Switchgear and Protection		Semester	VII
Course Code	BEE701	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3:0:2:0	SEE Marks	50
Total Hours of Pedagogy	40 hours Theory + 10 Lab slots	Total Marks	100
Credits	04	Exam Hours	03
Examination nature (SEE)	Theory		

Course objectives:

- To discuss performance of protective relays, components of protection scheme and relay terminology.
- To explain Over current protection using electromagnetic and static relays and Over current protective schemes and microprocessor -based Protective Relays.
- To discuss pilot protection; wire pilot relaying and carrier pilot relaying differential protection, 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.
- Experimentally verify the characteristics of over current, over voltage, under voltage using electromagnetic, static, distance and impedance relays.
- To discuss protection Against Over voltages and Gas Insulated Substation (GIS).
- To discuss the construction, operating principles and performance characteristics of protective devices.
- To conduct experiments and verify the characteristics of electromechanical and microprocessor based relays.
- To verify the operation of motor protection for different faults

Teaching-Learning Process (General Instructions)

These are sample Strategies, which teachers can use to accelerate the attainment of the various course outcomes.

1. Lecturer method (L) needs not to be only traditional lecture method, but alternative effective teaching methods could be adopted to attain the outcomes.
2. Use of Video/Animation to explain functioning of various concepts.
3. Encourage collaborative (Group Learning) Learning in the class.
4. Ask at least three HOT (Higher order Thinking) questions in the class, which promotes critical thinking.
5. Adopt Problem Based Learning (PBL), which fosters students' Analytical skills, develop design thinking skills such as the ability to design, evaluate, generalize, and analyse information rather than simply recall it.
6. Introduce Topics in manifold representations.
7. Show the different ways to solve the same problem with different circuits/logic and encourage the students to come up with their own creative ways to solve them.
8. Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding.

MODULE-1

Introduction to Power System Protection: Need for protective schemes, Nature and Cause of Faults, Types of Fault, Effects of Faults, Fault Statistics, Zones of Protection, Primary and Backup Protection, Essential Qualities of Protection, Performance of Protective Relaying, Classification of Protective Relays, Automatic Reclosing, Current Transformers for protection, Voltage Transformers for Protection.

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

Overcurrent Protection Introduction, Time – current Characteristics, Current Setting, Time Setting. Overcurrent Protective Schemes, Reverse Power or Directional Relay, Protection of Parallel Feeders, Protection of Ring Mains, Earth Fault and Phase Fault Protection, Combined Earth Fault and Phase Fault Protective Scheme, Phase Fault Protective Scheme, Directional Earth Fault Relay, Static Overcurrent Relays, Numerical Overcurrent Relays.

Microprocessor -based Protective Relays: Introduction, Overcurrent relays, Impedance relay.

MODULE-3

Pilot Relaying Schemes: Introduction, Wire Pilot Protection, Carrier Current Protection.

Differential Protection: Introduction, Differential Relays, Simple Differential Protection, Percentage or Biased Differential Relay, Differential Protection of 3 Phase Circuits, Balanced (Opposed) Voltage Differential Protection.

Rotating Machines Protection: Introduction, Protection of Generators.

Transformer and Bus zone Protection: Introduction, Transformer Protection, Bus zone Protection, Frame Leakage Protection.

MODULE-4

Circuit Breakers: Introduction, Fault Clearing Time of a Circuit Breaker, Arc Voltage, Arc Interruption, Restriking Voltage and Recovery Voltage, Current Chopping, Interruption of Capacitive Current, Classification of Circuit Breakers, Air – Break Circuit Breakers, Oil Circuit Breakers, Air – Blast Circuit Breakers, SF6 Circuit Breakers, Vacuum Circuit Breakers, High Voltage Direct Current Circuit Breakers, Rating of Circuit Breakers, Testing of Circuit Breakers.

MODULE-5

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

Protection against Over voltages: 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).

PRACTICAL COMPONENT OF IPCC (Any 10 Experiments. But recommended to carryout others experiments)

Sl.NO	Experiments
1	Over Current Relay: (a) Inverse Definite Minimum Time (IDMT) Non - Directional Characteristics (b) Directional Features (c) IDMT Directional.
2	IDMT Characteristics of Over Voltage or Under Voltage Relay (Solid State or Electromechanical type).

3	Operation of Negative Sequence Relay.
4	IDMT Characteristics of Over Voltage or Under Voltage Relay (Solid State or Electromechanical type)
5	Operating Characteristics of Microprocessor Based (Numeric) Over –Current Relay
6	Operating Characteristics of Microprocessor Based (Numeric) Distance Relay.
7	Operating Characteristics of Microprocessor Based (Numeric) Over/Under Voltage Relay.
8	Generation Protection: Merz Price Scheme.
9	Feeder Protection against Faults.
10	Motor Protection against Faults.
11	Fuse Characteristics
12	Measurement of Breakdown Strength of Transformer Oil as per IS 1876 :2005
13	Field Mapping using Electrolytic Tank for any one of the following Models: Cable/ Capacitor/ Transmission Line/ Sphere Gap.

Course outcomes (Course Skill Set):

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

1. Discuss the general concepts of power system protection, construction and operation of relays.
2. Explain the construction and operation of different types of overcurrent relays and protection schemes.
3. Discuss pilot protection, construction, operating principles and performance of differential relays and discuss protection of generators, motors, transformer and Bus Zone Protection.
4. Explain the construction and operation of different types of circuit breakers.
5. Outline features of fuse, causes of over voltages and its protection, also modern trends in Power System Protection.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). The student is declared as a pass in the course if he/she secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

The IPCC means the practical portion integrated with the theory of the course. CIE marks for the theory component are **25 marks** and that for the practical component is **25 marks.**

CIE for the theory component of the IPCC

- 25 marks for the theory component are split into **15 marks** for two Internal Assessment Tests (Two Tests, each of 15 Marks with 01-hour duration, are to be conducted) and **10 marks** for other assessment methods mentioned in 22OB4.2. The first test at the end of 40-50% coverage of the syllabus and the second test after covering 85-90% of the syllabus.

- Scaled-down marks of the sum of two tests and other assessment methods will be CIE marks for the theory component of IPCC (that is for **25 marks)**.
- The student has to secure 40% of 25 marks to qualify in the CIE of the theory component of IPCC.

CIE for the practical component of the IPCC

- **15 marks** for the conduction of the experiment and preparation of laboratory record, and **10 marks** for the test to be conducted after the completion of all the laboratory sessions.
- On completion of every experiment/program in the laboratory, the students shall be evaluated including viva-voce and marks shall be awarded on the same day.
- The CIE marks awarded in the case of the Practical component shall be based on the continuous evaluation of the laboratory report. Each experiment report can be evaluated for 10 marks. Marks of all experiments' write-ups are added and scaled down to **15 marks**.
- The laboratory test **(duration 02/03 hours)** after completion of all the experiments shall be conducted for 50 marks and scaled down to **10 marks.**
- Scaled-down marks of write-up evaluations and tests added will be CIE marks for the laboratory component of IPCC for **25 marks**.
- The student has to secure 40% of 25 marks to qualify in the CIE of the practical component of the IPCC.

SEE for IPCC

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the course (**duration 03 hours**)

1. The question paper will have ten questions. Each question is set for 20 marks.
2. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.
3. The students have to answer 5 full questions, selecting one full question from each module.
4. Marks scored by the student shall be proportionally scaled down to 50 Marks

The theory portion of the IPCC shall be for both CIE and SEE, whereas the practical portion will have a CIE component only. Questions mentioned in the SEE paper may include questions from the practical component.

- The minimum marks to be secured in CIE to appear for SEE shall be 10 (40% of maximum marks-25) in the theory component and 10 (40% of maximum marks -25) in the practical component. The laboratory component of the IPCC shall be for CIE only. However, in SEE, the questions from the laboratory component shall be included. The maximum of 04/05 sub-questions are to be set from the practical component of IPCC, the total marks of all questions should not be more than 20 marks.
- SEE will be conducted for 100 marks and students shall secure 35% of the maximum marks to qualify for the SEE. Marks secured will be scaled down to 50.
- The student is declared as a pass in the course if he/she secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Suggested Learning Resources:

Text Books

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

2. Power System Protection and Switchgear Bhuvanesh Oza et al McGraw Hill 1st Edition, 2010

Reference Books

1. Protection and Switchgear Bhavesh et al Oxford 1st Edition, 2011
2. Power System Switchgear and Protection N. Veerappan S.R. Krishnamurthy S. Chand 1st Edition, 2009
3. Fundamentals of Power System Protection Y.G.Paithankar S.R. Bhide PHI 1st Edition, 2009

Web links and Video Lectures (e-Resources):

- https://nptel.ac.in
- http:// acl.digimat.in/nptel/courses/video/108105017/108105017.html

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

Quizzes, Seminars

Visit substations

Industries related to manufacturing of relays and circuit breakers

B. E. ELECTRICAL AND ELECTRONICS ENGINEERING CHOICE BASED CREDIT SYSTEM (CBCS) AND OUTCOME BASED EDUCATION (OBE) SEMESTER – VII			
INDUSTRIAL DRIVES AND APPLICATION (PCC)			
Course Code	BEE702	CIE Marks	50
Teaching Hours/Week (L:T:P)	(3:0:0)	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	04	Exam Hours	03
Examination nature (SEE)	Theory		

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.
Dynamics of Electrical Drives: Fundamental Torque Equations, Speed Torque Conventions and Multi-quadrant Operation. Equivalent values of Drive parameters, Components of Load Torques, Nature and Classification of Load Torques, Calculation of Time and Energy Loss in Transient Operations, Steady State Stability, Load Equalization.
Control Electrical Drives: Modes of Operation, Speed Control and Drive Classifications, Closed loop Control of Drives. Phase locked Loop control (PLL)

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. 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 inverter (CSI) Control, Comparision of VSI and CSI, current regulated voltage source inverter control, speed control of single phase induction motors.

Module-4

Synchronous Motor Drives: Operation from fixed frequency supply-starting, synchronous motor variable speed drives, variable frequency control of multiple synchronous motors. Self-controlled synchronous motor drive employing loadcommutated 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.

Module-5

Energy conservation in Electrical Drives: Losses in electrical drive system, Measures for energy conservation in Electrical drives, Energy efficient operation of drive, use of right rating motors, improvement of quality of supply.
Solar powered Drives: Solar powered pump drives, solar powered Electric vehicles.
Industrial Drives: Textile Mills, Steel Rolling Mills, Cranes and Hoists, Machine Tools, use of single to three phase semiconductor converters in rural applications.

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

1. Explain the advantages, choice and control of electric drive
2. Explain the dynamics, generating and motoring modes of operation of electric drives
3. Analyze the performance & control of DC motor drives and AC motor drives using controlled rectifiers.
4. Analyze the solar powered drives.
5. Explain the application of drives in industry and in rural areas.

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.

Sl No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbooks				
1	Fundamentals of Electrical Drives	Gopal K. Dubey	Narosa Publishing	2nd Edition, 2001
2	Electrical Drives: Concepts and Applications (Refer to chapter 07 for Industrial Drives	Vedum Subrahmanyam	McGraw Hill	2nd Edition, 2011
Reference Books				
1	Electric Drives	N.K De, P.K. Sen	PHI Learning	1st Edition, 2009

POWER SYSTEM ANALYSIS II		Semester	VII
Course Code	BEE 703	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3:0:2:0	SEE Marks	50
Total Hours of Pedagogy	40 hours Theory + 10 Lab slots	Total Marks	100
Credits	04	Exam Hours	03
Examination nature (SEE)	Theory		

Course 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.
- 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.

Teaching-Learning Process (General Instructions)

These are sample Strategies; which teachers can use to accelerate the attainment for various course outcomes.

1. Lecturer method (L) needs not to be only tradition lecture method, but alternative effective teaching methods could be adopted to attain the outcomes.
2. Use of Video/Animation to explain functioning of various concepts.
3. Encourage collaborative (Group Learning) Learning in the class.
4. Ask at least three HOT (Higher order Thinking) questions in the class, which promotes critical thinking.
5. Adopt Problem Based Learning(PBL), which fosters students 'Analytical skills, develop design thinking Skill such as the ability to design, evaluates, generalize, and analyze information rather than simply recall it.
6. Introduce Topics in manifold representations.
7. Show the different ways to solve the same problem with different circuits/logic and encourage the students to come up with their own creative ways to solve them.
8. Discuss how every concept can be applied to the real world-and when that's possible, it helps improve the students understanding.

MODULE-1

Network Topology: Introduction and basic definitions of Elementary graph theory Tree, cut-set, loop. Formation of Incidence Matrices. Primitive network-Impedance form and admittance form, Formation of Y Bus by Singular Transformation. Y bus by Inspection Method. Illustrative examples.

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

Load Flow Studies(continued): Newton-Raphson method derivation in Polar form, Fast decoupled load flow method, Flow charts of LF methods. Comparison of Load Flow Methods. Illustrative examples

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

PRACTICAL COMPONENT OF IPCC

Sl.NO	Experiments
1	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. (Using suitable simulation package.)
2	Y-Bus Formation for Power Systems with and without Mutual Coupling, by Singular Transformation.
3	Y-Bus Formation for Power Systems without Mutual Coupling, by Inspection method
4	Formation of Z-Bus (without mutual coupling) using Z-Bus Building Algorithm.
5	Formation of Jacobian matrix in Polar Coordinates, for a System having less than 4 Buses.
6	Determination of Bus Currents, Bus Power and Line Flows, for a Specified System Voltage.
7	Load Flow Analysis using Gauss Siedal Method for the system with both PQ buses and PV Buses. By simulation
8	Load Flow Analysis using NR Method and Fast Decoupled Method for the system with both PQ buses and PV Buses. (Using suitable simulation package.)
9	Write a program to generate unit commitment schedule for a system with three units using priority listing method (priority based on least cost).
10	Optimal Generation Scheduling for Thermal power plants (Using suitable simulation package.)

Course outcomes (Course Skill Set):

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

1. Formulate network matrices and models for solving load flow problems.
2. Perform steady state power flow analysis of power systems using numerical iterative techniques.
3. Solve issues of economic load dispatch and unit commitment problems.
4. Analyse short circuit faults in power system networks using bus impedance matrix. Apply Point by Point method and Runge Kutta Method to solve Swing Equation.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). The student is declared as a pass in the course if he/she secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

The IPCC means the practical portion integrated with the theory of the course. CIE marks for the theory component are **25 marks** and that for the practical component is **25 marks.**

CIE for the theory component of the IPCC

- 25 marks for the theory component are split into **15 marks** for two Internal Assessment Tests (Two Tests, each of 15 Marks with 01-hour duration, are to be conducted) and **10 marks** for other assessment methods mentioned in 22OB4.2. The first test at the end of 40-50% coverage of the syllabus and the second test after covering 85-90% of the syllabus.

- Scaled-down marks of the sum of two tests and other assessment methods will be CIE marks for the theory component of IPCC (that is for **25 marks)**.
- The student has to secure 40% of 25 marks to qualify in the CIE of the theory component of IPCC.

CIE for the practical component of the IPCC

- **15 marks** for the conduction of the experiment and preparation of laboratory record, and **10 marks** for the test to be conducted after the completion of all the laboratory sessions.
- On completion of every experiment/program in the laboratory, the students shall be evaluated including viva-voce and marks shall be awarded on the same day.
- The CIE marks awarded in the case of the Practical component shall be based on the continuous evaluation of the laboratory report. Each experiment report can be evaluated for 10 marks. Marks of all experiments' write-ups are added and scaled down to **15 marks**.
- The laboratory test **(duration 02/03 hours)** after completion of all the experiments shall be conducted for 50 marks and scaled down to **10 marks.**
- Scaled-down marks of write-up evaluations and tests added will be CIE marks for the laboratory component of IPCC for **25 marks**.
- The student has to secure 40% of 25 marks to qualify in the CIE of the practical component of the IPCC.

SEE for IPCC

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the course (**duration 03 hours**)

1. The question paper will have ten questions. Each question is set for 20 marks.
2. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.
3. The students have to answer 5 full questions, selecting one full question from each module.
4. Marks scored by the student shall be proportionally scaled down to 50 Marks

The theory portion of the IPCC shall be for both CIE and SEE, whereas the practical portion will have a CIE component only. Questions mentioned in the SEE paper may include questions from the practical component.

- The minimum marks to be secured in CIE to appear for SEE shall be 10 (40% of maximum marks-25) in the theory component and 10 (40% of maximum marks -25) in the practical component. The laboratory component of the IPCC shall be for CIE only. However, in SEE, the questions from the laboratory component shall be included. The maximum of 04/05 sub-questions are to be set from the practical component of IPCC, the total marks of all questions should not be more than 20 marks.
- SEE will be conducted for 100 marks and students shall secure 35% of the maximum marks to qualify for the SEE. Marks secured will be scaled down to 50.
- The student is declared as a pass in the course if he/she secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Suggested Learning Resources:

Books

1. Modern Power System Analysis, D P Kothari, I J Nagrath, McGraw Hill, 4th Edition, 2011.
2. Computer Methods in Power Systems Analysis, Glenn W. Stagg, Ahmed H Ei- Abiad, Scientific International, Pvt. Ltd,1stEdition, 2019.
3. Power Generation Operation and Control, AllenJ Wood etal, Wiley, 2nd Edition, 2016.
4. Computer Techniques in Power System Analysis, M.A. Pai,McGraw Hill, 2ndEdition, 2012.
5. Power System Analysis, Hadi Saadat, McGraw Hill, 2nd Edition, 2002.

Web links and Video Lectures (e-Resources):

https://nptel.ac.in/courses/108102047
https://nptel.ac.in/courses/108105067
https://nptel.ac.in/courses/108104051

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

Activity Based Learning, Quizzes, Seminars

Power System Operation and Control		Semester	VII
Course Code	**BEE714A**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3:0:0:0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03
Examination type (SEE)	Theory		

Course objectives:

- To describe various levels of controls in power systems and the vulnerability of the system.
- To explain components, architecture and configuration of SCADA.
- To explain basic generator control loops, functions of Automatic generation control, speed governors and mathematical models of Automatic Load Frequency Control
- To explain automatic generation control, voltage and reactive power control in an interconnected power system.
- To explain reliability and contingency analysis, state estimation and related issues.

Teaching-Learning Process (General Instructions)

These are sample Strategies, which teacher can use to accelerate the attainment of the various course outcomes.

1. Lecturer method (L)needs not to be only traditional lecture method, but alternative effective teaching methods could be adopted to attain the outcomes.
2. Use of Video/Animation to explain functioning of various concepts.
3. Encourage collaborative (Group Learning) Learning in the class.
4. Ask at least three HOT (Higher order Thinking) questions in the class, which promotes critical thinking.
5. Adopt Problem Based Learning(PBL),which fosters students' Analytical skills, develop design thinking skills

Such as the ability to design, evaluate, generalize, andanalyzeinformation rather than simply recall it.

6. Introduce Topics in manifold representations.
7. Show the different ways to solve the same problem with different circuits/logic and encourage the students to come up with their own creative ways to solve them.
8. Discuss how every concept can be applied to the real world -and when that's possible, it helps improve the students' understanding.

Module-1

Introduction: Operating States of Power System, Objectives of Control, Key Concepts of Reliable Operation, Preventive and Emergency Controls, Energy Management Centers.

Supervisory Control and Data acquisition (SCADA): Introduction, components, applicationin Power System, basic functions and advantages. Building blocks of SCADA system, components of RTU, communication subsystem, IED functional block diagram.

Classification of SCADA system: Single master–single remote; Single master–multiple RTU; Multiple master–multiple RTUs; and Singlemaster, multiple submaster, multiple remote.

Module-2

Automatic Generation Control(AGC): Introduction, Schematic diagram of load frequency and excitation voltage regulators of turbo generators.

Load frequency control(Single area case), Turbine speed governing system, Model of speed governing system, Turbine model, Generator load model, Complete block diagram of Representation of load frequency control of an isolated power system, Steady state analysis, Control area concept, Proportional plus Integral Controller

Module-3

Automatic Generation Control in Interconnected Power system: Two real load frequency control, Optimal(Two area) load frequency control by state variable, Automatic voltage control, Load frequency control with generation rate constraints (GRCs), Speed governor and its effect on AGC, Digital LF Controllers, Decentralized control.

Module-4

Control of Voltage and Reactive Power: Introduction, Generation and absorption of reactive power, Relation Between voltage, power and reactive power at a node, Methods of voltage control, Injection of reactive power, Shunt capacitors and reactors, Series capacitors, Synchronous compensators, Series injection. Tap changing transformers. Combined use of tap changing transformers and reactive power injection, Booster transformers, Phase shift transformers, Voltage collapse.

Module-5

Power System Security: Introduction, Factors affecting power system security, Contingency Analysis, Linear Sensitivity Factors, AC power flow methods, Contingency Selection and Ranking.

State estimation of Power Systems: Introduction, Linear Least Square Estimation.

Course outcome(Course Skill Set)

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

1. Describe various levels of controls in power systems, architecture and configuration of SCADA.
2. Develop and analyse mathematical models of Automatic Load Frequency Control.
3. Develop mathematical model of Automatic Generation Control in Interconnected Power system.
4. Discuss the Control of Voltage, Reactive Power and Voltage collapse.
5. Explain security, contingency analysis, and state estimation of power systems.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). The student is declared as a pass in the course if he/she secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

- There are 25 marks for the CIE's Assignment component and 25 for the Internal Assessment Test component.
- Each test shall be conducted for 25 marks. The first test will be administered after 40-50% of the coverage of the syllabus, and the second test will be administered after 85-90% of the coverage of the syllabus. The average of the two tests shall be scaled down to 25 marks
- Any two assignment methods mentioned in the 22OB2.4, if an assignment is project-based then only one assignment for the course shall be planned. The schedule for assignments shall be planned properly by the course teacher. The teacher should not conduct two assignments at the end of the semester if two assignments are planned. Each assignment shall be conducted for 25 marks. (If two assignments are conducted then the sum of the two assignments shall be scaled down to 25 marks)
- The final CIE marks of the course out of 50 will be the sum of the scale-down marks of tests and assignment/s marks.

Internal Assessment Test question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the course (**duration 03 hours).**

1. The question paper will have ten questions. Each question is set for 20 marks.
2. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.
3. The students have to answer 5 full questions, selecting one full question from each module.
4. Marks scored shall be proportionally reduced to 50 marks.

Suggested Learning Resources:

Books

1. Power System Operation and Control, K. Uma Rao, Wiley, 1st Edition, 2012.
2. Modern Power System Analysis, D. P.Kothari, McGraw Hill, 4thEdition, 2011.
3. Power Generation Operation and Control, Allen J Wood etal, Wiley, 2nd Edition, 2003.
4. Electric Power Systems, B M Weedy, B J Cory, Wiley. 4th Edition, 2012.

Web links and Video Lectures (e-Resources):

- https://nptel.ac.in/courses/108101040
- https://nptel.ac.in/courses/108104052

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

- Seminar, Quizzes

AI TECHNIQUES FOR ELECTRIC AND HYBRID ELECTRIC VEHICLES		Semester	VII
Course Code	**BEE714B**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3:0:0:0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	
Examination type (SEE)	Theory		

Course 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 for electric vehicles.

Teaching-Learning Process (General Instructions)

These are sample Strategies, which teachers can use to accelerate the attainment of the various course outcomes.

1. .

Module-1

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 outcome (Course Skill Set)

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

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

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). The student is declared as a pass in the course if he/she secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

- There are 25 marks for the CIE's Assignment component and 25 for the Internal Assessment Test component.
- Each test shall be conducted for 25 marks. The first test will be administered after 40-50% of the coverage of the syllabus, and the second test will be administered after 85-90% of the coverage of the syllabus. The average of the two tests shall be scaled down to 25 marks
- Any two assignment methods mentioned in the 22OB2.4, if an assignment is project-based then only one assignment for the course shall be planned. The schedule for assignments shall be planned properly by the course teacher. The teacher should not conduct two assignments at the end of the semester if two assignments are planned. Each assignment shall be conducted for 25 marks. (If two assignments are conducted then the sum of the two assignments shall be scaled down to 25 marks)
- The final CIE marks of the course out of 50 will be the sum of the scale-down marks of tests and assignment/s marks.

Internal Assessment Test question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the course (**duration 03 hours).**

1. The question paper will have ten questions. Each question is set for 20 marks.
2. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.
3. The students have to answer 5 full questions, selecting one full question from each module.
4. Marks scored shall be proportionally reduced to 50 marks.

Suggested Learning Resources:

Books

1. Artificial Intelligent Techniques for Electric and Hybrid Electric Vehicles, Chitra A, P. Sanjeevikumar, and S. Himavathi, Wiley, 2020.

Web links and Video Lectures (e-Resources):

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Activity Based Learning (Suggested Activities in Class)/ Practical Based learning •

Programmable Logic Controllers		Semester	VII
Course Code	BEE714C	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3:0:0:0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	
Examination type (SEE)	Theory		

Course objectives:

(1) To explain advantages and disadvantages, main parts and their functions, basic sequence of operation of PLC.
(2) To describe the hardware components: I/O modules, CPU, memory devices, other support devices and the functions of PLC memory map.
(3) To describe program scan sequence, the communication of information to the PLC using different languages, internal relay instruction.
(4) To explain identification of common operating modes found in PLCs, writing and entering the ladder logic programs.
(5) To define the functions of Relays, Contactors, Motor Starters, Switches, Sensors, Output Control Devices, Seal-In Circuits and Latching Relays.
(6) To explain conversion of relay schematics into PLC ladder logic programs and writing PLC programs directly from narrative descriptions.
(7) To explain the functions of PLC counter instructions, applying combinations of counters and timers to control systems.
(8) To describe the function of selectable timed interrupt and fault routine files and use of temporary end instruction.
(9) To explain the execution of data transfer instructions, interruption of data transfer and data compare instructions.
(10) To explain the basic operation of PLC closed-loop control system, various forms of mechanical sequencers and their operations.
(11) To describe the operation of bit and word shift registers and develop programs that use shift registers.
(12) To discuss the operation of various processes, structures of control systems and the method of communication between different industrial processes.

Teaching-Learning Process (General Instructions)

These are sample Strategies, which teachers can use to accelerate the attainment of the various course outcomes.

1 Lecturer method (L) needs not to be only traditional lecture method, but alternative effective teaching methods could be adopted to attain the outcomes.
2 Use of Video/Animation to explain functioning of various concepts.
3 Encourage collaborative (Group Learning) Learning in the class.
4 Ask at least three HOT (Higher order Thinking) questions in the class, which promotes critical thinking.
5 Adopt Problem Based Learning (PBL), which fosters students' Analytical skills, develop design thinking skills such as the ability to design, evaluate, generalize, and analyse information rather than simply recall it.
6 Introduce Topics in manifold representations.
7 Show the different ways to solve the same problem with different circuits/logic and encourage the students to come up with their own creative ways to solve them.
8 Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding.

Module-1

Programmable Logic Controllers: Introduction, Parts of a PLC, Principles of Operation, Modifying the Operation, PLCs versus Computers, PLC Size and Application.

PLC Hardware Components: The I/O Section, Discrete I/O Modules, Analog I/O Modules, Special I/O Modules, I/O Specifications, The Central Processing Unit (CPU), Memory Design, Memory Types, Programming Terminal Devices, Recording and Retrieving Data, Human Machine Interfaces (HMIs)

Basics of PLC Programming: Processor Memory Organization, Program Scan, PLC Programming Languages, Relay-Type Instructions, Instruction Addressing, Branch Instructions, Internal Relay Instructions, Programming Examine If Closed and Examine If Open Instructions, Entering the Ladder Diagram, Modes of Operation.

Module-2
Developing Fundamental PLC Wiring Diagrams and Ladder Logic Programs: Electromagnetic Control Relays, Contactors, Motor Starters, Manually Operated Switches, Mechanically Operated Switches, Sensors, Output Control Devices, Seal-In Circuits, Latching Relays, Converting Relay Schematics into PLC Ladder Programs, Writing a Ladder Logic Program Directly from a Narrative Description. **Programming Timers:** Mechanical Timing Relays, Timer Instructions, On-Delay Timer Instruction, Off-Delay Timer Instruction, Retentive Timer, Cascading Timers.
Module-3
Programming Counters: Counter Instructions, Up-Counter, Down-Counter, Cascading Counters, Incremental Encoder-Counter Applications, Combining Counter and Timer Functions. **Program Control Instructions:** Master Control Reset Instruction, Jump Instruction, Subroutine Functions, Immediate Input and Immediate Output Instructions, Forcing External I/O Addresses, Safety Circuitry, Selectable Timed Interrupt, Fault Routine, Temporary End Instruction, Suspend Instruction
Module-4
Data Manipulation Instructions: Data Manipulation, Data Transfer Operations, Data Compare Instructions, Data Manipulation Programs, Numerical Data I/O Interfaces, Closed-Loop Control. **Math Instructions:** Math Instructions, Addition Instruction, Subtraction Instruction, Multiplication Instruction, Division Instruction, Other Word-Level Math Instructions, File Arithmetic Operations
Module-5
Sequencer and Shift Register Instructions: Mechanical Sequencers, Sequencer Instructions, Sequencer Programs, Bit Shift Registers, Word Shift Operations. **Process Control, Network Systems, and SCADA:** Types of Processes, Structure of Control Systems, On/Off Control, PID Control, Motion Control, Data Communications, Supervisory Control and Data Acquisition (SCADA).
Course outcome (Course Skill Set) At the end of the course the student will be able to: 1. Describe the hardware components of PLC: I/O modules, CPU, memory devices, other support devices,operating modes and PLC programming. 2. Develop Fundamental PLC Wiring Diagrams and Ladder Logic Programs 3. Describe the operation of different program control instructions. 4. Discuss the execution of data transfer instructions, data compare instructions and the basic operation of PLC closed-loop control system. 5. Describe the operation of mechanical sequencers, bit and word shift registers, processes and structure of control systems and communication between the processes.
Assessment Details (both CIE and SEE) The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). The student is declared as a pass in the course if he/she secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

- There are 25 marks for the CIE's Assignment component and 25 for the Internal Assessment Test component.
- Each test shall be conducted for 25 marks. The first test will be administered after 40-50% of the coverage of the syllabus, and the second test will be administered after 85-90% of the coverage of the syllabus. The average of the two tests shall be scaled down to 25 marks
- Any two assignment methods mentioned in the 22OB2.4, if an assignment is project-based then only one assignment for the course shall be planned. The schedule for assignments shall be planned properly by the course teacher. The teacher should not conduct two assignments at the end of the semester if two assignments are planned. Each assignment shall be conducted for 25 marks. (If two assignments are conducted then the sum of the two assignments shall be scaled down to 25 marks)
- The final CIE marks of the course out of 50 will be the sum of the scale-down marks of tests and assignment/s marks.

Internal Assessment Test question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the course (**duration 03 hours).**

1. The question paper will have ten questions. Each question is set for 20 marks.
2. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.
3. The students have to answer 5 full questions, selecting one full question from each module.
4. Marks scored shall be proportionally reduced to 50 marks.

Suggested Learning Resources:

Books

Textbook

1. Programmable Logic Controllers, Frank D Petruzella, McGraw Hill, 4th Edition, 2011

Reference Books

1. Programmable Logic Controllers anEngineer's Guide, E A Parr Newnes, 3rd Edition, 2013
2. Introduction Programmable LogicControllers, Gary Dunning, Cengage, 3rd Edition, 2006

Web links and Video Lectures (e-Resources):

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Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

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B. E. ELECTRICAL AND ELECTRONICS ENGINEERING

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

SEMESTER – VII

BIG DATA ANALYTICS IN POWER SYSTEMS (PROFESSIONAL ELECTIVE)			
Course Code	BEE714D	CIE Marks	50
Teaching Hours/Week (L:T:P)	(3:0:0)	SEE Marks	50
Credits	03	Exam Hours	03

Course objectives:

- To define big data and to explain big data application and analytics to power systems.
- To explain the role of big data in smart grid communications and optimization of big data in electric power systems.
- To explain security methods for the infrastructure communication and data mining methods for theft detection in power systems.
- To explain the application of unit commitment method in the control of smart grid.
- To explain protection algorithm for transformer based on data pattern recognition

Module-1

Introduction: Big Data, Future Power Systems.

Big Data Application and Analytics in a Large - Scale Power System: Introduction, General Applications of Big Data, Algorithms for Processing Big Data, Application of Big Data in Power Systems.

Module-2

Role of Big Data in Smart Grid Communications: Introduction, The Grid Modernization, The Grid Interconnection with the Internet of Things, Data Traffic Pattern in a Smart Grid Environment, The Massive Flow of Information in a Smart Scenario ,The Volume of Generated Data in a Smart Distribution System: A Case of Study.

Big Data Optimization in Electric Power Systems: Introduction, Background, Scientometric Analysis of Big Data, Big Data and Power Systems, Optimization Techniques Used in the Big Data Analysis.

Module-3

Security Methods for Critical Infrastructure Communications: Introduction, Effects of Successful Communication System Threats, General Communication System Operations, Industrial Control Networks and Operations, High-Level Communication System Threats, Cyber Threats and Security.

Data - Mining Methods for Electricity Theft Detection: Introduction, Transmission and Distribution System Losses, Electricity Theft Methods, Data Mining and Electricity Theft, Issues and Directions in Electricity Theft-Related Data-Mining Research.

Module-4

Unit Commitment Control of Smart Grids: Introduction, Renewable Energy Resources, The Unit Commitment Problem, A Multi-agent Architecture, Illustrative Example.

Module-5

Transformer Differential Protection Algorithm Based on Data Pattern Recognition: Big Data and Power System Protection, Methods for Differential Protection Blocking, Principal Component Analysis, Curvilinear Component Analysis (CCA), PCA Applied to Discriminate Between Inrush and Fault, Currents in Transformers, Application of the CCA as a Base for a Differential Protection System Under Study, Results.

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

- Discuss role of big data and machine-learning methods applicable to power systems and in particular to Smart Grid communications.
- Discuss optimization methods which are suitable for big data models in power systems.
- Discuss various cyber security issues, electricity theft detection and mitigation that exist in IoT-enabled future power systems.
- Discuss renewable energy planning concerns associated with planned future power systems that have high renewable penetration.

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.

Sl No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook				
1	**Big Data Analytics in Future Power Systems**	**Ahmed F. Zobaa and Trevor J. Bihl**	**CRC Press 2019.**	**2019.**

ELECTRIC VEHICLE TECHNOLOGIES		Semester	VII
Course Code	BEE755A	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	2:2:0:0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03
Examination type (SEE)	Theory		

Course objectives:

- To understand the workingof ElectricVehicles and recent trends.
- To design Hybrid Electric Drive Train
- To design converters for battery charging
- To analyze different power grid used for electric vehicle application.
- To develop the modes of control for electrical vehicles

Teaching-Learning Process (General Instructions)

These are sample Strategies, which teachers can use to accelerate the attainment of the various course outcomes.

1. Chalk and Talk
2. PPT
3. Demo

Module-1

Electric and Hybrid Electric Vehicles:

History of Electric Vehicles, Hybrid Electric Vehicles, Fuel Cell Vehicles, Performance of EVs - Traction Motor Characteristics, Tractive Effort and Transmission Requirement, Vehicle performance, Energy Consumption

Hybrid Electric Vehicles Concept of Hybrid Electric Drive Trains, Architectures of Hybrid Electric Drive Trains

Module-2

Design Principle of Series and parallel Hybrid Electric Drive Train

Operation Patterns, Control Strategies-Max. SOC-of-PPS and Engine On–Off

Series Hybrid Electric Drive Train Design Electrical Coupling Device, Power Rating Design of the Traction Motor, Power Rating Design of the Engine/Generator, Design of PPS, Power Capacity of PPS, Energy Capacity of PPS.

Parallel Hybrid Electric Drive Train Design

Drive Train Configuration and Design Objectives, Control Strategies, Max. SOC-of-PPS Control Strategy Engine On–Off (Thermostat) Control Strategy, Constrained Engine On–Off Control Strategy.

Module-3

Batteries in Electric and Hybrid vehicles

Basics of Battery-Battery cell Structure and Chemical reactions. Battery Parameters -Battery capacity, Open circuit voltage, Terminal voltage, Practical capacity, Discharge rate, State of charge, Battery energy, Battery power, Specific power,

Fuel Cells

Operating Principles, Fuel Cell System Characteristics, Fuel Cell Technologies, Proton Exchange Membrane Fuel Cells (PEMFC)Types of fuel cells-Alkaline,, Phosphoric Acid, Molten Carbonate, Solid Oxide, Direct Methanol.

Module-4

Power Grid of Electric Vehicles

Vehicle grid interface -electric vehicle charging -dc fast chargers,480 V Fast Charger, MV Fast Charger, Electric vehicle Charging station, Grid impact of fast chargers, Electric vehicles in micro grids. Micro grid and controls --Primary- and Secondary-Level Controls, Droop-Based Controls, Oscillator-Based Controls, Tertiary control,V2G and G2V power converter, Solar generation Integration with electric Vehicles --Coordinated Control of Solar PV Generation, Storage and PEV

Module-5

Strategy of Hybrid Vehicle Control
vehicle supervisory controller, Mode selection strategy--Mechanical power-split hybrid modes, Electric Only (Low Speeds, Reverse, Battery Charging), Parallel Mode, Power-Split Mode, Engine Brake Mode, Regeneration mode. Modal control strategies --series and parallel control.

Course outcome (Course Skill Set)

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

1. Explain the working of Electric Vehicles and recent trends.
2. Design Hybrid Electric Drive Train
3. Develop a converters for battery charging
4. Different power grid used for electric vehicle application.
5. Develop the modes of control for electrical vehicles.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). The student is declared as a pass in the course if he/she secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

- There are 25 marks for the CIE's Assignment component and 25 for the Internal Assessment Test component.
- Each test shall be conducted for 25 marks. The first test will be administered after 40-50% of the coverage of the syllabus, and the second test will be administered after 85-90% of the coverage of the syllabus. The average of the two tests shall be scaled down to 25 marks
- Any two assignment methods mentioned in the 22OB2.4, if an assignment is project-based then only one assignment for the course shall be planned. The schedule for assignments shall be planned properly by the course teacher. The teacher should not conduct two assignments at the end of the semester if two assignments are planned. Each assignment shall be conducted for 25 marks. (If two assignments are conducted then the sum of the two assignments shall be scaled down to 25 marks)
- The final CIE marks of the course out of 50 will be the sum of the scale-down marks of tests and assignment/s marks.

Internal Assessment Test question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the course (**duration 03 hours).**

1. The question paper will have ten questions. Each question is set for 20 marks.
2. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.
3. The students have to answer 5 full questions, selecting one full question from each module.
4. Marks scored shall be proportionally reduced to 50 marks.

Suggested Learning Resources:

Books

1. Mehrdad Ehsani, Yimin Gao, sebastien E. Gay and Ali Emadi, "Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design", CRC Press, 2009. 2. Electric and Hybrid Vehicles: Design Fundamentals by Iqbal Husain, CRC Press, 2003.
Web links and Video Lectures (e-Resources):
• https://archive.nptel.ac.in/courses/108/106/108106170/
Activity Based Learning (Suggested Activities in Class)/ Practical Based learning •

Energy Conservation and Audit		Semester	VII
Course Code	**BEE755B**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3:0:0:0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03
Examination type (SEE)	Theory		

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.

Teaching-Learning Process (General Instructions)

These are sample Strategies, which teachers can use to accelerate the attainment of the various course outcomes.

1. Lecturer method (L) needs not to be only traditional lecture method, but alternative effective teaching methodscould be adopted to attain the outcomes.
2. Use of Video/Animation to explain functioning of various concepts.
3. Encourage collaborative (Group Learning) Learning in the class.
4. Ask at least three HOT (Higher order Thinking) questions in the class, which promotes critical thinking.
5. Adopt Problem Based Learning (PBL), which fosters students' Analytical skills, develop design thinking skills such as the ability to design, evaluate, generalize, and analyse information rather than simply recall it.
6. Introduce Topics in manifold representations.
7. Show the different ways to solve the same problem with different circuits/logic and encourage the students tocome up with their own creative ways to solve them.
8. Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding.

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
Energy Audit Applied to Buildings: Energy – Saving Measures in New Buildings, Water Audit, Method of Audit, General Energy – Savings Tips Applicable to New as well as Existing Buildings. **Demand side Management:** Scope of DSM, Evolution of DSM concept, DSM planning and Implementation, Load management as a DSM strategy, Applications of Load Control, End use energy conservation, Tariff options for DSM.

Course outcome (Course Skill Set)

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

1. Analyze about energy scenario nationwide and worldwide, also outline Energy Conservation Act and it features.
2. Discuss load management techniques and energy efficiency.
3. Understand the need of energy audit and energy audit methodology.
4. Understand various pillars of electricity market design.
5. Conduct energy audit of electrical systems and buildings.
6. Show an understanding of demand side management and energy conservation.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). The student is declared as a pass in the course if he/she secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

- There are 25 marks for the CIE's Assignment component and 25 for the Internal Assessment Test component.
- Each test shall be conducted for 25 marks. The first test will be administered after 40-50% of the coverage of the syllabus, and the second test will be administered after 85-90% of the coverage of the syllabus. The average of the two tests shall be scaled down to 25 marks
- Any two assignment methods mentioned in the 22OB2.4, if an assignment is project-based then only one assignment for the course shall be planned. The schedule for assignments shall be planned properly by the course teacher. The teacher should not conduct two assignments at the end of the semester if two assignments are planned. Each assignment shall be conducted for 25 marks. (If two assignments are conducted then the sum of the two assignments shall be scaled down to 25 marks)
- The final CIE marks of the course out of 50 will be the sum of the scale-down marks of tests and assignment/s marks.

Internal Assessment Test question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the course (**duration 03 hours).**

1. The question paper will have ten questions. Each question is set for 20 marks.
2. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.
3. The students have to answer 5 full questions, selecting one full question from each module.
4. Marks scored shall be proportionally reduced to 50 marks.

Suggested Learning Resources:

Textbooks

1. Energy Management Handbook, W.C. Turner, John Wiley, and Sons.
2. Energy Efficient Electric Motors and Applications, H.E. Jordan Plenum Pub Corp.
3. Energy Management W. R. Murphy, G. Mckay Butterworths.

Reference Books

1. Energy Science Principles, Technologies and Impact, J. Andrews, N. Jelley Oxford University Press.
2. Market operations in power systems: Forecasting, Scheduling, and Risk Management, Shahedepour M.,Yamin H., Zuyi Li, John Wiely & Sons, New York.
3. Energy Conservation, Diwan, P, Pentagon Press, (2008).

Web links and Video Lectures (e-Resources):

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Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

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PLC and SCADA		Semester	VII
Course Code	BEE755C	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3:0:0:0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	
Examination type (SEE)	Theory		

Course objectives:

(1) To explain advantages and disadvantages, main parts and their functions, basic sequence of operation of PLC.
(2) To describe the hardware components: I/O modules, CPU, memory devices, other support devices, and the functions of PLC memory map.
(3) To describe program scan sequence, the communication of information to the PLC using different languages, internal relay instruction.
(4) To explain identification of common operating modes found in PLCs, writing and entering the ladder logic programs.
(5) To define the functions of Relays, Contactors, Motor Starters, Switches, Sensors, Output Control Devices, Seal-in circuits and Latching Relays.
(6) To explain conversion of relay schematics into PLC ladder logic programs and writing PLC programs directly from narrative descriptions.
(7) To explain the functions of PLC counter instructions, applying combinations of counters and timers to control systems.
(8) To describe the function of selectable timed interrupt and fault routine files and use of temporary end instruction.
(9) To explain the execution of data transfer instructions, interruption of data transfer and data compare instructions.
(10) To explain the basic operation of PLC closed-loop control system, various forms of mechanical sequencers, and their operations.
(11) To describe the operation of bit and word shift registers and develop programs that use shift registers.
(12) To discuss the operation of various processes, structures of control systems and the method of communication between different industrial processes.

Teaching-Learning Process (General Instructions)

These are sample Strategies, which teachers can use to accelerate the attainment of the various course outcomes.

1 Lecturer method (L) needs not to be only traditional lecture method, but alternative effective teaching methods could be adopted to attain the outcomes.
2 Use of Video/Animation to explain functioning of various concepts.
3 Encourage collaborative (Group Learning) Learning in the class.
4 Ask at least three HOT (Higher order Thinking) questions in the class, which promotes critical thinking.
5 Adopt Problem Based Learning (PBL), which fosters students' Analytical skills, develop design thinking skills such as the ability to design, evaluate, generalize, and analyse information rather than simply recall it.
6 Introduce Topics in manifold representations.
7 Show the different ways to solve the same problem with different circuits/logic and encourage the students to come up with their own creative ways to solve them.
8 Discuss how every concept can be applied to the real world - and when that's possible, it helps improve the students' understanding.

Module-1

Programmable Logic Controllers: Introduction, Parts of a PLC, Principles of Operation, Modifying the Operation, PLCs versus Computers, PLC Size and Application.

PLC Hardware Components: The I/O Section, Discrete I/O Modules, Analog I/O Modules, Special I/O Modules, I/O Specifications, The Central Processing Unit (CPU), Memory Design, Memory Types, Programming Terminal Devices, Recording and Retrieving Data, Human Machine Interfaces (HMIs).

Basics of PLC Programming: Processor Memory Organization, Program Scan, PLC Programming Languages, Relay-Type Instructions, Instruction Addressing, Branch Instructions, Internal Relay Instructions, Programming Examine If Closed and Examine If Open Instructions, Entering the Ladder Diagram, Modes of Operation.

Module-2
Developing Fundamental PLC Wiring Diagrams and Ladder Logic Programs: Electromagnetic Control Relays, Contactors, Motor Starters, Manually Operated Switches, Mechanically Operated Switches, Sensors, Output Control Devices, Seal-In Circuits, Latching Relays, Converting Relay Schematics into PLC Ladder Programs, Writing a Ladder Logic Program Directly from a Narrative Description. **Programming Timers:** Mechanical Timing Relays, Timer Instructions, On-Delay Timer Instruction, Off-Delay Timer Instruction, Retentive Timer, Cascading Timers.
Module-3
Programming Counters: Counter Instructions, Up-Counter, Down-Counter, Cascading Counters, Incremental Encoder-Counter Applications, Combining Counter and Timer Functions. **Program Control Instructions:** Master Control Reset Instruction, Jump Instruction, Subroutine Functions, Immediate Input and Immediate Output Instructions, Forcing External I/O Addresses, Safety Circuitry, Selectable Timed Interrupt, Fault Routine, Temporary End Instruction, Suspend Instruction.
Module-4
Data Manipulation Instructions: Data Manipulation, Data Transfer Operations, Data Compare Instructions, Data Manipulation Programs, Numerical Data I/O Interfaces, Closed-Loop Control. Math Instructions: Math Instructions, Addition Instruction, Subtraction Instruction, Multiplication Instruction, Division Instruction, Other Word-Level Math Instructions, File Arithmetic Operations.
Module-5
Sequencer and Shift Register Instructions: Mechanical Sequencers, Sequencer Instructions, Sequencer Programs, Bit Shift Registers, Word Shift Operations. **Process Control, Network Systems, and SCADA:** Types of Processes, Structure of Control Systems, On/Off Control, PID Control, Motion Control, Data Communications, Supervisory Control and Data Acquisition (SCADA).
Course outcome (Course Skill Set) At the end of the course the student will be able to : 1. Discuss history of PLC and describe the hardware components of PLC: I/O modules, CPU, memory devices, other support devices, operating modes and PLC programming. 2. Describe field devices Relays, Contactors, Motor Starters, Switches, Sensors, Output Control Devices, Seal-In Circuits, and Latching Relays commonly used with I/O module. 3. Analyze PLC timer and counter ladder logic programs and describe the operation of different program control instructions 4. Discuss the execution of data transfer instructions, data compare instructions and the basic operation of PLC closed-loop control system. 5. Describe the operation of mechanical sequencers, bit and word shift registers, processes and structure of control systems and communication between the processes.
Assessment Details (both CIE and SEE) The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). The student is declared as a pass in the course if he/she secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

- There are 25 marks for the CIE's Assignment component and 25 for the Internal Assessment Test component.
- Each test shall be conducted for 25 marks. The first test will be administered after 40-50% of the coverage of the syllabus, and the second test will be administered after 85-90% of the coverage of the syllabus. The average of the two tests shall be scaled down to 25 marks
- Any two assignment methods mentioned in the 22OB2.4, if an assignment is project-based then only one assignment for the course shall be planned. The schedule for assignments shall be planned properly by the course teacher. The teacher should not conduct two assignments at the end of the semester if two assignments are planned. Each assignment shall be conducted for 25 marks. (If two assignments are conducted then the sum of the two assignments shall be scaled down to 25 marks)
- The final CIE marks of the course out of 50 will be the sum of the scale-down marks of tests and assignment/s marks.

Internal Assessment Test question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the course (**duration 03 hours).**

1. The question paper will have ten questions. Each question is set for 20 marks.
2. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.
3. The students have to answer 5 full questions, selecting one full question from each module.
4. Marks scored shall be proportionally reduced to 50 marks.

Suggested Learning Resources:

Books

Textbook

1. Programmable Logic Controllers, Frank D Petruzella, McGraw Hill, 4th Edition, 2011.

Reference Books

1. Programmable Logic Controllers an Engineer's Guide, E A Parr, Newnes, 3rd Edition, 2013.
2. Introduction Programmable Logic Controllers, Gary Dunning, Cengage, 3rd Edition, 2006.

Web links and Video Lectures (e-Resources):

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Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

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OPTIMISATION TECHNIQUES		Semester	VII
Course Code	BEE755D	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3:0:0:0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	
Examination type (SEE)	Theory		

Course objectives:

- To introduce the basic concepts of linear programming
- To educate on the advancements in Linear programming techniques
- To introduce non-linear programming techniques
- To introduce the interior point methods of solving problems
- To introduce the dynamic programming method

Teaching-Learning Process (General Instructions)

These are sample Strategies, which teachers can use to accelerate the attainment of the various course outcomes.

1.

Module-1

LINEAR PROGRAMMING:

Introduction - formulation of linear programming model-Graphical solution–solving LPP using simplex algorithm – Revised Simplex Method.

Module-2

ADVANCES IN LP:

Duality theory- Dual simplex method - Sensitivity analysis–-Transportation problems–Assignment problems-Travelling sales man problem -Data Envelopment Analysis.

Module-3

NON LINEAR PROGRAMMING:

Classification of Non Linear programming – Lagrange multiplier method – Karush – Kuhn Tucker conditions–Reduced gradient algorithms–Quadratic programming method – Penalty and Barrier method.

Module-4

INTERIOR POINT METHODS:

Karmarkar's algorithm–Projection Scaling method–Dual affine algorithm–Primal affine algorithm Barrier algorithm.

Module-5

DYNAMIC PROGRAMMING:

Formulation of Multi stage decision problem–Characteristics–Concept of sub-optimization and the principle of optimality–Formulation of Dynamic programming–Backward and Forward recursion– Computational procedure–Conversion offinal value problem in to Initial value problem.

Course outcome (Course Skill Set)

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

1. Understand and formulate Linear Programming model.
2. Solve problems on Duality theory, transportation, Assignment problems-Travelling sales man problem.
3. Classify Non Linear programming and solve related problems.
4. Understand interior point methods.
5. Understand and formulate multi stage decision problem and explain the concept of sub optimisation.

Assessment Details (both CIE and SEE)

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4. Marks scored shall be proportionally reduced to 50 marks.

Suggested Learning Resources:

Books

1. Hillier and Lieberman "Introduction to Operations Research", TMH, 2000.
2. R.Panneerselvam, "Operations Research", PHI, 2006
3. Hamdy ATaha, "Operations Research –An Introduction", Prentice Hall India, 2003.

Web links and Video Lectures (e-Resources):
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Activity Based Learning (Suggested Activities in Class)/ Practical Based learning   •