# VII SEMESTER DETAILED SYLLABUS

## B. E. ELECTRICAL AND ELECTRONICS ENGINEERING

Choice Based Credit System (CBCS) and Outcome Based Education (OBE)

**SEMESTER – VII**

## POWER SYSTEM ANALYSIS – 2 (Core Course)

<table>
<thead>
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<th>Course Code</th>
<th>CIE Marks</th>
<th>Credits</th>
<th>Exam Hours</th>
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</thead>
<tbody>
<tr>
<td>18EE71</td>
<td>40</td>
<td>03</td>
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</table>

### Course Learning Objectives:

- To explain formulation of network models and bus admittance matrix for solving load flow problems.
- To discuss optimal operation of generators on a bus bar and optimum generation scheduling.
- To explain symmetrical fault analysis and algorithm for short circuit studies.
- To explain formulation of bus impedance matrix for the use in short circuit studies on power systems.
- To explain numerical solution of swing equation for multi-machine stability

## Module-1


## Module-2

**Load Flow Studies:** Introduction, Classification of buses. Power flow equation, Operating Constraints, Data for Load flow, Gauss Seidal iterative method. Illustrative examples.

## Module-3


## Module-4

**Economic Operation of Power System:** Introduction and Performance curves Economic generation scheduling neglecting losses and generator limits Economic generation scheduling including generator limits and neglecting losses Economic dispatch including transmission losses Derivation of transmission loss formula. Illustrative examples.

**Unit Commitment:** Introduction, Constraints and unit commitment solution by prior list method and dynamic forward DP approach (Flow chart and Algorithm only).
Module-5

**Symmetrical Fault Analysis:** Z Bus Formulation by Step by step building algorithm without mutual coupling between the elements by addition of link and addition of branch. Illustrative examples. Z bus algorithm for Short Circuit Studies excluding numerical. T1

**Power System Stability:** Numerical Solution of Swing Equation by Point by Point method and Runge Kutta Method. Illustrative examples. T1

**Course Outcomes:** At the end of the course the student will be able to:
- Formulate network matrices and models for solving load flow problems.
- Perform steady state power flow analysis of power systems using numerical iterative techniques.
- Solve issues of economic load dispatch and unit commitment problems.
- Analyze short circuit faults in power system networks using bus impedance matrix.
- Apply Point by Point method and Runge Kutta Method to solve Swing Equation.

**Question paper pattern:**
- The question paper will have ten questions.
- Each full question is for 20 marks.
- There will be 2 full questions (with a maximum of three sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module.

Module 1 Ybus Matrix size limited to 3X3 for illustrative examples.
Module 2 NR Method limited to 3 bus system with one iteration for illustrative examples.

**Text Books**

<table>
<thead>
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B. E. ELECTRICAL AND ELECTRONICS ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER – VII

POWER SYSTEM PROTECTION (Core Subject)

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<tr>
<td>Credits</td>
<td>03</td>
<td>Exam Hours</td>
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</table>

Course Learning Objectives:
- To discuss performance of protective relays, components of protection scheme and relay terminology.
- To explain relay construction and operating principles.
- To explain Over current protection using electromagnetic and static relays and Over current protective schemes.
- To discuss types of electromagnetic and static distance relays, effect of arc resistance, power swings, line length and source impedance on performance of distance relays.
- To discuss pilot protection; wire pilot relaying and carrier pilot relaying.
- To discuss construction, operating principles and performance of various differential relays for differential protection.
- To discuss protection of generators, motors, Transformer and Bus Zone Protection.
- To explain the principle of circuit interruption and different types of circuit breakers.
- To describe the construction and operating principle of different types of fuses and to give the definitions of different terminologies related to a fuse.
- To discuss protection Against Over voltages and Gas Insulated Substation (GIS).

Module-1


Relay Construction and Operating Principles: Introduction, Electromechanical Relays, Static Relays – Merits and Demerits of Static Relays, Numerical Relays, Comparison between Electromechanical Relays and Numerical Relays.


Module-2


Module-3


Rotating Machines Protection: Introduction, Protection of Generators.

Module-4


Module-5

**Fuses:** Introductions, Definitions, Fuse Characteristics, Types of Fuses, Applications of HRC Fuses, Selection of Fuses, Discrimination.

**Protection against Overvoltages:** Causes of Overvoltages, Lightning phenomena, Wave Shape of Voltage due to Lightning, Over Voltage due to Lightning, Klydonograph and Magnetic Link, Protection of Transmission Lines against Direct Lightning Strokes, Protection of Stations and Sub – Stations from Direct Strokes, Protection against Travelling Waves, Insulation Coordination, Basic Impulse Insulation Level (BIL).

**Modern Trends in Power System Protection:** Introduction, gas insulated substation/switchgear (GIS).

**Course Outcomes:** At the end of the course the student will be able to:
- Discuss performance of protective relays, components of protection scheme and relay terminology over current protection.
- Explain the working of distance relays and the effects of arc resistance, power swings, line length and source impedance on performance of distance relays.
- Discuss pilot protection, construction, operating principles and performance of differential relays and discuss protection of generators, motors, transformer and Bus Zone Protection.
- Explain the construction and operation of different types of circuit breakers.
- Outline features of fuse, causes of overvoltages and its protection, also modern trends in Power System Protection.

**Question paper pattern:**
- The question paper will have ten questions.
- Each full question is for 20 marks.
- There will be 2 full questions (with a maximum of three sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module.

**Text Books**

| 1 | Power System Protection and Switchgear | Badri Ram, D.N. Vishwakarma | McGraw Hill | 2nd Edition |

**Reference Books**

## Module 1


## Module 2

### Module-3


### Module-4


**Wind energy systems:** Environment and Economics Environmental benefits and problems of wind energy, Economics of wind energy, Factors influence the cost of energy generation, machine parameters, Life cycle cost analysis.

### Module-5


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

- Discuss the importance of the role of renewable energy, the concept of energy storage and the principles of energy storage devices.
- Discuss the concept of solar radiation data and solar PV system fabrication, operation of solar cell, sizing and design of PV system.
- Describe the process of harnessing solar energy and its applications in heating and cooling.
- Explain basic Principles of Wind Energy Conversion, collection of wind data, energy estimation and site selection.
- Discuss the performance of Wind-machines, energy storage, applications of Wind Energy and environmental aspects.

### Question paper pattern:
- The question paper will have ten questions.
- Each full question is for 20 marks.
- There will be 2 full questions (with a maximum of three sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module.

### Textbook

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B. E. ELECTRICAL AND ELECTRONICS ENGINEERING
CHOICE BASED CREDIT SYSTEM (CBCS) AND OUTCOME BASED EDUCATION (OBE)
SEMESTER – VII

MICRO- AND NANO-SCALE SENSORS AND TRANSUDCERS (PROFESSIONAL ELECTIVE)

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<tr>
<td>Credits</td>
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Course Learning Objectives:
- To explain measurement of pressure using sensors, based nanotechnology, their structure, theory of operation.
- To explain structure, theory of operation of sensors based on nanotechnology for Motion, acceleration, measurement, gas and smoke detection.
- To explain sensors based on nanotechnology for the measurement of atmospheric moisture and moisture inside the electronic components.
- To explain Optoelectronic and Photonic Sensors used in optical microphones, fingerprint readers, and highly sensitive seismic sensors.
- To explain the structure, operation of Biological Sensors, Chemical Sensors, and the so-called “Lab-on-a-Chip” sensors used in multipurpose biological and chemical analysis devices and Electric, Magnetic, and RF/Microwave, Integrated Sensor/Actuator Units and Special Purpose Sensors driven by nanotechnology.

Module-1

Module-2
Motion and Acceleration Sensors: Ultrahigh Sensitivity, Wide Dynamic Range Sensors, Other Motion and Acceleration Microsensors.
Gas and Smoke Sensors: A CO Gas Sensor Based on Nanotechnology, Smoke Detectors.

Module-3
Moisture Sensors: Structure, Theory, Main Experimental Results, Auxiliary Experimental Results.
Optoelectronic and Photonic Sensors: Optoelectronic Microphone, Other Optoelectronic and Photonic Micro Sensors.

Module-4
Biological, Chemical, and “Lab on a Chip” Sensors: Lab on a Chip Sensors, Other Biochemical Micro- and Nano-Sensors.
Electric, Magnetic, and RF/Microwave Sensors: Magnetic Field Sensors, Other Important Electromagnetic/RF Micro- and Nano-Sensors.

Module-5
Integrated Sensor/Actuator Units and Special Purpose Sensors: Aircraft Icing Detectors, Other Special Purpose Small-Scale Devices.

Course Outcomes: At the end of the course the student will be able to:
- Understand the differences between the sensor and transducer technology based on nanotechnology and nanofabrication and the classical sensor technologies
- Make an informed selection of a sensor or transducer for a particular application;
- Become knowledgeable about the technologies that are available commercially at the present time.

Question paper pattern:
- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub-questions) from each module.
- Each full question will have sub-question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

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B. E. ELECTRICAL AND ELECTRONICS ENGINEERING
CHOICE BASED CREDIT SYSTEM (CBCS) AND OUTCOME BASED EDUCATION (OBE)
SEMESTER – VII

INTEGRATION OF DISTRIBUTION GENERATION (PROFESSIONAL ELECTIVE)

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<td>(3:0:0)</td>
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<td>3</td>
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</table>

Course Learning Objectives:
- To explain power generation by alternate energy source like wind power and solar power.
- To explain selection of size of units and location for wind and solar systems.
- Discuss the effects of integration of distributed generation on the performance the system.
- To provide practical and useful information about grid integration of distributed generation.

Module-1


Module-2


Module-3


Module-4


Module-5

Synchronous Machines Balanced Dips and Unbalanced Dips, Induction generators and unbalanced dips. Increasing the Hosting Capacity: Strengthening the Grid, Emission Limits for Generator Units, Emission Limits for Other Customers, Higher Disturbance Levels, Passive Harmonic Filters, Power Electronics Converters, Reducing the Number of Dips, Broadband and High-Frequency Distortion.

**Course Outcomes:** At the end of the course the student will be able to:
- Explain energy generation by wind power and solar power.
- Discuss the variation in production capacity at different time scales, the size of individual units, and the flexibility in choosing locations with respect to wind and solar systems.
- Explain the performance of the system when distributed generation is integrated to the system.
- Discuss effects of the integration of DG: the increased risk of overload, increased losses, increased risk of overvoltages and increased levels of power quality disturbances.
- Discuss effects of the integration of DG: incorrect operation of the protection.
- Discuss the impact the integration of DG on power system stability and operation.

**Question paper pattern:**
- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub-questions) from each module.
- Each full question will have sub-question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

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<tr>
<td>Textbook</td>
<td>Integration of Distributed Generation in the Power System</td>
<td>Math Bollen</td>
<td>Wiley</td>
<td>2011</td>
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B. E. ELECTRICAL AND ELECTRONICS ENGINEERING
CHOICE BASED CREDIT SYSTEM (CBCS) AND OUTCOME BASED EDUCATION (OBE)
SEMESTER – VII
ADVANCED CONTROL SYSTEMS (PROFESSIONAL ELECTIVE)

<table>
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<tr>
<td>Exam Hours</td>
<td>03</td>
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Course objectives:
- To introduce state variable approach for linear time invariant systems in both the continuous and discrete time systems.
- To explain development of state models for linear continuous – time and discrete – time systems.
- To explain application of vector and matrix algebra to find the solution of state equations for linear continuous – time and discrete – time systems.
- To define controllability and observability of a system and testing techniques for controllability and observability of a given system.
- To explain design techniques of pole assignment and state observer using state feedback.
- To explain about inherent and intentional nonlinearities that can occur in control system and developing the describing function for the nonlinearities.
- To explain stability analysis of nonlinear systems using describing function analysis.
- To explain the analysis of nonlinear systems using Lyapunov function and design of Lyapunov function for stable systems.

Module-1


Module-2

State Variable Analysis and Design (continued): Diagonalization, Solution of State Equations, Concepts of Controllability and Observability.

Module-3


Module-4


Module-5


Course Outcomes: At the end of the course the student will be able to:
- Discuss state variable approach for linear time invariant systems in both the continuous and discrete time systems.
- Develop state models for linear continuous–time and discrete–time systems.
- Apply vector and matrix algebra to find the solution of state equations for linear continuous–time and discrete–time systems.
- Define controllability and observability of a system and test for controllability and observability of a given system.
- Design pole assignment and state observer using state feedback.
• Develop the describing function for the nonlinearity present to assess the stability of the system.

• Develop Lyapunov function for the stability analysis of nonlinear systems.

**Question paper pattern:**
- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub-questions) from each module.
- Each full question will have sub-question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

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</thead>
<tbody>
<tr>
<td>1</td>
<td>Control Systems Engineering (For the Modules 1 and 2)</td>
<td>IJ. Nagarathand M. Gopal</td>
<td>NewAge</td>
<td>5th Edition, 2007</td>
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</tbody>
</table>
B. E. ELECTRICAL AND ELECTRONICS ENGINEERING
CHOICE BASED CREDIT SYSTEM (CBCS) AND OUTCOME BASED EDUCATION (OBE)
SEMESTER – VII
REACTIVE POWER CONTROL IN ELECTRIC POWER SYSTEMS (PROFESSIONAL ELECTIVE)

<table>
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Credits 03

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

Module-1

Module-2
Theory of Steady State Reactive Power in Uncompensated & Compensated Transmission Line: Fundamental requirement in AC power transmission, advantages & disadvantages of different types of compensating equipment for transmission systems, fundamental transmission line equation, surge impedance and natural loading, voltage and current profiles of uncompensated line on open circuit, uncompensated line under load, effect of line length, load power and power factor on voltage and reactive power.
Compensated Transmission Line: Types of compensation, passive and active compensators, Uniformly distributed fixed compensation: Effect of distributed compensation on voltage control and effect of distributed compensation on line charging reactive power. T1

Module-3
Passive shunt compensation: Control of open circuit voltage with shunt reactors, required reactance values of shunt reactors. T1
Series compensation: Objectives and practical limitations, Symmetrical line with mid-point series capacitor and shunt reactor, Power transfer characteristics and maximum transmissible power. Fundamental concepts of compensation by sectioning. T1

Module-4
Static Compensation: Practical applications of static compensators in electrical power systems, main types of compensators, principle of operation of Thyristor Controlled Reactor (TCR), Thyristor Controlled Transformer, TCR with shunt capacitors and Thyristor Switched Capacitor (TSC), principle of operation of saturated reactor compensators.
Series Capacitors: compensation factor, protective gear, Varistor protective gear, Resonance effects with series capacitors
Synchronous Condenser: Condenser operation, Power system Voltage control, Emergency reactive power supply, HVDC application. Comparison of basic types of compensator. T1

Module-5
Harmonics: Effect of harmonics on electrical equipment, resonance, shunt capacitors and filters, telephone interferences.
Reactive Power Co-ordination: Reactive power management, transmission benefits, reactive power dispatch & equipment impact. T1
**Reactive Power Planning:** Economic justification for reactive power planning, methods followed by the electricity boards in India, zonal reactive power requirements EHV & MV, low tension capacitors, placement in distribution, line capacitors. T3

**Course Outcomes:** At the end of the course the student will be able to:
- Distinguish the importance of load compensation in symmetrical as well as unsymmetrical loads.
- Observe various compensation methods in transmission lines.
- Distinguish demand side reactive power management & user side reactive power management.
- Construct model for reactive power coordination and effects of harmonics on electrical equipment.
- Discuss the Reactive Power Planning for the electricity boards.

**Question paper pattern:**
- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.
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- The students will have to answer five full questions, selecting one full question from each module.

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<td>1</td>
<td>Reactive power control in electric power systems</td>
<td>T. J. E. Miller</td>
<td>John Wiley &amp; Sons</td>
<td>2009</td>
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### B. E. ELECTRICAL AND ELECTRONICS ENGINEERING

**CHOICE BASED CREDIT SYSTEM (CBCS) AND OUTCOME BASED EDUCATION (OBE)**

**SEMESTER – VII**

**INDUSTRIAL DRIVES AND APPLICATION (PROFESSIONAL ELECTIVE)**

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**Course Learning Objectives:**
- To define electric drive, its parts, advantages and explain choice of electric drive.
- To explain dynamics and modes of operation of electric drives.
- To explain selection of motor power ratings and control of DC motor using rectifiers.
- To analyze the performance of induction motor drives under different conditions.
- To explain the control of induction motor, synchronous motor and stepper motor drives.
- To discuss typical applications electrical drives in the industry.

**Module-1**

**Electrical Drives:** Electrical Drives, Advantages of Electrical Drives. Parts of Electrical Drives, Choice of Electrical Drives, Status of DC and ac Drives.


**Control Electrical Drives:** Modes of Operation, Speed Control and Drive Classifications, Closed loop Control of Drives.

**Module-2**

**Direct Current Motor Drives:** Controlled Rectifier Fed DC Drives, Single Phase Fully Controlled Rectifier Control of DC Separately Excited Motor, Single Phase Half Controlled Rectifier Control of DC Separately Excited Motor, Three Phase Fully Controlled Rectifier Control of DC Separately Excited Motor, Three Phase Half Controlled Rectifier Control of DC Separately Excited Motor, Multi-quadrant Operation of DC Separately Excited Motor Fed Form Fully Controlled Rectifier, Rectifier Control of DC Series Motor, Supply Harmonics, Power Factor and Ripple in Motor Current, Chopper Control of Separately Excited DC Motor, Chopper Control of Series Motor.

**Module-3**

**Induction Motor Drives:** Analysis and Performance of Three Phase Induction Motors, Operation with Unbalanced Source Voltage and Single Phasing, Operation with Unbalanced Rotor Impedances, Analysis of Induction Motor Fed From Non-Sinusoidal Voltage Supply, Starting, Braking, Transient Analysis. Speed Control Techniques-Stator Voltage Control, Variable Voltage Frequency Control from Voltage Sources.

**Module-4**

**Induction Motor Drives (continued):** Voltage Source Inverter (VSI) Control, Cycloconverter Control, Closed Loop Speed Control and Converter Rating for VSI and Cycloconverter Induction Motor Drives, Variable Frequency Control from a Current Source, Current Source (CSI) Control, current regulated voltage source inverter control, speed control of single phase induction motors.

**Synchronous Motor Drives:** Operation from fixed frequency supply-starting, synchronous motor variable speed drives, variable frequency control of multiple synchronous motors.

**Module-5**

**Synchronous Motor Drives (continued):** Self-controlled synchronous motor drive employing load commutated thyristor inverter, Starting Large Synchronous Machines, Permanent Magnet ac (PMAC) Motor Drives, Sinusoidal PMAC Motor Drives, Brushless DC Motor Drives.

**Stepper Motor Drives:** Variable Reluctance, Permanent Magnet, Important Features of Stepper Motors, Torque Versus Stepping rate Characteristics, Drive Circuits for Stepper Motor.

**Industrial Drives:** Textile Mills, Steel Rolling Mills, Cranes and Hoists, Machine Tools.
**Course Outcomes:** At the end of the course the student will be able to:
- Explain the advantages, choice and control of electric drive
- Explain the dynamics, generating and motoring modes of operation of electric drives
- Explain the selection of motor power rating to suit industry requirements
- Analyze the performance & control of DC motor drives using controlled rectifiers
- Analyze the performance & control of converter fed Induction motor, synchronous motor & stepper motor drives.

**Question paper pattern:**
- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub-questions) from each module.
- Each full question will have sub-question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

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UNIVERSITY OF ODISHA
B. E. ELECTRICAL AND ELECTRONICS ENGINEERING
CHOICE BASED CREDIT SYSTEM (CBCS) AND OUTCOME BASED EDUCATION (OBE)
SEMESTER – VII

UTILIZATION OF ELECTRICAL POWER (PROFESSIONAL ELECTIVE)

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**Course Learning Objectives:**
- To discuss electric heating, air-conditioning and electric welding.
- To explain laws of electrolysis, extraction and refining of metals and electro deposition.
- To explain the terminology of illumination, laws of illumination, construction and working of electric lamps.
- To explain design of interior and exterior lighting systems- illumination levels for various purposes light fittings- factory lighting- flood lighting-street lighting
- To discuss systems of electric traction, speed time curves and mechanics of train movement.
- To discuss motors used for electric traction and their control.
- To discuss braking of electric motors, traction systems and power supply and other traction systems.
- Give awareness of technology of electric and hybrid electric vehicles.

**Module-1**


**Module-2**

**Illumination:** Introduction, Radiant Energy, Definitions, Laws of Illumination, Polar Curves, Photometry, Measurement of Mean Spherical Candle Power by Integrating Sphere, Illumination Photometer, Energy Radiation and luminous Efficiency, electric Lamps, Cold Cathode Lamp, Lighting Fittings, Illumination for Different Purposes, Requirements of Good Lighting.

**Module-3**


**Motors for Electric traction:** Introduction, Series and Shunt Motors for Traction Services, Two Similar Motors (Series Type) are used to drive a Motor Car, Tractive Effort and Horse Power, AC Series Motor, Three Phase Induction Motor.

**Control of motors:** Control of DC Motors, Tapped Field Control or Control by Field Weakening, Multiple Unit Control, Control of Single Phase Motors, Control of Three Phase Motors.

**Module-4**

**Braking:** Introduction, Regenerative Braking with Three Phase Induction Motors, Braking with Single Phase Series Motors, Mechanical braking, Magnetic Track Brake, Electro – Mechanical Drum Brakes.


**Trams, Trolley Buses and Diesel – Electric Traction:** Tramways, The Trolley – Bus, Diesel Electric Traction.

**Module-5**

**Electric Vehicles:** Configurations of Electric Vehicles, Performance of Electric Vehicles, Tractive Effort in Normal Driving, Energy Consumption.

**Hybrid Electric Vehicles:** Concept of Hybrid Electric Drive Trains, Architectures of Hybrid Electric Drive Trains.
Course Outcomes: At the end of the course the student will be able to:
• Discuss different methods of electric heating & welding.
• Discuss the laws of electrolysis, extraction, refining of metals and electro deposition process.
• Discuss the laws of illumination, different types of lamps, lighting schemes and design of lighting systems.
• Analyze systems of electric traction, speed time curves and mechanics of train movement.
• Explain the motors used for electric traction, their control & braking and power supply system used for electric traction.

Question paper pattern:
• The question paper will have ten full questions carrying equal marks.
• Each full question will be for 20 marks.
• There will be two full questions (with a maximum of four sub-questions) from each module.
• Each full question will have sub-question covering all the topics under a module.
• The students will have to answer five full questions, selecting one full question from each module.

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B. E. ELECTRICAL AND ELECTRONICS ENGINEERING
CHOICE BASED CREDIT SYSTEM (CBCS) AND OUTCOME BASED EDUCATION (OBE)
SEMESTER – VII

AI TECHNIQUES FOR ELECTRIC AND HYBRID ELECTRIC VEHICLES (PROFESSIONAL ELECTIVE)

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**Course Learning Objectives:**

- To explain IoT Based Battery Management System (BMS) and types of batteries for Hybrid Electric Vehicles (HEV).
- To explain advantages of AI, the use of brushless DC motor and its control in electric vehicle.
- To explain the optimization techniques and control strategies for active magnetic bearing (AMB) system for electric vehicle.
- To explain the modelling and analysis of power converters and hybrid energy storage system foe electric vehicles.

**Module-1**

**IoT-Based Battery Management System for Hybrid Electric Vehicle:** IoT Based Battery Management System (BMS) for Hybrid Electric Vehicles (HEV) : Introduction, Battery configuration, Types of batteries for HEV and Electric Vehicles (EV), Functional Blocks of Battery Management Systems, IoT based BMS.

**Module-2**

**Brushless Direct Current Motor Drive Using Artificial Intelligence for Optimum Operation of the Electric Vehicle:** Basics of Artificial Intelligence, Advantages of Artificial Intelligence in EV, Brushless DC Motor, Mathematical Representation Brushless DC Motor, Closed-Loop Model of BLDC Motor Drive, PID Controller, Fuzzy Control, Auto-Tuning Type Fuzzy PID Controller, Genetic Algorithm, Artificial Neural Network-Based Controller, BLDC Motor Speed Controller with ANN Based PID Controller, Analysis of Different Speed Controllers.

**Module-3**

**Optimization Techniques Used in Active Magnetic Bearing System for Electric Vehicles:** Basic Components of an Active Magnetic Bearing (AMB), Active Magnetic Bearing in Electric Vehicles System, Control Strategies for AMB in EVs.

**Module-4**

**Small-Signal Modeling Analysis of Three-Phase Power Converters for EV Applications:** Introduction, Overall System Modeling, Mathematical Modeling and Analysis of Small Signal Modeling.

**Module-5**

**Energy Management of Hybrid Energy Storage System (HESS) in PHEV With Various Driving Mode:** Introduction, Problem Description, and Formulation, Modeling of HESS and its Analysis.

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

- Discuss IoT Based Battery Management System and type of batteries for EV and HEV.
- Explain AI Based BLDC drive for optimum operation of EV.
- Explain Active Magnetic Bearing system for EVs.
- Model and analyse three phase converters for EV applications.
- Model and analyse Energy Management of HESS in PHEV.

**Question paper pattern:**

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub-questions) from each module.
- Each full question will have sub-question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.
| 1 | Artificial Intelligent Techniques for Electric and Hybrid Electric Vehicles | Chitra A, P. Sanjeevikumar, and S. Himavathi | Wiley | 2020 |
### COURSE CODE: 18EE744

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</table>

#### Course Learning Objectives:
- To understand the basic concept of smart grid, attributes of Smart Grid
- To describe the overview of the perfect power system configuration
- To know about DC power delivering systems, data centres and information technology loads
- To educate the importance of Technology Alternatives in smart Grid
- To understand the Dynamic energy systems in Smart Grid
- To describe the overview of Demand side planning and evaluation.

### Module-1

**Introduction:** Introduction to smart grid, electricity network, local energy networks, electric transportation, low carbon central generation, attributes of the smart grid.

**Smart Grid to Evolve a Perfect Power System:** Introduction, overview of the perfect power system configurations, device level power system, building integrated power systems, distributed power systems, fully integrated power system.

### Module-2

**DC Distribution and Smart Grid:** AC Vs. DC sources, benefits of and drives of DC power delivery systems, powering equipment and appliances with DC, data centers and information technology loads, potential future work and research

**Intelligrid Architecture for the Smart Grid:** Introduction, launching intelligrid, intelligrid today, smart grid vision based on the intelligrid architecture.

### Module-3

**Dynamic Energy Systems Concept:** Smart energy efficient end use devices, smart distributed energy resources, advanced whole building control systems, integrated communications architecture, energy management, role of technology in demand response, current limitations to dynamic energy management, distributed energy resources, overview of a dynamic energy management, key characteristics of smart devices, key characteristics of advanced whole building control systems, key characteristics of dynamic energy management system.

### Module-4

**Efficient Electric End Use Technology Alternatives:** Existing technologies, lighting, space conditioning, indoor air quality, domestic water heating, hyper efficient appliances, ductless residential heat pumps and air conditioners, variable refrigerant flow air conditioning, heat pump water heating, hyper efficient residential appliances, data center energy efficiency, LED street and area lighting, industrial motors and drives, equipment retrofit and replacement, process heating, cogeneration, thermal energy storage, industrial energy management programs, manufacturing process, electro -technologies, residential, commercial and industrial sectors.

### Module-5


**Demand-Side Evaluation:** Levels of Analysis. General Information Requirements, Context, Transferability, Data Requirement, Cost/Benefit Analysis, Program Interaction.

### Course Outcomes:
At the end of the course the student will be able to:
- Explain the concept of Smart grid enables the ElectricNet and need of smart grid.
- Outline the benefits and drivers of DC Power delivery system.
- Summarize the Intelligrid Architecture for the smart grid.
- Explain the Efficient Electric End-use Technology Alternatives.
- Discuss Demand side planning and Evaluation.
Question paper pattern:
- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub-questions) from each module.
- Each full question will have sub-question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

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Textbook

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<tbody>
<tr>
<td>1</td>
<td>Smart Grid :Technology and Applications</td>
<td>Janaka Ekanayake et al</td>
<td>Wiley</td>
<td>2012</td>
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Reference Books
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**Course Learning Objectives:**
- To understand the fundamental concepts and models of Artificial Neural Systems.
- To understand neural processing, learning and adaptation, Neural Network learning rules.
- Ability to analyze multilayer feed forward networks.
- Ability to develop various ancillary techniques applied to power system and control of power systems.

**Module-1**

**Fundamental Concepts and Models of Artificial Neural Systems**

**Module-2**

**Neural Processing, Learning and Adaptation, Neural Network Learning Rules**

**Module-3**

**Multilayer Feedforward Networks**

**Module-4**

**Neural Network and its Ancillary Techniques as Applied to Power Systems**
- Introduction, Learning versus Memorization, Determining the Best Net Size, Network Saturation, Feature Extraction, Inversion of Neural Networks, Alternative Training Method: Genetic Based Neural Network, Fuzzified Neural Network.

**Module-5**

**Control of Power Systems**
- Introduction, Background, Neural Network Architectures for modeling and control, Supervised Neural Network Structures, Diagonal Recurrent Neural Network based Control System, Convergence and Stability.

**Course Outcomes:** At the end of the course the student will be able to:
- Develop Neural Network and apply elementary information processing tasks that neural network can solve.
- Develop Neural Network and apply powerful, useful learning techniques.
- Develop and Analyze multilayer feed forward network for mapping provided through the first network layer and error back propagation algorithm.
- Analyze and apply algorithmic type problems to tackle problems for which algorithms are not available.
- Develop and Analyze supervised/unsupervised, learning modes of Neural Network for different applications.

**Question paper pattern:**
- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub-questions) from each module.
- Each full question will have sub-question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

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<tr>
<td>1</td>
<td>Introduction to Artificial Neural Systems.</td>
<td>Jacek M. Zurada</td>
<td>JAICO Publishing House</td>
<td>2006</td>
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<tr>
<td>2</td>
<td>Artificial Neural Networks with Applications to Power Systems</td>
<td>Edited by – Mohamed El – Sharkawi and Dagmar Niebur</td>
<td>IEEE, Inc.</td>
<td>1996</td>
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</tbody>
</table>
Module-1

Introduction: The carbon cycle, Mitigating growth of the atmospheric carbon inventory, The process of technology innovation.

Overview of carbon capture and storage: Carbon capture, Carbon storage.

Power generation fundamentals: Physical and chemical fundamentals, Fossil-fueled power plant, Combined cycle power generation, Future developments in power-generation technology.

Module-2

Carbon capture from power generation: Introduction, Precombustion capture, Postcombustion capture, Oxyfuel combustion capture, Chemical looping capture systems, Capture-ready and retrofit power plant, Approaches to zero-emission power generation.

Carbon capture from industrial processes: Cement production, Steel production, Oil refining, Natural gas processing.

Absorption capture systems: Chemical and physical fundamentals, Absorption applications in post-combustion capture, Absorption technology RD and D status.

Module-3

Adsorption capture systems: Physical and chemical fundamentals, Adsorption process applications, Adsorption technology RD and D status.

Membrane separation systems: Physical and chemical fundamentals, Membrane configuration and preparation and module construction, Membrane technology RD and D status, Membrane applications in pre-combustion capture, Membrane and molecular sieve applications in oxyfuel combustion, Membrane applications in postcombustion CO₂ separation, Membrane applications in natural gas processing.

Module-4

Cryogenic and distillation systems: Physical Fundamentals, Distillation column configuration and operation, Cryogenic oxygen production for oxyfuel combustion, Ryan–Holmes process for CO₂ –CH₄ separation, RDand D in cryogenic and distillation technologies.

Mineral carbonation: Physical and chemical fundamentals, Current state of technology development, Demonstration and deployment outlook.

Geological storage: Introduction, Geological and engineering fundamentals, Enhanced oil recovery, Saline aquifer storage, Other geological storage options.

Module-5

Ocean storage: Introduction, Physical, chemical, and biological fundamentals, Direct CO₂ injection, Chemical sequestration, Biological sequestration.


Other sequestration and use options: Enhanced industrial usage, Algal biofuel production.

Carbon dioxide transportation: Pipeline transportation, Marine transportation.

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

- Discuss the impacts of climate change and the measures that can be taken to reduce emissions.
- Discuss carbon capture and carbon storage.
- Explain the fundamentals of power generation.
- Explain methods of carbon capture from power generation and industrial processes.
- Explain different carbon storage methods: storage in coal seams, depleted gas reservoirs and saline formations.
**Question paper pattern:**
The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.
- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

**Textbook**
B. E. ELECTRICAL AND ELECTRONICS ENGINEERING
CHOICE BASED CREDIT SYSTEM (CBCS) AND OUTCOME BASED EDUCATION (OBE)
SEMESTER – VII

ELECTRIC VEHICLES (OPEN ELECTIVE)

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Course objectives:
- To understand the fundamental laws and vehicle mechanics.
- To understand working of Electric Vehicles and recent trends.
- Ability to analyze different power converter topology used for electric vehicle application.
- Ability to develop the electric propulsion unit and its control for application of electric vehicles.

Module-1

Module-2

Module-3
Energy Storage for EV and HEV: Energy storage requirements, Battery parameters, Types of Batteries, Modelling of Battery, Fuel Cell basic principle and operation, Types of Fuel Cells, PEMFC and its operation, Modelling of PEMFC, Supercapacitors.

Module-4
Electric Propulsion:
EV consideration, DC motor drives and speed control, Induction motor drives, Permanent Magnet Motor Drives, Switch Reluctance Motor Drive for Electric Vehicles, Configuration and control of Drives.

Module-5
Design of Electric and Hybrid Electric Vehicles: Series Hybrid Electric Drive Train Design: Operating patterns, control strategies, Sizing of major components, power rating of traction motor, power rating of engine/generator, design of PPS Parallel Hybrid Electric Drive Train Design: Control strategies of parallel hybrid drive train, design of engine power capacity, design of electric motor drive capacity, transmission design, energy storage design.

Course outcomes:
At the end of the course the student will be able to:
- Explain the roadway fundamentals, laws of motion, vehicle mechanics and propulsion system design.
- Explain the working of electric vehicles and hybrid electric vehicles in recent trends.
- Model batteries, Fuel cells, PEMFC and super capacitors.
- Analyze DC and AC drive topologies used for electric vehicle application.
- Develop the electric propulsion unit and its control for application of electric vehicles.
### Question paper pattern:
- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub-questions) from each module.
- Each full question will have sub-question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

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<tr>
<td>1</td>
<td>Electric and Hybrid Vehicles: Design Fundamentals</td>
<td>Iqbal Husain</td>
<td>CRC Press</td>
<td>2003</td>
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<tr>
<td>2</td>
<td>Modern Electric Vehicle Technology</td>
<td>C.C. Chan and K.T. Chau</td>
<td>OXFORD University</td>
<td>2001</td>
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<td>1</td>
<td>Hybrid Electric Vehicles Principles And Applications With Practical Perspectives</td>
<td>Chris Mi, M. Abul Masrur, David Wenzhong Gao</td>
<td>Wiley Publication</td>
<td>2011</td>
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**B. E. ELECTRICAL AND ELECTRONICS ENGINEERING**

**CHOICE BASED CREDIT SYSTEM (CBCS) AND OUTCOME BASED EDUCATION (OBE)**

**SEMESTER – VII**

**DISASTERS MANAGEMENT (OPEN ELECTIVE)**

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**Course Learning Objectives:**
- To explain disaster management, its planning, occurrence of cyclones and their hazard potential
- To explain the role of IMD, cyclone prediction and cyclone warning system in India
- To explain the role of different institutions, defence and other services in natural disaster management.
- To explain the role of Central Water Commission in river water sharing, draught, its assessment and draught management plan
- To explain reasons for the occurrence of earthquake, Tsunamis and thunderstorms.

**Module-1**

**Disaster Management Plan (DMP):** - General.

**Cyclones and their Hazard Potential:** Classification of Low-Pressure Systems, Statistics of Cyclonic Storms Over Indian Seas, Movement of Cyclones in Indian Seas, Storm Surges.

**Module-2**

**India Meteorological Department and Cyclone Warnings in India:** Hazard Potential of Cyclonic Storms, Cyclone Prediction and Dissemination of Warnings, Dissemination of Cyclone Warnings through INSAT, Port Warnings with Day and Night hoisting Sib'Talas.

**Cyclones Disaster Management – Plan:** Hazard Potentials Associated with Cyclones, Vulnerability Reduction, Early Warning.

**Module-3**

**Action Plan for Cyclone Disaster Management.**

**Role of Different Institutions in Natural Disaster Management:** Role of Zilla Parishad, Role of PRA Groups in Disaster Management, Role of NGOs, Self Help Groups in Disaster Management, Role of Red Cross in Disaster Management.

**The Role of Defence and other Services in Disaster Management:** Role of Air Force in Disaster Management, Role of Medical and Health Department in Cyclone disaster management, National Disaster Response Force (NDRF), Role of Remote Sensing in Disaster Management, Role of Broadcast, Educational Media in disaster management.

**Module-4**

**Floods:** Water Wealth of India, Definition of Flood, Role of Central Water Commission, Monsoons, Flood Warning Signals and Precautionary Actions, Water Purification Technologies in Flood Affected Areas.

**Drought:** Meteorological Drought, Breaks in the Monsoon, Drought Management Plan, Drought Years for Different Met Subdivision of India, Drought Assesment, Drought Parameters, Role of Banking, Insurance, Microfinance in drought mitigation, Drought Monitoring, Drought Research Unit (IMD), Rainwater harvesting.

**Module-5**

**Earthquakes:** Interior Structure of the Earth, Plate Tectonics, Seismicity of India, Earthquake Forecast and disaster management, Tsunamis, Landslides and Avalanches, Volcanoes.

**Hazards associated with Convective Clouds:** Climatology of World Thunderstorms, Lightning, Some Effects of Electric Shock, Favours and Frownings of Thunderstorms, Hailstorms, Tornadoes, Waterspouts, Dust-Devils, Nowcasting, Summer Thunderstorms over India, Cold Waves and Heat Waves - Cold Waves in India, Heat Waves in India.

**Course Outcomes:** At the end of the course the student will be able to:
- Discuss disaster management plan, cyclones and their hazard potential
- Understand the role of IMD and cyclone prediction and cyclone warning system in India
- Understand the role of different institutions defence and other services in natural disaster management.
- Understand the role of Central Water Commission in river water sharing, Draught, its assessment and draught management plan
• Understand occurrence of earthquake, Tsunamis and thunderstorms.

**Question paper pattern:**
• The question paper will have ten full questions carrying equal marks.
• Each full question will be for 20 marks.
• There will be two full questions (with a maximum of four sub-questions) from each module.
• Each full question will have sub-question covering all the topics under a module.
• The students will have to answer five full questions, selecting one full question from each module.

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Course Code: 18EE754
CIE Marks: 40

Teaching Hours/Week (L:T:P): (3:0:0)
SEE Marks: 60

Credits: 03
Exam Hours: 03

Course objectives:
• Understand the current energy scenario and importance of energy conservation.
• Understand the methods of improving energy efficiency in different electrical systems.
• Realize energy auditing.
• Explain about various pillars of electricity market design.
• To explain the scope of demand side management, its concept and implementation issues and strategies.

Module-1
Energy Scenario: Commercial and Non-commercial energy, primary energy resources, commercial energy production, final energy consumption, energy needs of growing economy, long term energy scenario, energy pricing, energy sector reforms, energy and environment, energy security, energy conservation and its importance, restructuring of the energy supply sector, energy strategy for the future, air pollution, climate change. Energy Conservation Act-2001 and its features.

Module-2
Energy Efficiency in Electrical Systems: Electricity billing, Electrical load management and maximum demand Control, Maximum demand controllers; Power factor improvement, Automatic power factor controllers, efficient operation of transformers, energy efficient motors, Soft starters, Variable speed drives; Performance evaluation of fans and pumps, Flow control strategies and energy conservation opportunities in fans and pumps, Electronic ballast, Energy efficient lighting and measures of energy efficiency in lighting system.

Module-3
Energy auditing: Introduction, Elements of energy audits, different types of audit, energy use profiles, measurements in energy audits, presentation of energy audit results.

Module-4
Electricity vis-à-vis Other Commodities: Distinguishing features of electricity as a commodity, Four pillars of market design: Imbalance, Scheduling and Dispatch, Congestion Management, Ancillary Services. Framework of Indian power sector and introduction to the availability based tariff (ABT).

Module-5

Course outcomes:
At the end of the course the student will be able to:
• Analyze about energy scenario nationwide and worldwide, also outline Energy Conservation Act and its features.
• Discuss load management techniques and energy efficiency.
• Understand the need of energy audit and energy audit methodology.
• Understand various pillars of electricity market design.
• Conduct energy audit of electrical systems and buildings.
• Show an understanding of demand side management and energy conservation.
**Question paper pattern:**
- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub-questions) from each module.
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<td>W.C. Turner</td>
<td>John Wiley and Sons</td>
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<td>2</td>
<td>Energy Efficient Electric Motors and Applications</td>
<td>H.E. Jordan</td>
<td>Plenum Pub. Corp</td>
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<tr>
<td>3</td>
<td>Energy Management</td>
<td>W. R. Murphy, G. Mckay</td>
<td>Butterworths</td>
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<table>
<thead>
<tr>
<th>Reference Books</th>
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<tr>
<td>2</td>
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</table>
**B. E. ELECTRICAL AND ELECTRONICS ENGINEERING**

*Choice Based Credit System (CBCS) and Outcome Based Education (OBE)*

**SEMESTER – VII**

**POWER SYSTEM SIMULATION LABORATORY**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>CIE Marks</th>
<th>SEE Marks</th>
<th>Exam Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>18EE76</td>
<td>40</td>
<td>60</td>
<td>03</td>
</tr>
</tbody>
</table>

**Number of Practical Hours/Week(L:T:P)**

| Credits | 02 |

**Course Learning Objectives:**

To explain the use of standard software package:

(Ex: MATLAB/C or C++/Scilab/Octave/Python software)

- To assess the performance of medium and long transmission lines.
- To obtain the power angle characteristics of salient and non-salient pole alternator.
- To study transient stability of radial power systems under three phase fault conditions.
- To develop admittance and impedance matrices of interconnected power systems.
- To explain the use of suitable standard software package.
- To solve power flow problem for simple power systems.
- To perform fault studies for simple radial power systems.
- To study optimal generation scheduling problems for thermal power plants.

**Sl. No.** | **Experiments** |
--- | --- |
1 | Formation for symmetric $\pi / T$ configuration for Verification of Determination of Efficiency and Regulation. |
2 | Determination of Power Angle Diagrams, Reluctance Power, Excitation, EMF and Regulation for Salient and Non-Salient Pole Synchronous Machines. |
3 | To obtain Swing Curve and to Determine Critical Clearing Time, Regulation, Inertia Constant/Line Parameters/Fault Location/Clearing Time/Pre-Fault Electrical Output for a Single Machine connected to Infinite Bus through a Pair of identical Transmission Lines Under 3-Phase Fault On One of the two Lines. |
4 | Y Bus Formation for Power Systems with and without Mutual Coupling, by Singular |
5 | Formation of Z Bus(without mutual coupling) using Z-Bus Building Algorithm. |
6 | Determination of Bus Currents, Bus Power and Line Flow for a Specified System Voltage |
7 | Formation of Jacobian for a System not Exceeding 4 Buses in Polar Coordinates. |
8 | Load Flow Analysis using Gauss Siedel Method, NR Method and Fast Decoupled Method for both PQ and PV Buses. |
9 | To Determine Fault Currents and Voltages in a Single Transmission Line System with |
10 | Optimal Generation Scheduling for Thermal power plants by simulation. |

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

- Develop a program in suitable package to assess the performance of medium and long transmission lines.
- Develop a program in suitable package to obtain the power angle characteristics of salient and non-salient pole alternator.
- Develop a program in suitable package to assess the transient stability under three phase fault at different locations in a of radial power systems.
- Develop programs in suitable package to formulate bus admittance and bus impedance matrices of interconnected power systems.
- Use suitable package to solve power flow problem for simple power systems.
- Use suitable package to study unsymmetrical faults at different locations in radial power systems.
- Use of suitable package to study optimal generation scheduling problems for thermal power plants.
**Conduct of Practical Examination:**
1. All laboratory experiments are to be included for practical examination.
2. Breakup of marks and the instructions printed on the cover page of answer script to be strictly adhered by the examiners.
3. Students can pick one experiment from the questions lot prepared by the examiners.
4. Change of experiment is allowed only once and 15% Marks allotted to the procedure part to be made zero.
**B. E. ELECTRICAL AND ELECTRONICS ENGINEERING**

Choice Based Credit System (CBCS) and Outcome Based Education (OBE)

**SEMESTER – VII**

**RELAY AND HIGH VOLTAGE LABORATORY**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>18EEEL77</th>
<th>CIE Marks</th>
<th>40</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Practical Hours/Week</td>
<td>0:2:2</td>
<td>SEE Marks</td>
<td>60</td>
</tr>
<tr>
<td>Credits</td>
<td>02</td>
<td>Exam Hours</td>
<td>03</td>
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</table>

**Course Learning Objectives:**
- To conduct experiments to verify the characteristics of over current, over voltage, under voltage relays both electromagnetic and static type.
- To verify the operation of negative sequence relay.
- To conduct experiments to verify the characteristics of microprocessor based over current, over voltage, under voltage relays and distance relay.
- To conduct experiments on generator, motor and feeder protection.
- To conduct experiments to study the spark over characteristics for both uniform and non-uniform configurations using High AC and DC voltages.
- To measure high AC and DC voltages
- To experimentally measure the breakdown strength of transformer oil.
- To experimentally measure the capacitance of different electrode configuration models using Electrolytic Tank. To generate standard lightning impulse voltage and determine efficiency, energy of impulse generator and 50% probability flashover voltage for air insulation.

<table>
<thead>
<tr>
<th>SL NO</th>
<th>Experiments</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total of Six experiments are to be conducted by selecting Two experiments from each Part – A, Part – B and Part – C. Five out of six experiments are to be conducted under Part – D.</strong></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td><strong>Part - A</strong> Over Current Relay: (a) Inverse Definite Minimum Time (IDMT) Non-Directional Characteristics (b) Directional Features (c) IDMT Directional.</td>
</tr>
<tr>
<td>2</td>
<td>IDMT Characteristics of Over Voltage or Under Voltage Relay (Solid State or Electromechanical type).</td>
</tr>
<tr>
<td>3</td>
<td>Operation of Negative Sequence Relay.</td>
</tr>
<tr>
<td>4</td>
<td><strong>Part - B</strong> Operating Characteristics of Microprocessor Based (Numeric) Over – Current Relay.</td>
</tr>
<tr>
<td>5</td>
<td>Operating Characteristics of Microprocessor Based (Numeric) Distance Relay.</td>
</tr>
<tr>
<td>6</td>
<td>Operating Characteristics of Microprocessor Based (Numeric) Over/Under Voltage</td>
</tr>
<tr>
<td>7</td>
<td><strong>Part - C</strong> Generation Protection: Merz Price Scheme.</td>
</tr>
<tr>
<td>8</td>
<td>Feeder Protection against Faults.</td>
</tr>
<tr>
<td>9</td>
<td>Motor Protection against Faults.</td>
</tr>
<tr>
<td>10</td>
<td><strong>Part - D</strong> Spark Over Characteristics of Air subjected to High Voltage AC with Spark Voltage Corrected to Standard Temperature and Pressure for Uniform [as per IS1876: 2005] and Non-uniform [as per IS2071(Part 1): 1993] Configurations: Sphere – Sphere, Point – Plane,</td>
</tr>
<tr>
<td>11</td>
<td>Spark Over Characteristics of Air subjected to High voltage DC.</td>
</tr>
<tr>
<td>12</td>
<td>Measurement of HVAC and HVDC using Standard Spheres as per IS 1876:2005</td>
</tr>
<tr>
<td>13</td>
<td>Measurement of Breakdown Strength of Transformer Oil as per IS 1876 :2005</td>
</tr>
<tr>
<td>14</td>
<td>Field Mapping using Electrolytic Tank for any one of the following Models: Cable/Capacitor/</td>
</tr>
<tr>
<td>15</td>
<td>(a) Generation of standard lightning impulse voltage and to determine efficiency and energy of impulse generator. (b) To determine 50% probability flashover voltage for air insulation subjected to impulse voltage.</td>
</tr>
</tbody>
</table>
Course Outcomes: At the end of the course the student will be able to:

- Verify the characteristics of over current, over voltage, under voltage and negative sequence relay both electromagnetic and static type.
- Verify the characteristics of microprocessor based over current, over voltage, under voltage relays and distance relay.
- Show knowledge of protecting generator, motor and feeders.
- Analyze the spark over characteristics for both uniform and non-uniform configurations using High A and DC voltages.
- Measure high AC and DC voltages and breakdown strength of transformer oil.
- Draw electric field and measure the capacitance of different electrode configuration models.
- Show knowledge of generating standard lightning impulse voltage to determine efficiency, energy of impulse generator and 50% probability flashover voltage for air insulation.

Conduct of Practical Examination:
1. All laboratory experiments are to be included for practical examination.
2. Breakup of marks and the instructions printed on the cover page of answer script to be strictly adhered by the examiners.
3. Students can pick one experiment from the questions lot prepared by the examiners.
4. Change of experiment is allowed only once and 15% Marks allotted to the procedure part to be made zero.
**Course Learning Objectives:**

- Support independent learning.
- Guide to select and utilize adequate information from varied resources maintaining ethics.
- Guide to organize the work in the appropriate manner and present information (acknowledging the sources) clearly.
- Develop interactive, communication, organization, time management, and presentation skills.
- Impart flexibility and adaptability.
- Inspire independent and team working.
- Expand intellectual capacity, credibility, judgment, intuition.
- Adhere to punctuality, setting and meeting deadlines.
- Instil responsibilities to oneself and others.
- Train students to present the topic of project work in a seminar without any fear, face audience confidently, enhance communication skill, involve in group discussion to present and exchange ideas.

**Project Phase-1**

Students in consultation with the guide/s shall carry out literature survey/visit industries to finalize the topic of the Project. Subsequently, the students shall collect the material required for the selected project, prepare synopsis and narrate the methodology to carry out the project work.

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

- Demonstrate a sound technical knowledge of their selected project topic.
- Undertake problem identification, formulation and solution.
- Design engineering solutions to complex problems utilizing a systems approach.
- Communicate with engineers and the community at large in written and oral forms.

**Continuous Internal Evaluation**

CIE marks for the project phase I 100 marks.

1. Report 50 marks
2. Partial result and presentation 50 marks

Marks shall be awarded (based on the quality of report and presentation skill, participation in the question and answer session by the student) by the committee constituted for the purpose by the Head of the Department. The committee shall consist of three faculty from the department with the senior most acting as the Chairman.