BASAVESHWAR ENGINEERING COLLEGE, BAGALKOT

COURSE PLAN - UEE732N

Title of Course	**:**	**Energy Conservation, Audit and Demand Side Management**	**Course Code**	**:**	**UEE852E**
Credits	**:**	**3**	**Contact Hours/ Week**	**:**	**8**
Total Hours	**:**	**40**	**Tutorial Hours**	**:**	**--**
CIE Marks	**:**	**50**	**SEE Marks**	**:**	**50**
Semester	**:**	**VIII**	**Year**	**:**	**2023-2024**

Prerequisites:

The students should have knowledge of, Renewable Energy Sources, Efficiency of electrical machines, Electrical Measurement, Analysis tools/Computation techniques for data handling

Course Objectives:

	The Course objectives are:
1	To study Energy Conservation, Energy Auditing, Demand Side Management
2	To formulate strategies for Energy Management (plans)
3	To study the alternative substitutes for the convectional energy
4	To understand different energy conservation policies

Course Outcomes:

	At the end of the course the student should be able to:
1	Define/list different energy resources, energy management/audits, energy efficient motors, lighting terminologies and demand side management terminologies
2	Describe/explain energy economic methods, energy audit methods, lighting criteria and DSM techniques
3	Compute/determine numerical problems and compare & contrast on selection of energy economic techniques, lighting criterion, energy efficient motors and energy alternative from DSM techniques
4	Evaluate various methods of energy conservation & DSM in different sectors like agriculture, commercial, transpiration and domestic and design & develop methods/techniques for energy conservation, audit & management

Course Articulation Matrix: Mapping of Course Outcomes (CO) with Programme Outcomes (PO) and Programme Specific Outcomes (PSO)

		PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
Sl.	PO's / CO's															
The students will be able to:																
1	**UEE852E.1**	**3**							**1**		**1**		**1**	**1**	**1**	**1**
2	**UEE852E.2**	**3**	**1**						**1**		**1**		**1**	**1**	**1**	**1**
3	**UEE852E.3**	**3**	**3**	**2**	**2**	**1**			**1**		**1**		**1**	**1**	**2**	**3**
4	**UEE852E.4**	**3**	**3**	**3**	**3**	**1**			**1**	**1**	**1**		**2**	**1**	**1**	**3**

Competencies Addressed in the course and Corresponding Performance Indicators

PO1. **Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO2. **Problem analysis**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3. **Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4. **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5. **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
PO6. **The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO7. **Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO8. **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO9. **Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO10. **Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO11. **Project management and finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO12**. Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Review Questions

Sl.	Review Questions	CO's	BLL	PI addressed
	Unit -II			
1.	**What is IEA? List the basic aims of IEA**	**1**	**1**	**2.2.2 2.2.4 2.4.4**
2.	**Compare GDP and GNP**	**3**	**3**	**2.2.2 2.2.4 2.4.4**
3.	**Give the equivalent conversion factors for the following, used in energy engineering calculations. a. 1 therm = (_____) Btu.**	**1**	**1**	**4.1.3**

	b. 1 kilolitre = (_____) barrel. c. 1 horsepower-hour = (_____) Btu. d. 1 kilowatt-hour = (_____) Btu. e. 1 US barrel = (_____) U.S. gallon.			
4.	A small sized project requiring an initial investment of Rs.20,00,000/- that provides a net cash of Rs. 5,00,000/- each year for 5 years. Assume cost of funds to be 10% per annum. Neglecting scrap value, calculate the net present value and comment whether the project is acceptable?	2	2	2.1.2 2.1.3 2.4.1
5.	Describe the outcome of energy Investment?	1	1	2.2.2 2.2.4 2.4.4
6.	Choose an appropriate option to fill in the blanks. I. The payback period of a project which has an investment of Rs. 50,000 and net profit of Rs. 6300 per year is_____ a) 7 years 10 months b) 7 years 9 months c) 7 years d) 8 years II. Loan ₹ 1000 compounded for 3 years at 10% per year. Cash outflow in 3rd year will be ____ a) ₹ 1331 b) ₹ 1100 c) ₹ 121 d) ₹ 110 III. Downward arrows in cash flow diagram represents(lender) ____ a) Cash outflows b) Cash inflows IV. Education loan of Rs. 2,00,000 at 5% per year for first 4 years and 10% for next 20 years. What will be the interest earned after 10 years? a) 1.6 lakhs b) 1.5 lakhs c) 1.9 lakhs d) 2.0 lakhs V. Internal rate of return is _____ a) The interest rate that makes the Net Present Value 0 b) The interest rate that makes the Net Present Value 1 c) The interest rate that enhance the Net Present Value d) The interest rate that makes the Net present value negative	2	2	4.1.3
7.	List the benefits of Energy Efficient Motors.	1	1	2.2.2 2.2.4 2.4.4
8.	Write a short note on Effect of variation of voltage on motor performance.	1	1	4.3.3
9.	Fill the blanks in the following statements. I. Indian Standard Allows ___ % tolerance on efficiency for motors upto50 kW rating and ___ % for motors over 50 kW rating. II. The power drawn at ___ % of loading can be a meaningful indicator of energy efficiency. III. Indian Standard Allows ___ % tolerance on Frequency variation IV. 90% of industrial motors are _____ motors	1	1	4.1.3
10.	Explain the criteria for efficient lightening.	1	1	2.2.2 2.2.4

				2.4.4
11.	**The total, upward and downward lamp output from a lamp are 1000 lm, 300 lm and 500 lm respectively. Calculate upward light output ratio (ULOR), downward light output ratio (DLOR), light output ratio (LOR) of luminaire and percentage of light energy absorbed in luminaire.**	**2**	**2**	**2.1.2 2.1.3 2.4.1**
12.	**Match the following parameters with their units** **Parameter — Unit** **Luminous flux — Candela/m^2** **Luminous efficacy — Lumen** **luminous intensity — candela** **Luminance — Lux** **Illuminance — Lumen per Watt**	**1**	**1**	**4.1.3**
13.	**Write a descriptive note on energy use profiles.**	**1**	**1**	**4.3.3**
14.	**Define Energy management and list it's objectives.**	**1**	**1**	**2.2.2 2.2.4 2.4.4**
15.	**What is the scope of Energy Audit?**	**3**	**3**	**2.2.2 2.2.4 2.4.4**
16.	**Draw Sankey diagram for a Solar PV Power Plant.**	**3**	**3**	**4.3.3 10.1.3**
17.	**Explain the elements of Energy Management Program.**	**2**	**2**	**2.2.2 2.2.4 2.4.4**
18.	**Define Energy Conservation and list the practical methods of Energy Conservation.**	**1**	**1**	**2.2.2 2.2.4 2.4.4**
19.	**Explain Peak clipping and Valley filling methods for load management.**	**3**	**3**	**4.3.3 10.1.3**
20.	**What is the motivation for demand Side Management?**	**2**	**2**	**2.2.2 2.2.4 2.4.4**
21.	**List DSM options in different sectors.**	**1**	**1**	**2.2.2 2.2.4 2.4.4**

Course Content:

Hours Required	Topic to be covered	Mode of Delivery
01	Introduction to Energy; Units and Conversions	Ppt
01	GDP, GNP and Per Capita Energy Consumption	Ppt
01	Renewable Energy Act, International Energy Agency	Ppt
01	OECD and Kyoto Protocol	Ppt, Discussions
01	Economic Analysis of Energy: Economic analysis of investment,	Ppt
01	Cash Flows and CF diagrams, Economic analysis	Ppt
01	technique – Simple payback period method	Ppt
01	Discounted cash flow method or Time adjustment technique, Net present value method	Ppt, Discussions

01	Present value index method or Profitability index method, Internal rate of return method, Accounting on average rate of return method	Ppt
01	Interest Factors – Single Payment Compound Amount (SPCA), Single Payment Present Worth (SPPW)	Ppt
01	Uniform Series Compound Amount (USCA), Sinking Fund Payment (SFP)	Ppt
01	Uniform Series Present Worth (USPW), Capital Recovery (CR)	Ppt
01	Motors: Introduction, Motor Characteristics - Speed, Slip & Efficiency, Motor Selection	Ppt
01	Determination of energy saving, Energy saving options in oversized motors	Ppt
01	Effect of variation of voltage on performance of motor, Effect on efficiency due to variation in load	Ppt
01	Energy Efficient Motors, Choice of energy efficient motor, Factors Affecting Energy Efficiency	Ppt, Discussions
01	Rewinding Effects on Energy Efficiency, Standards and Star Labeling of Energy Efficient Induction Motors	Ppt
01	Lighting: Introduction, Terms and definitions	Ppt
01	Lumen, Lux, Load efficacy, Lamp circuit efficacy, Color rendering index (CRI)	Ppt
01	Characteristic of different types of lamps. Energy saving opportunities in lighting	Ppt
01	Criteria for Energy Efficient Lighting. Designing Lighting system – Indoor and Outdoor	Ppt
01	Effect of reduction in supply voltage on energy consumption. Timers and occupancy sensors	Ppt
01	Energy Management and Audit: Energy management	Ppt
01	Developing energy use profiles; Sankey Diagram; Process flow diagrams; Material and energy balance	Ppt, Discussions
01	Energy auditing instruments. Energy audit – Need for energy audit, Scope of energy audit	Ppt, Discussions
01	Types of energy audit – Preliminary energy audit, Detailed energy audit	Ppt
01	Energy Conservation: Introduction	Ppt
01	Results of energy conservation, Principles of energy conservation, Energy conservation planning	Ppt, Discussions
01	Energy conservation Act	Ppt
01	Energy conservation in residential and commercial sectors, Energy conservation in transportation	Ppt, Discussions
01	considerations for Energy conservation in industry	Ppt, Discussions
01	Energy conservation in electricity generation, transmission and distribution, Energy conservation in agricultural sector	Ppt, Discussions
01	Demand Side Management: Introduction to DSM – Definition, Evolution, Benefits and Scope	Ppt
01	Role of Energy Companies, Load Management, Application of Load Control, DSM Implementation Issues	Ppt
01	Strategies to implement and Promote DSM, Customer acceptance of DSM, Environment & DSM	Ppt
01	International experience with DSM, DSM in India	Ppt

Chalk and talk in classroom/Lecture combined with discussions/Lecture with a quiz/ Tutorial/ Assignments/ Demonstration/ Invited lectures/ Group Assignment/ Project / Seminars, Presentations/Group Discussion/Asynchronous Discussion

Course Contents:

UNIT – I	**(10 Hours)**
Energy Scenario: Introduction to Energy; Units and Conversions; GDP, GNP and Per Capita Energy Consumption; Renewable Energy Act, International Energy Agency, OECD and Kyoto Protocol (only overview) **Economic Analysis of Energy:** Economic analysis of investment, Cash Flows and CF diagrams, Economic analysis technique – Simple payback period method, Discounted cash flow method or Time adjustment technique, Net present value method, Present value index method or Profitability index method, Internal rate of return method, Accounting on average rate of return method; Interest Factors – Single Payment Compound Amount **(SPCA),** Single Payment Present Worth (**SPPW**), Uniform Series Compound Amount (**USCA**), Sinking Fund Payment (**SFP**), Uniform Series Present Worth (**USPW**), Capital Recovery (**CR). (**Simple Numerical problems**).**	
UNIT – II	**(10 Hours)**
Motors: Introduction, Motor Characteristics - Speed, Slip & Efficiency, Motor Selection; Determination of energy saving, Energy saving options in oversized motors, Effect of variation of voltage on performance of motor, Effect on efficiency due to variation in load; Energy Efficient Motors, Choice of energy efficient motor, Factors Affecting Energy Efficiency, Rewinding Effects on Energy Efficiency, Standards and Star Labeling of Energy Efficient Induction Motors. **Lighting:** Introduction, Terms and definitions – Lumen, Lux, Load efficacy, Lamp circuit efficacy, Color rendering index (**CRI**); Characteristic of different types of lamps. Energy saving opportunities in lighting. Criteria for Energy Efficient Lighting. Designing Lighting system – Indoor and Outdoor. Effect of reduction in supply voltage on energy consumption. Timers and occupancy sensors.	
UNIT – III	**(10 Hours)**
Energy Management and Audit: Energy management; Developing energy use profiles; Sankey Diagram; Process flow diagrams; Material and energy balance; Energy auditing instruments. Energy audit – Need for energy audit, Scope of energy audit, Types of energy audit – Preliminary energy audit, Detailed energy audit;	
UNIT – IV	**(10 Hours)**
Energy Conservation: Introduction, Results of energy conservation, Principles of energy conservation, Energy conservation planning, Energy conservation Act,; Energy conservation in residential and commercial sectors, Energy conservation in transportation, considerations for Energy conservation in industry, Energy conservation in electricity generation, transmission and distribution, Energy conservation in agricultural sector. **Demand Side Management:** Introduction to DSM – Definition, Evolution, Benefits and Scope; Role of Energy Companies, Load Management, Application of Load Control, DSM Implementation Issues, Strategies to implement and Promote DSM, Customer acceptance of DSM, Environment & DSM, International experience with DSM, DSM in India.	

Reference Books:

1. Suresh Kumar Soni and Manoj Nair, Energy Conservation and Audit, Satya Prakashan, New Delhi, 2010
2. Rajiv Shankar, Energy Auditing in Electrical Utilities, Viva Books, New Delhi 2010
3. Larry C. White, Philip S. Schmidt, David R. Brown, "Industrial Energy Management Systems", Hemisphere Publishing Corp, New York.
4. Albert Thumann, "Fundamentals of Energy Engineering", Prentice Hall Inc, Englewood Cliffs, New Jersey.

Evaluation Scheme:

Assessment	Marks	Weightage
CIE-I	20	20
CIE-II	20	20
Assignments/ Quizzes/ Case Study/ Course Project/ Term Paper/Field Work	10	10
SEE	100	50
Total	150	100

Details of Assignment:

Assignment	Marks (10)	CO	PI	CA	PO
Assignment 1 (Write and Submit)	02	1,2,3,4	2.2.2 2.2.4 2.4.4 4.1.3 2.1.2 2.1.3 2.4.1 4.3.3 10.1.3		Po1, PO2, PO4
Assignment 2 (Write and Submit)	02	1,2,3,4			PO1, PO2, PO4
Assignment 3 (Case Study in BEC)	02	1,2,3,4			PO4, PO6
Assignment 4 (Case Study ESCOM's)	02	1,2,3,4			PO4, PO6
Assignment 5 (Quiz)	02	1,2,3,4			PO1, PO2, PO4

Dr. Basanagouda F Ronad

BASAVESHWAR ENGINEERING COLLEGE(AUTONOMOUS), BAGALKOT

DEPARTMENT ELECTRICAL AND ELECTRONICS ENGINEERING

COURSE PLAN

Title of Course	**:**	**Power System Operation and Control**	**Course Code**	**:**	**UEE841E**
Credits	**:**	**03**	**Contact Hours/ Week**	**:**	**03**
Total Hours	**:**		**Tutorial Hours**	**:**	**-**
CIE Marks	**:**	**50**	**SEE Marks**	**:**	**50**
Semester	**:**	**VIII**	**Year**	**:**	**2021**

Prerequisites:

Course Objectives:

	The Course objectives are:
1	To impart the knowledge of control loops applied to power system networks and to understand to develop the model of Automatic Load Frequency Controller and Automatic Voltage Controller along with steady state and Dynamic Analysis
2	To impart the knowledge of concept of generation and absorption of reactive power at different points of the power systems. To provide the information of various voltage control methods. To impart the concept of voltage stability and voltage collapse. To impart the knowledge the of principal operation various FACTS devices like TSC, TCR and STATCOM
3	To impart the knowledge about the concept of unit commitments of thermal generators, importance of the spinning reserves and constraints of thermal generators. To understand the concept of priority listing and dynamic programming methods for unit commitments
4	To provide the knowledge regarding the security aspects of power systems, to provide the concept of system monitoring and contingency analysis of power system. To provide the information regarding the selection of contingency using 1P1Q method.
5	To impart the knowledge of various methods (Maximum likely hood concept) for state estimation of various parameters of power systems. To understand the concept of state estimation using matrix formulation and detection of the Pseduo measurement and bad data.

Course Outcomes:

	After completion of the course, students shall be able to:
1	To apply/analyse control loops, Commitment, reactive power management and security of the power systems
2	Develop the model of AVR and ALFC applied to the thermal generators in order to regulate the frequency and terminal voltage
3	To identify suitable compensating devices and design and analysis of various compensating devices and FACTs devices applied to power systems
4	Write power system algorithms like power system security and state estimations

Course Articulation Matrix: Mapping of Course Outcomes (CO) with Programme Outcomes (PO) and Programme Specific Outcomes (PSO)

Sl.	Programme Outcomes / Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	To apply/analyse control loops, Commitment, reactive power management and security of the power systems	3	2	1	-	-	-	-	-	-	-	-	-	2	2	1
2	Develop the model of AVR and ALFC applied to the thermal generators in order to regulate the frequency and terminal voltage	3	2	-	1	-	-	-	-	-	-	-	-	2	1	1
3	To identify suitable compensating devices and design and analysis various compensating devices and FACTs devices applied to power systems	3	-	-	-	-	-	-	-	-	-	-	-	2	1	1
4	Write power system algorithms like power system security and state estimations	3	3	3	1	-	-	-	-	-	-	-	-	3	2	1

Unit Learning Outcomes (ULO):

Sl.	Unit Learning Outcome (ULO)	CO's	BLL
	Unit -I		
1.	Students shall be able to assess the importance of the control loops involved in power systems	**1**	**2**
2.	Students shall be able to model the Automatic Load frequency Control for change in the demand and deviation in the frequency	**2**	**3**
3.	Students shall be able to assess the performance of ALFC through steady state and dynamic analysis	**2**	**3**
4.	Students shall be able to list the objectives and advantages of ALFC and AVR	**2**	**1**
5.	Students shall be able to model the Automatic Voltage Regulator and Excitation systems applied to synchronous generators	**2**	**4**
6.	Students shall be able to describe the control rules for change in the demand and frequency in two area systems	**1**	**2**
7.	Students shall be able to solve the numericals on two area systems and tie line control	**2**	**4**
	Unit -II		
8.	Students shall be able to identify and describe the various components of power systems are responsible for generation and absorption of the reactive power	**1**	**2**
9.	Students shall be able to list and explain various methods of voltage control	**1**	**2**
10.	Students shall be able to derive the expression for voltage in-terms of active and reactive power for SMIB systems	**3**	**3**
11.	Students shall be able to solve the numericals on requirement of the reactive power for the fault or any increase and decrease in the demand at Bus	**3**	**4**
12.	Students shall be able to describe the power system stability and voltage collapse using PV and QV curves	**3**	**3**
13.	Students shall be able to explain the objective of SVC and its characteristics	**1**	**2**
14.	Students shall be able to explain the operation of TCR and derive expression of current in-terms of susceptance	**3**	**2**
15.	Students shall be able to describe the principle operation of TSC along with waveform	**3**	**3**
16.	Students shall be able to derive the condition for transient free /minimum transient operation of TSC	**3**	**4**
17.	Students shall be able to explain the principle operation of STATCOM and Importance of Power converter in STATCOM	**3**	**3**
	Unit-III		
20.	Students shall be able to define the terms related to unit commitment of thermal generators	**1**	**1**
21.	Students shall be able to assess necessity of unit commitment and illustrate process of unit commitment for the load curve	**1**	**2**
22.	Students shall be able to explain the importance of spinning reserves in unit commitment	**1**	**2**
23.	Students shall be able to list and explain constraints of thermal generators during unit commitments	**1**	**2**
24.	Students shall be able to explain the importance of spinning reserves in unit commitment	**1**	**2**

24.	Students shall be able to describe the different start up cost for the starting of thermal generators	**1**	**2**
25.	Students shall be able to describe the priority listing method of unit commitments	**3**	**3**
26	Students shall be able to describe the dynamic programming method of unit commitments	**3**	**3**
	Unit-IV		
20.	Students shall be able to assess importance of security analysis algorithms in the power systems	**1**	**1**
21.	Students shall be able to list and explain the various functions involved in the security analysis algorithms	**1**	**2**
22.	Students shall be able to assess the importance and describe the AC power flow analysis in the security analysis	**1**	**2**
23.	Students shall be able to derive the expression of power flow using sensitivity analysis or d and a factor	**1**	**3**
24.	Students shall be able to describe the contingency selection algorithms for handling the outage of the lines or generators due to faults	**4**	**3**
24.	Students shall be able to derive the expression of power flow using 1P1Q fast decouple load flow analysis for contingency selection	**4**	**3**
25.	Students shall be able to define the terms related to state estimation of power systems	**4**	**1**
26	Students shall be able to describe the maximum likely hood concept using voltage source connected to resistive load	**4**	**3**
27	Students shall be able to derive the Hessian Matrix for state estimation for various conditions	**1**	**3**
28	Students shall be able to describe the elimination of bad data using Chi-square method during the data measurements	**4**	**3**

Course Content:

Hours Required	Topic to be covered	Mode of Delivery
01	Automatic Generation Control-Introduction	Chalk and talk in classroom/ Lecture combined with discussions/Lecture with a quiz/ Tutorial/ Assignments/ Demonstration/ Invited lectures/ Group Assignment/
01	Control loops of power systems	
01	Modelling of AVR and performance of AVR	
01	Modelling and performance of ALFC	
01	ALFC of Two Area Systems	
01	Expressions for tie-line flow and frequency deviations	
01	Tie-line bias control and area control error	
01	Parallel operation of generators	
01	Static response of tie-line bias control and examples	
01	Numerical problems	
01	Introduction of voltage & reactive power	
01	Generation & absorption of reactive power	
01	Relation between voltage, power & reactive power at nodes	
01	Methods of voltage control, shunt capacitor	
01	Series capacitor	
01	Tap changing transformer & boost transformer compensating devices	
01	Characteristics of SVC, TCR, TSC and STATCOM	
01	Voltage stability, PV & QV curves,	
01	Voltage collapse & prevention of voltage collapse	
01	Unit commitment, statement of problem	
01	Need and importance of unit	
01	Constraints in unit commitment, spinning reserve	
01	Thermal unit constraints, other constraints, hydro constraints	
01	Must run, fuel constraints, unit commitment solution methods, priority -list methods	
01	Security constrained optimal unit commitment, start-up considerations	
01	Optimal generation scheduling reliability in unit commitment	
01	Power system security introduction, factors affecting power system security	
01	Power system contingency analysis	
01	Detection of network problems	
01	Network sensitivity methods, calculation of network sensitivity factor, contingency ranking	
01	Introduction of power system state estimation	
01	Maximum likelihood least square estimation	
01	Maximum likelihood concept with example	
01	Matrix formula	

01	Detection and identification of bad measurements	
01	Problems & summary	

Review Questions:

Sl.	Review Questions	BLL
2	Derive the complete model of ALFC to regulate the frequency for the change in the load? Perform steady state and dynamic state analyses on the ALFC model	L4
3	Mention the control strategies for deviation of frequency and change in the demand of intertie power flow between two area systems? Derive the expression for Area Control Error and represent using the block diagram	L3
4	Develop the model of AVR using transfer function? How the roots affect the performance of the AVR during dynamic change in the demand? Explain	L4
5	A 100 MVA synchronous generator operates on full load at a frequency of 50Hz. The load suddenly reduced to 50 MW. Due to time lag in governor system, the system valve begins to close after 0.4 s, Determine the change in frequency that occurs in this time , H= 5KWs/kVA of generator capacity	L4
6	Two generator rated 200 MW and 400 MW are operating in parallel. The drop characteristics of their governors are 4% and 5% respectively, from no load to full load. Assuming that the generators are operating at 50 Hz at no load, how would a load of 600 MW be shared between them? What will be system frequency at this load?	L3
7	Specify various power system components responsible of generation and absorption of the reactive power? When the shunt reactor is preferred in the power system?	L2
8	Develop the model of SVS for the reactive power compensation in power system? Demonstrate its principle of operation for the regulation bus voltage	L3
9	Derive the expression of current flowing through the reactor as a function of gating angle of TCR? Discuss the variation of susceptance as gating signal varies from 0 to 180 degree	L3
10	Three supply points A, B and C are connected to a common bus bar M. Supply point A is maintained at a nominal 275 KV and is connected to M through a 275/132 KV transformer (0.1 p.u reactance) and a 132 KV line of reactance 50 Ω. Supply point B is nominally at 132 kV and is connected to M through a 132KV line of 50Ω reactance. Supply point C is nominally at 275 kV and is connected to M by a 275/132 kV transformer (0.1 p. u reactance) and is 132 kV line of 50 Ω. If, at a particular system load, the line voltage of M falls below its nominal value by 5 kV, Calculate the magnitude of the reactive volt-ampere injection required at M to re-establish the original voltage. The p.u values are expressed on a 500 MVA base and resistance may be neglected through out	L4
11	Derive the optimum conditions for the transient free operation of thyristor switched capacitor	L4
12	Discuss the various control strategies for the mitigation of harmonic generated by TCR	L3
13	The fuel cost functions in Rs/h for three thermal plants are given by $F_1=350+7.2P_1+0.004P_1^2$, $F_2=500+7.3P_2+0.0025P_2^2$, $F_3=600+6.74P_3+0.003P_3^2$ P_1, P_2, P_3 are in MW. Find the optimal scheduling using iterative technique for P_D=800MW, initial value of λ=8 Rs/MWh	L3
15	Derive and specify the assumptions considered for obtaining the B-Coefficients using current distribution factor	L3
16	Specify the importance of the incremental characteristics during the scheduling of thermal generators and obtain the necessary conditions of scheduling of thermal generators	L2
17	Obtain the unit commitment table using priority listing method for three units given below for the variation of loads from 400MW to 1200 MW Unit 1: Max=600 MW, $C1=5610+79.2P_1+0.01562P_1^2$ Rs/hr	L3

	Unit 2: Max=400 MW, C2=3100+78.5P_2+0.194P_2^2 Rs/hr Unit 3: Max=200 MW, C3=936+95.64P_3+0.05784P_3^2 Rs/hr	
18	Specify the importance of spinning reserve during unit commitment? Identify suitable starting method of thermal generator is used if it is turned off for long period	L2
19	Why the monitoring of the power system is considered as highest priority for security of power system? Justify	L2
20	How the speed of AC power flow solution and number of contingency cases are handled by the security algorithm? Discuss	L2
21	What is a maximum Likelihood concept of state estimation in power system? Explain with a suitable example.	L2
22	What is the contingency analysis in power system? How the contingency selections is carried out and explain with flow chart 1P1Q contingency selection method?	L2
23	Derive matrix formulation of state estimation for different condition of measurement	L3
24	Discuss the importance of probability density function chi-squared distribution in detection and identification of bad data during state estimation of power system variables	L3

Evaluation Scheme:

Assessment	Marks	Weightage
CIE-I	**22.5**	**22.5**
CIE-II	**22.5**	**22.5**
Assignments/ Quizzes	**05**	**05**
SEE	**100**	**50**
Total	**150**	**100**

Details of Assignment:

Assignment	Marks (05)	CO
Assignment 1	1.25	1,3,4
Assignment 2	1.25	2,3,4
Quiz 1	2.5	1,2,3
Quiz 2	2.5	4,3,4

SEE Model Question Paper:

SEE Scheme

Semester end assessment (SEE) is written examination of three hours duration of 100 marks with 50% weightage

Course Utilization for CIE and SEE

Unit	Chapter		Teaching Hours	Number of Questions in		Number of Questions in SEE
				CIE-I	CIE-II	
I	1	Control Centre Operation of Power Systems	5	04		2.0
	2	Automatic Generation Control	5			
II	3	Control of Voltage and Reactive Power	8			2.0
	4	Compensating Devices	5			
III	5	Unit Commitment	10		04	2.0
IV	6	Power System Security	6	-		2.0
	7	Power System State Estimation	4	-		

BASAVESHWAR ENGINEERING COLLEGE (AUTONOMOUS), BAGALKOT

Department of Electrical and Electronics Engineering

COURSE PLAN

Title of Course	**:**	**Over Voltage in Power System**	**Course Code**	**:**	**UEE847E**
Credits	**:**	**03**	**Contact Hours/ Week**	**:**	**03**
Total Hours	**:**	**40**	**Tutorial Hours**	**:**	**00**
CIE Marks	**:**	**50**	**SEE Marks**	**:**	**50**
Semester	**:**	**8th**	**Year**	**:**	**2023 -24 (EVEN Sem)**

Prerequisites: Electrical Machines-I, Electrical Machines-II, Transmission & Distribution, Testing and Commissioning of Electrical Equipment, High Voltage Switchgear and Protection

Course Objectives:

1	Generation of switching transients and their control using circuit - theoretical concept.
2	Propagation, reflection and refraction of travelling waves.
3	Mechanism of lighting strokes and the production of lighting surges.
4	Voltage transients caused by faults and protect these faults on lightning arrestors, surge diverters, surge capacitors, reactors, and overhead ground wires.

Course Outcomes:

	At the end of the course the student should be able to:
1	Classify the internal and external causes of overvoltage in power systems and carry out simple, analytical calculations of transient overvoltage's and currents in power systems.
2	Analyse the importance of wave propagation, reflection, and refraction of travelling waves, and utilize EMTP programs in a critical and effective way for the calculation of transients in power system.
3	Review the theories of cloud formation and analyse the mechanisms of lighting strokes, lightning discharges, and their characteristics in a power system.
4	Instruct the protective measures against transient over-voltages occurred in lightning, lightning arrestors, Surge diverters, Surge capacitors and reactors, Overhead ground wires.

Course Articulation Matrix: Mapping of Course Outcomes (CO) with Programme Outcomes (PO) and Programme Specific Outcomes (PSO)

No	Programme Outcomes / Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
The students will be able to:																
1	UEE847E.1	3	3	1	1			1					1	2	1	2
2	UEE847E.2	3	3	3	1	2		1					1	2	1	2
3	UEE847E.3	3	3	3	1			1					1	2	1	2
4	UEE847E.4	3	1	2	3			1					1	2	1	2

Competencies Addressed in the course and Corresponding Performance Indicators

Programme Outcome: Any of 1 to 12 PO's:

Sl.	Unit Learning Outcome (ULO)	CO's	BLL	PI addressed
	Unit -I			
1.	List the causes of over voltage in Power System.	01	L1	1.3.1
2.	List the internal and external causes of over voltage in power system.	01	L1	1.3.1
3.	Define a travelling wave?	02	L1	1.3.1
4.	List the factors that cause a travelling wave?	02	L1	1.3.1
5.	What are the values of characteristic impedance for transmission lines, cables and transformers?	02	L1	1.3.1
6.	Derive the expression on velocity of travelling waves with respect to velocity of light.	02	L3	2.3.1
7.	Derive the expression on surge impedance with respect to travelling waves.	02	L3	2.3.1
8.	A transmission line of surge impedance Z_0 is terminated through a resistance R. Give the coefficients of refraction and reflection.	02	L4	3.1.5
9.	A transmission line of surge impedance Z_0 is terminated through a inductance L. Give the coefficients of refraction and reflection.	02	L4	3.1.5
10.	A transmission line of surge impedance Z_0 is terminated through a Capacitance C. Give the coefficients of refraction and reflection.	02	L4	3.1.5
	Unit -II			
11.	Define Switching transients.	01	L1	1.3.1
12.	Explain briefly about the resistance switching in power system.	01	L2	
13.	Write a short note on resistance switching and develop the equivalent circuit	01	L1	1.3.1
14.	What is restriking voltage?	01	L1	1.3.1
15.	Explain the load switching in both normal and abnormal conditions with neat sketches	01	L2	2.1.1
16.	Describe briefly about characteristic of Ferro-resonance	01	L3	2.1.2
17.	What is called capacitance switching? With necessary sketches, explain capacitive switching with a resrike and multiple resrikes.	01	L3	2.4.1
18.	Write the short notes on (i) Ferro resonance (ii) Current chopping	01	L1	1.3.1
19.	Differentiate normal and abnormal switching transients	01	L2	2.1.1

20.	What are the objectives of resistive switching?	**01**	**L1**	**1.3.1**
	Unit -III			
21.	Draw the model for lightning stroke	**03**	**L3**	**2.1.2**
22.	What are the factors in which the tower footing resistance depend on	**03**	**L1**	**1.3.1**
23.	Explain the formation of thunder clouds with the aid of various theories	**03**	**L2**	**2.1.1**
24.	Derive the mathematical model for lightning	**03**	**L3**	**2.1.2**
25.	Explain in detail how the charges are formed in the clouds.	**03**	**L2**	**2.1.1**
26.	Explain the lightning protection schemes for transmission lines.	**03**	**L2**	**2.1.1**
27.	List out the important characteristics of lightning	**03**	**L1**	**1.3.1**
28.	Give the measurement details of induced voltage on overhead lines due to lightning	**03**	**L4**	**3.1.5**
29.	Define lightning?	**03**	**L1**	**1.3.1**
30.	What are the different types of strokes?	**03**	**l2**	**2.1.1**
	Unit -IV			
31.	Explain briefly Protection of power systems against transient over-voltage due to switching and lightning,	**04**	**L4**	**6.2.1**
32.	Explain briefly Protection of power systems against transient over-voltage due to lightning,	**04**	**L4**	**6.2.1**
33.	Explain briefly on Lightning arrestors	**04**	**L2**	**2.1.1**
34.	Explain briefly on Surge diverters, Surge capacitors and reactors,	**04**	**L2**	**2.1.1**
35.	Explain briefly protection on Overhead ground wires	**04**	**L2**	**2.1.1**
36.	Explain briefly on Insulation coordination	**04**	**L2**	**2.1.1**

Competencies Addressed in the course and Corresponding Performance Indicators

Programme Outcome: Any of 1 to 12 PO's:

PO	**Competency**		**Performance Indicators**	
1	**1.3**	Demonstrate competence in engineering fundamentals	**1.3.1**	Apply elements of electrical engineering principles and laws
2	**2.1**	Demonstrate an ability to identify and characterize an engineering problem	**2.1.1**	Evaluate problem statements and Identify objectives
			2.1.2	Identify engineering systems, variables, and parameters to solve the problems
	2.4	Demonstrate an ability to execute a solution, process and analyse results	**2.4.1**	Apply engineering mathematics and computations to solve (form & analyse) mathematical models.
3	**3.1**	Demonstrate an ability to define a complex open-ended problem in engineering terms	**3.1.5**	Explore and synthesize engineering requirements From larger social and professional concerns
6	**6.2**	Demonstrate an understanding of professional engineering regulations, legislation and standards	**6.2.1**	Interpret legislation, regulations, codes, and standards relevant to electrical and electronics engineering discipline (such as IEEE) and explain its contribution to the Protection of the public

PO1. **Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO2. **Problem analysis**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO3. **Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO4. **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO5. **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.

PO6. **The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO7. **Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO8. **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO9. **Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO10. **Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO11. **Project management and finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO12. Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

Course Content:

Hours Required	Topic to be covered	Mode of Delivery
01	Internal and external causes of over voltages	**Chalk and talk in classroom/Lecture combined with discussions**
01	Travelling waves in transmission lines	
01	Circuits with distributed constants	
01	Wave equations – Reflection and Refraction of travelling waves	
01	Problems on Reflection and Refraction	
01	Travelling waves at different line terminations	
01	Travelling waves on line terminations at open ended	
01	Travelling waves on line terminations at Short circuit ended , Resistance	
01	Travelling waves on line terminations at capacitance and inductance	
01	Problems on travelling wave's line terminated at different lines.	
01	Over voltages due to switching transients	**Chalk and talk in classroom/Lecture combined with discussions**
01	Resistance switching and the equivalent circuit for interrupting the resistor.	
01	load switching and equivalent circuit - waveforms for transient voltage across the load	
01	Normal and abnormal switching transients.	
01	Current suppression - current chopping	
01	Effective equivalent circuit	
01	Capacitance switching - effect of source regulation	
01	Capacitance switching with a re-strike	
01	Capacitance switching with multiple re-strikes	
01	Illustration for multiple re-striking transients – Ferro-resonance	
01	Review of the theories in the formation of clouds and charge formation	**Chalk and talk in classroom/Lecture combined with discussions**
01	Rate of charging of thunder Clouds	
01	Mechanism of lightning discharges and characteristics of lightning strokes	
01	Model for Lightning stroke	
01	Factors contributing to good line design	
01	Protection using ground wires	
01	Tower footing resistance	
01	Interaction between lightning and power system	
01	Problems	
01	Problems	
02	Protection of power systems against transient	**Chalk and talk in classroom/Lecture combined with discussions**
02	over-voltage due to switching and lightning,	
02	Lightning arrestors, Surge diverters,	
02	Surge capacitors and reactors,	
01	Overhead ground wires,	
01	Insulation coordination,	

Review Questions:

Review Questions	CO	BLL	PI addressed
What is a travelling wave?	**02**	**L1**	**1.3.1**
What are the factors that cause a travelling wave?	**02**	**L1**	**1.3.1**
What are the values of characteristic impedance for transmission lines, cables and transformers?	**02**	**L1**	**1.3.1**
What is the velocity of propagation of a surge in overhead lines and cables?	**02**	**L1**	**1.3.1**
What are the expressions for the voltage and current when a line is terminated by an (i) inductance (ii) a capacitance?	**02**	**L2**	**2.1.1**
Why is the velocity of propagation same for all overhead lines?	**02**	**L1**	**1.3.1**
What is meant by crest of a wave?	**02**	**L1**	**1.3.1**
What is meant by "wave front"?	**02**	**L1**	**1.3.1**
A transmission line of surge impedance Z_0 is terminated through a resistance R. Give the coefficients of refraction and reflection.	**02**	**L4**	**3.1.5**
What is the effect of shunt capacitance at the terminal of a transmission line?	**02**	**L1**	**1.3.1**
What is meant by abnormal switching transients	**02**	**L1**	**1.3.1**
Sketch the restrike waveform of the capacitance switching	**02**	**L3**	**2.1.2**
Define ferro resonance	**02**	**L1**	**1.3.1**
Give a power system example for the occurrence of Ferro resonance	**02**	**L3**	
What is the need of resistance switching	**01**	**L1**	**1.3.1**
Why multiple restrike occur due to capacitance switching	**01**	**L1**	**1.3.1**
Briefly describe the normal and abnormal switching transients	**01**	**L3**	**2.1.2**
Explain the phenomenon of current suppression with an example.	**01**	**L2**	**2.1.1**
Distinguish between lightning surges and switching surges	**01**	**L3**	**2.1.2**
Explain capacitance switching with circuit and waveforms showing the effect of source regulation, one and multiple restrikes	**01**	**L4**	**2.4.1**
What are the factors contributing to good line design	**03**	**L1**	**1.3.1**
What is the significance of tower footing resistance?	**03**	**L1**	**1.3.1**
Mention the different theories of charge formation	**03**	**L1**	**1.3.1**
Discuss the mechanism of lightning discharge	**03**	**L3**	**2.1.2**
Explain the formation of thunder clouds with the aid of various theories	**03**	**L2**	**2.1.1**
Sketch the characteristics of lightning strokes and also discuss the parameters of lightning flash.	**03**	**L3**	**2.1.2**
Explain in detail how the charges are formed in the clouds. What are the two theories of charge formation in the clouds? Explain them in detail.	**03**	**L2**	**2.1.1**
Explain the concept of tower footing resistance.	**03**	**L2**	**2.1.1**
Derive the mathematical model for lightning	**03**	**L3**	**2.1.2**
Describe the interaction between lightning and power system. Explain With necessary diagrams and equivalent circuit, discuss the interaction between lightning and power system.	**03**	**L3**	**2.1.2**
Explain briefly Protection of power systems against transient over-voltage due to switching and lightning,	**04**	**L2**	**6.2.1**
Explain briefly Protection of power systems against transient over-voltage due to lightning,	**04**	**L2**	**6.2.1**
Explain briefly working on Lightning arrestors	**04**	**L2**	**2.1.1**
Explain briefly working onSurge diverters, Surge capacitors and reactors.	**04**	**L2**	**2.1.1**
Explain briefly working on protection of Overhead ground wires	**04**	**L2**	**6.2.1**
Explain briefly working on Insulation coordination	**04**	**L2**	**2.1.1**

Evaluation Scheme:

Assessment	Marks	Weightage
CIE-I	20	20
CIE-II	20	20
Assignments/ Quizzes/ Case Study/ Course Project/ Term Paper/Field Work	10	10
SEE	100	50
Total	150	100

Details of Assignment:

Assignment	Marks (10)	CO	PI	CA	PO
Assignment 1	Descriptive Questions with numericals (05M)	01,02,03,04	1.3.1,2.4.1,2.1.2,3.1.5,6.1.2	1.3,2.4,2.1,3.1,6.2	01,02,03,06
Assignment 2	Quiz (05M)	01,02,03,04	1.3.1,2.4.1,2.1.2,3.1.5,6.1.2	1.3,2.4,2.1,3.1,6.2	01,02,03,06