Electrical Engineering | | | |
|---|---|---|---|
| **ELP706** | **High Power Converters** | **L** | **T** |
| | | **3** | **0** |

**Prerequisite:** Power Electronics

**Course Outcomes:**

After successful completion of course, the students will be able to:

| COs | Description |
|---|---|
| CO 1 | **Analyze** controlled rectifier circuits. |
| CO 2 | **Explain** in basic operation and compare the performance of various power semiconductor devices and switching circuits. |
| CO3 | **Design** and **analyze** power converter circuits and learn to select suitable power electronic devices and assessing the requirements of applications field. |
| CO 4 | **Illustrate** the operation of line-commutated rectifiers–6 pulse and multi-pulse configurations. |
| CO 5 | **Explain** the operation of PWM rectifiers–operation in rectification and regeneration modes and lagging, leading and unity power factor mode. |

**CO's-PO's Mapping Matrix:**

Enter correlation levels1, 2 or 3 as defined below-

1. Slight (low) 2. Moderate (Medium) 3. Substantial (High)

| COs/POs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 3 | 1 | 1 | 2 | 1 | | | | | | | |
| **CO2** | 1 | 3 | 1 | 2 | | | | | | | | |
| **CO3** | 1 | 1 | 2 | 2 | 1 | | | | | | | |
| **CO4** | 2 | 2 | | 1 | 2 | | | | | | | |
| **CO5** | 2 | 1 | 2 | 1 | 2 | | | | | | | |
| **Avg.** | **1.8** | **1.6** | **1.5** | **1.6** | **1.5** | | | | | | | |

## DETAILED SYLLBUS

**Module I: Diode rectifiers with passive filtering (6 Lectures)**

Half-wave diode rectifier with RL and RC loads; 1-phase full-wave diode rectifier with L, C and LC filter; 3-phase diode rectifier with L, C and LC filter; continuous and discontinuous conduction, input current wave shape, effect of source inductance; commutation overlap.

**Module II: Thyristor rectifiers with passive filtering (6 Lectures)**

Half-wave thyristor rectifier with RL and RC loads; 1-phase thyristor rectifier with L and LC filter; 3-phase thyristor rectifier with L and LC filter; continuous and discontinuous conduction, input current waveshape.

**Module III: Multi-Pulse converter (8 Lectures)**

Review of transformer phase shifting, generation of 6-phase ac voltage from 3-phase ac, 6-pulse converter and 12-pulse converters with inductive loads, steady state analysis, commutation overlap, notches during commutation.

**Module IV: Single-phase AC-DC single-switch boost converter (6 Lectures)**
Review of dc-dc boost converter, power circuit of single-switch ac-dc converter, steady state analysis, unity power factor operation, closed-loop control structure.

**Module V: AC-DC bidirectional boost converter (6 Lectures)**
Review of 1-phase inverter and 3-phase inverter, power circuits of 1-phase and 3-phase ac-dc boost converter, steady state analysis, operation at leading, lagging and unity power factors. Rectification and regenerating modes. Phasor diagrams, closed-loop control structure.

**Module VI: Isolated single-phase AC-DC flyback converter (10 Lectures)**
DC-DC flyback converter, output voltage as a function of duty ratio and transformer turns ratio. Power circuit of ac-dc flyback converter, steady state analysis, unity power factor operation, closed loop control structure

**Text / References Books:**

[1]. G. De, “Principles of Thyristorised Converters”, Oxford & IBH Publishing Co, 1988.

[2]. J.G. Kassakian, M. F. Schlecht and G. C. Verghese, “Principles of Power Electronics”, Addison-Wesley, 1991.

[3]. L. Umanand, “Power Electronics: Essentials and Applications”, Wiley India, 2009.

[4]. N. Mohan and T. M. Undeland, “Power Electronics: Converters, Applications and Design”, John Wiley & Sons, 2007.

[5]. R. W. Erickson and D. Maksimovic, “Fundamentals of Power Electronics”, Springer Science &Business Media, 2001

| Electrical Engineering | | | |
|---|---|---|---|
| **ELP707** | **HVDC Transmission and Facts** | **L** | **T** |
| | | **3** | **0** |

**Prerequisite:** Power Electronics, Power System-II

**Course Outcome:-**

After successful completion of the course, the students will be able to:

| COs | CO Description |
|---|---|
| CO1 | **Compare** HVDC and EHVAC transmission systems |
| CO2 | **Analyze** converter configurations used in HVDC and evaluate the performance metrics. |
| CO3 | U**nderstand** controllers for controlling the power flow through a dc link and compute filter Parameters |
| CO4 | **Apply** impedance, phase angle and voltage control for real and reactive power flow in ac transmission systems with FACTS controller |

**CO's-PO's Mapping Matrix:**

Enter correlation levels1, 2 or 3 as defined below-

1. Slight (low) 2. Moderate (Medium) 3. Substantial (High)

| COs/ POs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 2 | 3 | - | - | 2 | 1 | 2 | 2 | - | - | - | 2 |
| **CO2** | 1 | 2 | - | 1 | 2 | 2 | 2 | - | - | - | 2 | - |
| **CO3** | - | 3 | - | 2 | 2 | - | - | - | - | - | - | 2 |
| **CO4** | - | 3 | - | 3 | 3 | 2 | 1 | - | - | - | - | - |
| **Avg.** | **1.5** | **2.75** | **-** | **2** | **2.25** | **1.67** | **1.67** | **2** | **-** | **-** | **2** | **2** |

## DETAILED SYLLABUS

**Module I: HVDC Power Transmission Technology (4 Lectures)**

Evolution of HVDC transmission, Comparison of HVDC & HVAC system, Economics of power transmission, Technical performance, Reliability, Applications of HVDC transmission, Types of HVDC transmission links, Components of Converter station, Planning for HVDC transmission, Operating problems in HVDC system.

**Module II: Analysis of HVDC converter (7 Lectures)**

Introduction, Types of converters, Line commutated converter, Analysis of Line commutated converter, Choice of converter configuration for any pulse number, Analysis of voltage source converter, Basic 2-level Graetz bridge converter, 3 level voltage source converter, Converter charts.

**Module III: HVDC System control (7 Lectures)**

Principles of HVDC control links, Converter control characteristics, Control schemes & control comparisons, Firing angle control, current & Extinction angle control, Energization & de-energization of bridges, Starting & stopping of DC links, power control. Effects of Harmonics, sources of harmonic generation, Types of filters–Design examples

**Module- IV: Flexible AC Transmission Systems (FACTS) (5 Lectures)**

FACTS concepts and general system conditions: Power flow in AC systems, Relative importance of controllable parameters, Basic types of FACTS controllers, shunt and series controllers, Current source and Voltage source converters.

**Module V: Static Shunt Compensators (8 Lectures)**

Objectives of shunt compensation, Methods of controllable VAR generation, Static Var Compensator, its characteristics, TCR, TSC, FC-TCR configurations, STATCOM, basic operating principle, control approaches and characteristics.

**Module VI: Static Series Compensators (6 Lectures)**

Objectives of series compensator, variable impedance type of series compensators, TCSC, TSSC-operating principles and control schemes, SSSC, Power Angle characteristics, Control range and VAR rating, Capability to provide reactive power compensation, external control.

**Module VII: Combined Compensators (5 Lectures)**

Introduction to Unified Power Flow Controller, Basic operating principles, Conventional control capabilities, Independent control of real and reactive power

**Text Books:**

[1]. K. R. Padiyar, “HVDC Power Transmission Systems”, New Age International Publishers, 2011

[2]. J. Arrillaga, “High Voltage Direct Current Transmission”, Peter Peregrinus Ltd., 1983.

[3]. Narain G.Honorani, Laszlo Gyugyi: Understanding FACTS –Concepts and Technology of Flexible AC Transmission Systems, Wiley-IEEE Press, 2000.

[4]. Yong Hua Song, Allan T Johns: Flexible AC Transmission Systems, The Institution of electrical Engineers, 1999.

**Reference Book:**

[1]. E. W. Kimbark, “Direct Current Transmission”, Vol.1, Wiley Inter science, 1971.

| Electrical Engineering | | | |
|---|---|---|---|
| **ELP708** | **Smart Grid Technology** | **L** | **T** |
| | | **3** | **0** |

**Course Outcomes:**

After successful completion of the course, students will be able to:

| CO's | CO Description |
|---|---|
| CO1 | **Understand** features of Smart Grid in the context of Indian Grid |
| CO2 | **Assess** the role of automation in Transmission/Distribution |
| CO3 | **Apply** Evolutionary Algorithms for the Smart Grid/Distribution Generation. |
| CO4 | **Understand** operation and importance of PMUs, PDCs, WAMS, Voltage and Frequency control in Micro Grids |

**CO's- PO's Mapping:**

Enter correlation levels1, 2 or 3 as defined below-

1. Slight (low) 2. Moderate (Medium) 3. Substantial (High)

| COs/POs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO 10 | PO 11 | PO 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | 2 | 2 | - | 1 | - | - | - | - | - | - |
| CO2 | 3 | 2 | 2 | 2 | - | 2 | - | - | 1 | - | - | - |
| CO3 | 3 | 2 | 2 | 2 | - | 2 | - | - | 2 | - | - | - |
| CO4 | 3 | 2 | 2 | 2 | - | 2 | - | - | 1 | - | - | - |
| **Avg.** | **3** | **2** | **2** | **2** | | **1.75** | | | **1** | | | |

## DETAILED SYLLABUS

**Module I:** **(5 Lectures)**

Introduction to Smart Grid, Architecture of Smart Grid System, Standards for Smart Grid System, Elements and Technologies of Smart Grid System.

**Module II** **(14 Lectures)**

Communication Technologies for Power System: Fiber Optical Networks, WAN base on Fiber Optical Networks, IP based Real Time data Transmission, Substation communication network, Zigbee. Information System for Control Centers (ICCS): ICCS Configuration, ICCS communication Network, ICCS Time Synchronization. E-Commerce of Electricity, GIS, GPS.

**Module III** **(8 Lectures)**

Integration, Control and Operation of Distributed Generation: Distributed Generation Technologies and its benefits, Distributed Generation Utilization Barriers, Distributed Generation integration to power grid.

**Module IV:** **(12 Lectures)**

Monitoring the smart grid: Load dispatch centers, wide-area monitoring system (WAMS), Phasor Measurement Unit(PMU), ;Smart sensors/telemetry, advanced metering infrastructure

(AMI);smart metering; smart grid system monitoring; communication infrastructure and technologies; self-healing. Concept of Islanding.

**Module V:** **(3 Lectures)**

Micro grid: Integration of distributed energy sources; concept, operation, control and protection of Micro.

**Text/Reference Books:**

[1]. Smart power grids by A Keyhani, M Marwali.
[2]. Computer Relaying for Power Systems by Arun Phadke
[3]. Microgrids Architecture and control by Nikos Hatziargyriou
[4]. Renewable Energy Systems by Fang Lin Luo, Hong Ye
[5]. Voltage-sourced converters in power systems_ modeling, control, and applications by Amirnaser Yazdani, Reza Iravani"grid. Hybrid Power Systems: Integration of conventional and non-conventional energy sources.

| Electrical Engineering | | | |
|---|---|---|---|
| **ELP709** | **Electrical and Hybrid Vehicles** | **L** | **T** |
| | | **3** | **0** |

**Course Outcomes:**

After successful completion of the course, students will be able to:

| CO's | CO Description |
|---|---|
| CO1 | **Demonstrate** the drive train and propulsion unit of hybrid vehicles and their performance |
| CO2 | **Identify** the different possible ways of energy storage. |
| CO3 | **Generalize** the different strategies related to energy management system. |
| CO4 | **Design** the hybrid electric vehicle and battery electric vehicle. |

**CO's-PO's Mapping Matrix:**

Enter correlation levels1, 2 or 3 as defined below-

1. Slight (low) 2. Moderate (Medium) 3. Substantial (High)

| COs/POs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 3 | 2 | - | 1 | 2 | 3 | 3 | - | - | - | 1 | 3 |
| **CO2** | - | 2 | 3 | 1 | 3 | - | 2 | 1 | - | - | - | - |
| **CO3** | 2 | 3 | - | 2 | 2 | - | 2 | 1 | - | - | 3 | 1 |
| **CO4** | 3 | 1 | 3 | 3 | 2 | 1 | 2 | - | - | - | 1 | 3 |
| **Total** | **2.67** | **2** | **3** | **1.75** | **2.25** | **2** | **2.25** | **1** | **-** | **-** | **1.67** | **2.33** |

## DETAILED SYLLABUS

**Module I: Introduction to Hybrid Electric Vehicles and Conventional Vehicles (3 Lectures)**

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, mathematical models to describe vehicle performance.

**Module II: Hybrid Electric Drive-trains (6 Lectures)**

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.

**Module III: Electric Propulsion Unit (9 Lectures )**

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.

**Module IV: Energy Storage** **(6 Lectures)**
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, Electrical overlay harness and communications.

**Module V: Sizing the Drive System** **(5 Lectures)**
Matching the electric machine and the internal combustion engine (ICE), Sizing the propulsion motor, sizing the power electronics, selecting the energy storage technology.

**Module VI Energy Management Strategies** **(13 Lectures)**
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, Rule and optimization based energy management strategies (EMS).
Case studies-Design of a Hybrid Electric Vehicle (HEV), Design of a Battery Electric Vehicle (BEV).

**Text Books:**

[1]. C. Mi, M. A. Masrur and D. W. Gao, "Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives", , John Wiley & Sons, 2011.
[2]. S. Onori, L. Serrao and G. Rizzoni, "Hybrid Electric Vehicles: Energy Management Strategies", Springer, 2015.

**Reference Books:**

[1]. M. Ehsani, Y. Gao, S. E. Gay and A. Emadi, "Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals, Theory, and Design", CRC Press, 2004.
[2]. T. Denton , "Electric and Hybrid Vehicles", Routledge, 2016.

| Electrical Engineering | | | |
|---|---|---|---|
| **ELO710** | **Soft Optimization Techniques** | **L** | **T** |
| | | **3** | **0** |

**Pre-requisite: None**

**Course Outcomes:**

After successful completion of the course, students should be able to:

| CO's | Descriptions |
|---|---|
| CO1 | **Understand** the concepts of population based optimization techniques. |
| CO2 | **Evaluate** the importance of parameters in heuristic optimization techniques. |
| CO3 | **Apply** for the solution of multi-objective optimization. |

**COs-POs Mapping Matrix:**

Enter correlation levels1, 2 or 3 as defined below-

1. Slight (low) 2. Moderate (Medium) 3. Substantial (High)

| COs/POs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 3 | 3 | 2 | 1 | 2 | 1 | - | - | - | - | - | 2 |
| **CO2** | 3 | 3 | 2 | 1 | 2 | - | - | 1 | - | - | - | 2 |
| **CO3** | 3 | 3 | 2 | 1 | 2 | - | - | 1 | - | - | 3 | 2 |
| **Avg.** | **3** | **3** | **2** | **1** | **2** | **1** | **-** | **1** | **-** | **-** | **-** | **2** |

## DETAILED SYLLABUS

**Module I: Genetic Algorithm and Particle Swarm Optimization (12 Lectures)**

Genetic algorithms- Genetic Algorithm versus Conventional Optimization Techniques - Genetic representations and selection mechanisms; Genetic operators- different types of crossover and mutation operators -Bird flocking and Fish Schooling – anatomy of a particle- equations based on velocity and positions -PSO topologies - control parameters. Application to SINX maximization problem.

**Module II: Ant Colony Optimization and Artificial Bee Colony Algorithms (10 Lectures)**

Biological ant colony system - Artificial ants and assumptions - Stigmergic communications - Pheromone updating- local-global - Pheromone evaporation - ant colony system- ACO models-Touring ant colony system-max min ant system - Concept of elistic ants-Task partitioning in honey bees - Balancing foragers and receivers - Artificial bee colony (ABC) algorithms-binary ABC algorithms.

**Module III: Shuffled Frog-Leaping Algorithm and Bat Optimization Algorithm (10 Lectures)**

Bat Algorithm- Echolocation of bats- Behavior of microbats- Acoustics of Echolocation-Movement of Virtual Bats- Loudness and Pulse Emission- Shuffled frog algorithm-virtual population of frogs-comparison of memes and genes -memeplex formation- memeplex updation.

**Module IV: Multi Objective Optimization (4 Lectures)**

Application to multi-modal function optimization.Introduction to Multi- Objetive optimization-Concept of Pareto optimality.

**Module V: Evolutionary Computing (6 Lectures)**

Evolutionary Computing, Simulated Annealing, Random Search, Downhill Simplex Search.

**Text Books/Reference:**


[1]. Xin-She Yang, “Recent Advances in Swarm Intelligence and Evolutionary Computation,Springer International Publishing, Switzerland, 2015.

[2]. Kalyanmoy Deb, Multi-Objective Optimization using Evolutionary Algorithms, John Wiley & Sons, 2001.

[3]. James Kennedy and Russel E Eberheart, Swarm Intelligence, The Morgan Kaufmann Series in Evolutionary Computation, 2001.

[4]. Eric Bonabeau, Marco Dorigo and Guy Theraulaz, Swarm Intelligence-From natural to Artificial Systems, Oxford university Press, 1999.

[5]. David Goldberg, Genetic Algorithms in Search, Optimization and Machine Learning, Pearson Education, 2007.

[6]. Konstantinos E. Parsopoulos and Michael N. Vrahatis, Particle Swarm Optimization and Intelligence: Advances and Applications, Information science reference, IGI Global, 2010.

[7]. N P Padhy, Artificial Intelligence and Intelligent Systems, Oxford University Press, 2005.

| Electrical Engineering | | | |
|---|---|---|---|
| **ELO711** | **Illumination Technology** | **L** | **T** |
| | | **3** | **0** |

**Course Outcomes:**
After successful completion of the course, students should be able to:

| COs | CO Description |
|---|---|
| CO1 | **Evaluate** the characteristics of illumination sources/devices. |
| CO2 | **Understand** and determine the performance of various lighting systems. |
| CO3 | **Design** of lighting controls and management. |
| CO4 | **Understand** the standards of lighting systems and commissioning. |

**CO's-PO's Mapping Matrix:**
Enter correlation levels1, 2 or 3 as defined below-
1.Slight (low) 2. Moderate (Medium) 3. Substantial (High)

| COs/POs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 3 | 3 | 2 | 1 | 1 | 1 | - | - | - | - | - | 2 |
| **CO2** | 3 | 3 | 2 | 1 | 1 | - | - | 1 | - | - | - | 2 |
| **CO3** | 3 | 3 | 2 | 1 | 1 | - | - | 1 | - | - | 3 | 2 |
| **CO4** | 3 | 3 | 2 | 1 | 1 | - | | 1 | - | - | - | 2 |
| **Avg.** | **3** | **3** | **2** | **1** | **1** | **1** | **-** | **1** | **-** | **-** | **-** | **2** |

## DETAILED SYLLABUS

**Module I: Ballast based Systems (6 Lectures)**
Introduction - Magnetic and Electronic Ballast – Dimming Electronic Ballast for Fluorescent lamps - Lamp Ballast interactions – Electronic Ballast for HID Lamps - Pulse start metal halide system, Compact Fluorescent lamp.

**Module II: Solid State Lamps (13 Lectures)**
Introduction - Review of Light sources - white light generation techniques- Characterization of LEDs for illumination application. Power LEDs- High brightness LEDs- Electrical and optical properties – LED driver considerations.

Power management topologies- Thermal management considerations- Heat sink design- photometry and colorimetry - color issues of white LEDs- Dimming of LED sources -Designing usable lamp from white LEDs,- Luminaire design steps-SSL test standards. Dimming control scheme - Lighting controls for LED lamps.

**Module III: Lighting Controls & Management (8 Lectures)**
Introduction to lighting control – lighting control strategies - Energy Management strategies – Switching Control – sensor technology - occupancy sensors – PIR – Ultrasonic – location, coverage area & mounting configuration – special features –

**Module IV: Applications of Sensors** **(3 Lectures)**

Application. Photo sensors – spectral sensitivity – Photo sensor based control algorithms – Daylight-artificial light integrated schemes.

**Module V: Commissioning of lighting controls** **(10 Lectures)**

NASHRAE / IESNA standards & energy codes – international energy conservation code – compliance with controls Lighting Control Applications: Commercial lighting – stage and entertainment lighting – Architectural lighting – Residential Lighting Energy Management and building control systems.

**Text Books/Reference:**


[1]. Arturas Zukauskus, Michael S. Shur and Remis Gaska, "Introduction to solid state lighting", Wiley- Interscience, 2002.

[2]. E. Fred Schubert, "Light Emitting Diodes" (2nd edition), Cambridge University Press, 2006.

[3]. Craig DiLouie, Advanced Lighting Controls: Energy Saving Productivity, Technology & Applications, Fairmont Press, Inc., 2006.

[4]. Mohan, Undeland and Robbins, "Power Electronics: Converters, Applications and Design", John Wiley and Sons, 1989.

[5]. Steve Winder, "Power Supplies for LED Driving" Newnens Publication, 2008.

[6]. Robert S Simpson, Lighting Control: Technology and Applications, Focal Press, 2003.

[7]. IES Lighting Handbook, 10th Edition IESNA, 2011.

| Electrical Engineering | | | |
|---|---|---|---|
| **ELO712** | **Process Instrumentation and Control** | **L** | **T** |
| | | **3** | **0** |

**Course Outcomes:**

After successful completion of the course, students should be able to:

| CO's | CO Description |
|---|---|
| CO1 | **Evaluate** the output of a digital system for a given input. |
| CO2 | **Describe** the dynamics of a Linear, Time Invariant systems through difference equations. |
| CO3 | **Analyze** digital systems using the Z-transformation, state space methods. |
| CO4 | **Design** digital controllers for physical systems. |

**CO's-PO's Mapping Matrix:**

Enter correlation levels1, 2 or 3 as defined below-

1. Slight (low) 2. Moderate (Medium) 3. Substantial (High)

| COs/POs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 3 | 3 | 2 | 1 | 1 | - | - | - | - | - | - | 2 |
| **CO2** | 3 | 3 | 2 | 1 | 1 | - | - | - | - | - | - | 2 |
| **CO3** | 3 | 3 | 2 | 1 | 1 | - | - | - | - | - | - | 2 |
| **CO4** | 3 | 3 | 2 | 1 | 1 | - | | - | - | - | - | 2 |
| **Avg.** | **3** | **3** | **2** | **1** | **1** | **-** | **-** | **-** | **-** | **-** | **-** | **2** |

## DETAILED SYLLABUS

**MODULE I: Introduction** **(7 Lectures)**

Special Characteristics of process systems: Large time constants, Interaction, Multistaging, Pure Lag; Control loops for simple systems: Dynamics and stability.

**MODULE II:** **(10 Lectures)**

Generation of control actions in electronic pneumatic controller. Tuning of controllers Zeigler Nichols and other techniques. Different control techniques and interaction of process parameters e.g. Feed forward,cascade, ratio, Override controls. Batch and continuous process controls. Multi variable control. Feed forward control schemes.

**MODULE III:** **(8 Lectures)**

Control valves, Valve positioners, Relief and safety valves, Relays,Volume boosters, Pneumatic transmitters for process variables.Various process schemes/ Unit operations and their control schemese.g. distillation columns , absorbers, Heat exchangers, Furnaces,Reactors, Mineral processing industries pH and blending processes.

**MODULE IV:** **(12 Lectures)**

Measurement, control and transmission of signals of process parameters like flow, pressure, level and temperature.

**MODULE V:** **(5 Lectures)**
Computer control of processes: Direct Digital Control, Supervisory Control and advanced control strategies.

**Text/Reference Books:**

[1]. Stephananopoulos G- Chemical Process control- An Introduction to theory and practice, PHI,1990
[2]. Luyben W L – Simulation and control for chemical engineers,1989, 2nd Edition, McGraw Hill,1989.

| Electrical Engineering | | | |
|---|---|---|---|
| **ELO713** | **Digital Signal Processing** | **L** | **T** |
| | | **3** | **0** |

**Course Outcomes:**

After successful completion of the course students will be able to:

| CO's | Description |
|---|---|
| CO1 | **Understand** the concepts of continuous time and discrete time systems. |
| CO2 | **Understand** the concepts of different discrete transforms. |
| CO3 | **Analyze** systems in complex frequency domain. |
| CO4 | **Design** of different types of filters. |

**CO's-PO's Mapping Matrix:**

Enter correlation levels1, 2 or 3 as defined below-

1. Slight (low) 2. Moderate (Medium) 3. Substantial (High)

| COs/POs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 3 | 3 | 3 | 1 | | | | | | | | 2 |
| **CO2** | 3 | 2 | 3 | 1 | | | | | | | | 2 |
| **CO3** | 3 | 3 | 2 | 2 | | | | | | | | 2 |
| **CO4** | 3 | 2 | 2 | 2 | | | | | | | | 2 |
| **Avg.** | **3** | **2.5** | **2.5** | **1.5** | | | | | | | | **2** |

## DETAILED SYLLABUS

**Module I: Discrete-Time Signals** **(04 Lectures)**

Concept of discrete-time signal, basic idea of sampling and reconstruction of signal, sampling theorem, sequences,-periodic, energy, power, unit-sample, unit step, unit ramp &complex exponentials, arithmetic operations on sequences..

**Module II: LTI Systems** **(06 Lectures)**

Definition, representation, impulse response, derivation for the output sequence, concept of convolution, graphical, analytical and overlap-add methods to compute convolution supported with examples and exercise, properties of convolution, interconnection of LTI systems with physical interpretations, stability and causality conditions, recursive and non recursive systems.

**Module III: Discrete Fourier Transform** **(10 Lectures)**

Concept and relations for DFT/IDFT, Relation between DTFT & DFT. Twiddle factors and their properties, computational burden on direct DFT, DFT/DFT as linear transformation,DFT/IDFT matrices, computation of DFT/IDFT by matrix method, multiplication of DFTs, circulation convolution, computation of circular convolution by graphical, DFT/IDFT and matrix methods, linear filtering using DFT, aliasing error, filtering of long data sequences-Overlap-Save and Overlap-Add methods with examples and exercises.

**Module IV: Discrete Time Fourier Transform** **(05 Lectures)**

Concept of frequency in discrete and continuous domain and their relationship (radian and radian/sec), freq. response in the discrete domain. Discrete system's response to sinusoidal/complex inputs (DTFT), Representation of LTI systems in complex frequency domain**.**

**Module V: Fast Fourier Transforms** **(04 Lectures)**

Radix-2 algorithm, decimation-in-time, decimation-in-frequency algorithm, signal flow graph, Butterflies, computations in one place, bit reversal, examples for DIT & DIF FFT Butterfly computations and exercises.

**Module VI: Z- Transforms** **(08 Lectures)**

Definition, mapping between s-plane & z-plane, unit circle, convergence and ROC, properties of Z-transform, Z-transform on sequences with examples & exercises, characteristic families of signals along with ROC, convolution, correlation and multiplication using Z- transform, initial value theorem, Perseval's relation, inverse Z transform by contour integration, power series & partial-fraction expansions with examples and exercises.

**ModuleVII: Filter Design** **(5 Lectures)**

Basic concepts of IIR and FIR filters, difference equations, design of Butterworth IIR analog filter using impulse invariant and bilinear transform, design of linear phase FIR filters no. of taps, rectangular, Hamming and Blackman windows. Effect of quantization.

**Text Books:**


[1]. Digital Signal Processing-A computer based approach, S. Mitra, TMH

[2]. Digital Signal Processing: Principles, Algorithms & Application, J.C. Proakis& M.G. Manslakis, PHI

[3]. Fundamental of Digital Signal Processing using MATLAB , Robert J. Schilling, S.L. Harris, Cengage Learning.

[4]. Digital Signal Processing-implementation using DSP microprocessors with examples from TMS320C54XX, Avtar Singh & S. Srinivasan, Cengage Leasrning.


**Reference Books**


[1]. Digital Signal Processing, Chen, OUP

[2]. Digital Signal Processing, Johnson, PHI

[3]. Digital Signal Processing using MATLAB, Ingle, Vikas.

| Electrical Engineering | | | |
|---|---|---|---|
| **ELO714** | **Energy Storage Systems** | **L** | **T** |
| | | **3** | **0** |

**Course Outcomes:**

After successful completion of this course, students will be able to:

| CO's | CO Descriptions |
|---|---|
| CO1 | analyze the characteristics of energy from various sources and need for storage |
| CO2 | classify various types of energy storage and various devices used for the purpose |
| CO3 | Identify various real time applications |

**CO's-PO's Mapping Matrix:**

Enter correlation levels1, 2 or 3 as defined below-

1. Slight (low)  2. Moderate (Medium)  3. Substantial (High)

| COs/POs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 3 | 3 | 3 | 1 | 1 | | | | | | | 2 |
| **CO2** | 3 | 3 | 3 | 2 | 1 | | | | | | | 2 |
| **CO3** | 3 | 3 | 3 | 2 | 1 | | | | | | | 2 |
| **CO4** | 3 | 3 | 3 | 3 | 1 | | | | | | | 2 |
| **CO5** | 3 | 3 | 3 | 2 | 1 | | | | | | | 2 |
| **Avg.** | **3** | **3** | **3** | **2** | **1** | | | | | | | **2** |

## DETAILED SYLLABUS

**Module I: Electrical Energy Storage Technologies (08 Lectures)**

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.

**Module II: Needs for Electrical Energy Storage (08 Lectures)**

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.

**Module III: Features of Energy Storage Systems (08 Lectures)**

Classification of EES systems , Mechanical storage systems, Pumped hydro storage (PHS), Compressed air energy storage (CAES), Flywheel energy storage (FES),Electrochemical storage systems, Secondary batteries, Flow batteries, Chemical energy storage, Hydrogen (H2),Synthetic natural gas (SNG).

**Module IV: Types of Electrical Energy Storage systems (06 Lectures)**

Electrical storage systems, Double-layer capacitors (DLC) ,Superconducting magnetic energy storage (SMES),Thermal storage systems ,Standards for EES, Technical comparison of EES technologies.

**Module V: Applications (10 Lectures)**

Present status of applications, Utility use (conventional power generation, grid operation & service) , Consumer use (uninterruptable power supply for large consumers),New trends in applications ,Renewable energy generation, Smart Grid, Smart Micro grid, Smart House, Electric vehicles, Management and control hierarchy of storage systems, 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.

**Text Books:**


[1]. "James M. Eyer, Joseph J. Iannucci and Garth P. Corey ", "Energy Storage Benefits and Market Analysis", Sandia National Laboratories, 2004.

[2]. The Electrical Energy Storage by IEC Market Strategy Board.


**Reference Book:**


[1]. "Jim Eyer, Garth Corey", Energy Storage for the Electricity Grid: Benefits and Market Potential Assessment Guide, Report, Sandia National Laboratories, Feb 2010.

| Electrical Engineering | | | |
|---|---|---|---|
| **ELO715** | **Electrical Machines and Power Systems** | **L** | **T** |
| | | **3** | **0** |

**Course Outcomes:**

After successful completion of the course, students should be able to:

| CO's | CO Description |
|---|---|
| CO1 | **Understand** the construction and principle of operation of transformers, auto transformers, asynchronous and synchronous machines. |
| CO2 | **Evaluate** performance characteristics of induction machine and synchronous machines. |
| CO3 | **Analyze** the effects of excitation and mechanical input on the operation of synchronous machine. |
| CO4 | **Understand** different elements and supply systems of power systems. |
| CO5 | **Determine** the parameters of transmission lines |

**COs-POs Mapping Matrix:**

Enter correlation levels1, 2 or 3 as defined below-

1. Slight (low) 2. Moderate (Medium) 3. Substantial (High)

| COs/POs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | 3 | 1 | 1 | 1 | 1 | | | | | 1 |
| CO2 | 3 | 1 | 3 | 2 | 2 | | | | | | | 1 |
| CO3 | 3 | 2 | 3 | 2 | 2 | | | | | | | 1 |
| CO4 | 3 | 3 | 3 | 3 | 3 | | 1 | | | | | 1 |
| CO5 | 3 | 2 | 3 | 2 | 2 | | | | | | | 1 |
| **Avg.** | **3** | **2** | **3** | **2** | **2** | **1** | **1** | | | | | **1** |

## DETAILED SYLLABUS

**Module I: Transformers (8 Lectures)**

Constructional features, types, Special constructional features – cruciform and multiple stepped cores, cooling methodology, conservators, breather, Buchholz relay, voltage, current and impedance relationships, equivalent circuits and phasor diagrams at no load and full load conditions,voltage regulation, losses and efficiency, all day efficiency, auto transformer and equivalent circuit, parallel operation and load sharing.

**Module II: Asynchronous Machines (8 Lectures)**

General constructional features of poly phase asynchronous motors, concept of rotating magnetic field, principle of operation, phasor diagram, Equivalent circuit, torque and power equations, torque-slip characteristics, losses and efficiency.

**Module III: Synchronous Machines (9 Lectures)**

General constructional features, armature winding, emf equation, effect of distribution and pitch factor,flux and mmf relationship, phasor diagram, non-salient pole machine, equivalent circuit, determination of equivalent circuit parameters by open and short circuit tests, voltage regulation using synchronous impedance method, power angle characteristics.

**Module IV: Introduction to Power Systems (9 Lectures)**
Single line diagram of power system, brief description of power system elements, synchronous machine, transformer, transmission line, bus bar, circuit breaker and isolator. Supply System: different kinds of supply system and their comparison, choice of transmission voltage.
Transmission Lines: configurations, types of conductors, resistance of line, skin effect.

**Module V: Transmission Lines (8 Lectures)**
Calculation of inductance and capacitance of single phase, three phase, single circuit and double circuit ,transmission lines, representation and performance of short, medium and long transmission lines, Ferranti effect,surge impedance loading.

**Text/Reference Books:**

[1]. Fitzgerald. A.E., Charles KingselyJr, Stephen D.Umans, ‘Electric Machinery’, Tata McGraw Hill, 2006.
[2]. M.G. Say, ‘Performance and Design of Alternating Current Machines’, CBS Publishers, New Delhi, 2008 Nagrath I. J and Kothari D.P. ‘Electric Machines’, Tata McGraw Hill Publishing company Ltd, 2010.
[3]. Power System Analysis, J. Grainger and W.D. Stevenson, TMH, 2006.
[4]. Electrical Power Systems,C. L.Wadhwa, New age international Ltd. Third Edition,2010
[5]. Electric Power Generation, Transmission&Distribution,S.N.Singh, PHI Learning.