INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad-500043

ELECTRICAL AND ELECTRONICS ENGINEERING

TUTORIAL QUESTION BANK

Course Name	**:**	**POWER SYSTEM OPERATION AND CONTROL**
Course Code	**:**	**AEE016**
Class	**:**	**B.Tech VII Semester**
Branch	**:**	**Electrical and Electronics Engineering**
Year	**:**	**2020 - 2021**
Course Coordinator	**:**	**Dr. P Sridhar, Professor**

COURSE OBJECTIVES:

The students will try to learn:	
I	The economic operation through optimal generation - load dispatch, hydro -thermal and pumped storage plant scheduling and their implementation through various classical methods.
II	The required mathematical and engineering fundamentals for controlling the governing system, turbine, excitation models and automatic, load frequency controllers in the power system.
III	The necessity and effective management of generation, transmission and distribution of electrical power for optimal operation of the system.
IV	The concepts of load frequency control in interconnected systems, its operation, reactive power control, compensation techniques in transmission line and types of loads with characteristics for real-world engineering problems and applications.
V	The control actions required on the system to meet the minute-to-minute variation of system demand and its significance in power system operation and control by maintaining the frequency and voltage as constant

COURSE OUTCOMES:

Upon the successful completion of this course, the students will be able to:	
CO1	**Apply** knowledge of engineering science including electrical circuits, control systems and electrical machines in power system operation and control.
CO2	**Determine** economic scheduling of generation in a power system to supply specific amount of demand.
CO3	**Outline** the problems related to the economic dispatch of power, plant scheduling, strategies for minimizing transmission line losses and penalties imbibed.
CO4	**Calculate** the cost of generation, economic dispatch of power among ‘n’ thermal units using incremental cost curves and coordinate equation using iteration method.
CO5	**Develop** the mathematical models of the mechanical and electrical components involved in the operation of power systems under steady and dynamic conditions.

CO6	**Model** excitation system using the fundamental characteristics and transfer function method.
CO7	**Analyze** the static performance of the system with automatic generation control, excitation voltage and reactive power control in an interconnected power system.
CO8	**Design** a compensation scheme in a transmission line for imparting knowledge of various controllers with its evolution, principle of operation and applications
CO9	**Determine** the optimal location of power capacitors for power factor improvement with economic justification.
CO10	**Demonstrate** the importance of load compensation in symmetrical as well as unsymmetrical loads with its characteristics.
CO11	**Solve** different numerical problems related to Economic Load Dispatch, Load Frequency Control and reactive power control.

TUTORIAL QUESTION BANK

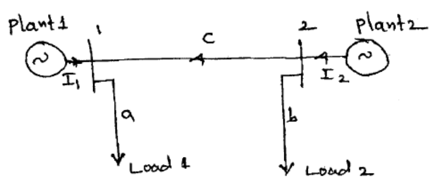
UNIT- I				
ECONOMIC OPERATION OF POWER SYSTEMS				
Part - A (Short Answer Questions)				
S No	**QUESTIONS**	**Blooms Taxonomy Level**	**How Does This Subsume the Level**	**Course Outcomes**
1	Define in detail the following? i. Control variables ii. Disturbance variables and iii. State variables.	Remember	This would require learner to recall different system variables to know the inequality constraints	CO 2
2	Draw incremental fuel cost curve?	Understand	This would require learner to understand the importance of fuel on operating cost.	CO 1
3	Define Production cost of power generating stations?	Understand	This would require learner to understand the input-output characteristics of generators.	CO 1
4	Write the expression for hourly loss of economy resulting from error in Incremental cost representation?	Remember	This would require the learner to recall the Incremental Cost and Understand, what is hourly loss of economy and the derive the expression for hourly loss of economy resulting from error in incremental cost representation.	CO 1
5	Mention the assumptions made in the formation of loss formula using B coefficient matrix?	Remember	This would help the learner to simplify the calculations in a basic system.	CO 2
6	Draw flow chart for economic scheduling without considering line losses.	Remember	This would help the learner to recall and develop the computer-based programs to get the solutions in the bulk network.	CO 2
7	What is the role of spinning reserve in unit commitment?	Remember	This would require learner to recall the effect of spinning reserve during load sharing in emergency.	CO 1

8	Write the equality and inequality constraints considered in the economic dispatch problem	Remember	This would require the learner to recall the concept of unit commitment and explain the role of spinning reserve in unit commitment.	CO 1
9	Define ‘‘Load Curve’’?	Remember	This would require learner to recall the load patterns over a period.	CO 1
10	Explain the long-term hydrothermal scheduling?	Remember	This would require the learner to recall the concept of hydrothermal scheduling and its classification then explain what long-term Hydrothermal scheduling is.	CO 1
11	What are the advantages of using forward dynamic programming method?	Remember	This would require learner to recall the static optimization problem for load scheduling.	CO 2
12	Write the relationship between λ and power demand when the cost curve is given?	Remember	This would help the learners to develop coordination equation in generating stations.	CO 2
13	Explain the penalty factor?	Understand	This would help the learners to understand the penalties imbibed.	CO 2
14	Compare with unit commitment and economic load dispatch?	Understand	This would require learner to understand the concept of optimization with respect to load flows and economics.	CO 1
15	What is the purpose of economic dispatch?	Remember	This would require the learner to recall the concept of economic dispatch and its importance in thermal stations.	CO 1
16	What is meant by total generator operating cost?	Understand	This would require the learner to recall the concept of transmission loss formula and solve B-Coefficients.	CO 1
17	What are the factors affecting the cost of generation (or) list the various constraints in the modern power systems?	Remember	This would require the learner to recall the concept of economic dispatch & the factors influencing the cost. It is also discussed various equality and inequality constraints.	CO 1
18	How is incremental operating cost related to economic dispatch?	Remember	This would require the learner to recall the concept of the economic dispatch problem and explain the equality and inequality constraints of static optimization problem.	CO 1
Part - B (Long Answer Questions)				
1	Describe in detail, with suitable examples, the methods of optimum scheduling of generation of power from a thermal station.	Understand	This would require the learner to understand the concept of thermal station and discuss about the different methods of optimum scheduling of generation of thermal station.	CO 4

2	Derive transmission loss formula in terms of B-coefficients	Understand	This would require the learner to understand the concept of transmission loss formula and then derive the B-Coefficients.	CO 3
3	Explain in detail the terms production costs, total efficiency, efficiency, and incremental rates with respect to a thermal power plant.	Understand	This would require the learner to understand the total efficiency, efficiency, and incremental rates from input - output characteristics of thermal stations.	CO 4
4	Give various uses of general loss formula and state the assumptions made for calculating B coefficients.	Understand	This would require the learner to understand the concept of transmission loss formula with B-Coefficients and the assumptions in terms of X/R ratios.	CO 3
5	Give step by step procedure for computing economic allocation of generation in a thermal station.	Understand	This would require the learner to understand the economic dispatch of thermal generation and then explain the complete procedure of generation.	CO 4
6	What is the objective in economic load scheduling? Describe the need for co-ordination of different power station.	Understand	This would require the learner to understand the concept of economic load scheduling and then explain the coordination of different power station.	CO 3
7	Explain the λ-iteration method for finding the solution of economic dispatch including transmission losses with a neat flow chart.	Understand	This would require the learner to understand economic load scheduling with transmission line losses.	CO 3
8	What is mean by unit commitment problem? Discuss a method for solving the same.	Understand	This would require the learner to understand the concept of unit commitment and explains load scheduling among the generators.	CO 3
9	Explain the various factors to be considered in allocating power generation to different power station s for optimum operation.	Understand	This would require the learner to understand the operation of different plants and explain allocating loads to different power stations for optimum operation.	CO 3
10	Give algorithm for economic allocation of generation among generators of a thermal system considering transmission losses. Give steps for implementing this algorithm and also derive necessary equations.	Understand	This would require the learner to understand the concept of transmission loss formula and develop algorithm for digital computations.	CO 4
11	Write a short note on a) Inequality constraints and b) Penalty function.	Understand	This would require the learner to understand the various inequality parameters and penalties imbibed.	CO 3
12	What are the methods of scheduling power generation of steam plants? Explain their merits and demerits?	Understand	This would require the learner to understand the concept of methods of scheduling power generation of thermal plant and explain with its merits and demerits	CO 4

13	Discuss optimal power flow problems without and with inequality constraints. How are these problems solved?	Understand	This would require the learner to understand the concept of the economic dispatch problem and then explain the equality and inequality constraints	CO 3
14	Develop loss formula coefficients for a two-plant system. State the assumption made?	Understand	This would require the learner to understand the concept of losses in transmission lines using B-Coefficients with simplified assumptions.	CO 2
15	Explain the problem of scheduling hydrothermal power plants. What are the constraints in the problem?	Understand	This would require the learner to understand the hydrothermal scheduling and its classification and explain the scheduling of load in hydrothermal stations.	CO 4
16	Explain the mathematical formulation of optimal scheduling of hydrothermal system with a typical example.	Understand	This would require the learner to understand the hydrothermal scheduling and its mathematical models for optimal scheduling with suitable examples.	CO 4
17	Derive general mathematical formulation of long-term hydrothermal scheduling.	Understand	This would require the learner to understand the hydrothermal scheduling and its mathematical models for optimal scheduling with suitable examples.	CO 4
18	State what is meant by base and peak load stations. Discuss the combined hydroelectric and steam station operation.	Understand	This would require the learner to understand the different load patterns and the scheduling with hydro stations in hydrothermal systems.	CO 4
Part - C (Problem Solving and Critical Thinking Questions)				
1	Incremental fuel cost is Rs/MWhr for a plant of two units. dc1/dpg1 = 0.25 Pg1 + 40; dc2/dpg2 =0.3 Pg2 + 30 Assume that both the units are operating at all times and total load varies from 40 MW to250 MW. How will the load be shared for a load of 200 MW? What is the corresponding value of plant incremental cost? Also determine the saving in the fuel cost in Rs/hr for one optimum scheduling of 250 MW as compared to equal distribution of same load between two plants.	Understand	This would require the learner to understand economic operation of plant and recall the concept of Incremental Cost. Apply the formula to determine the fuel cost as per coordination equation.	CO 2
2	The fuel cost for a two-unit steam power plant are given by $C1 = 0.1\ P1^2 + 25\ P1 + 1.6$ Rupees/hour $C2 = 0.1\ P_2^2 + 32\ P2 + 2.1$ Rupees/hour Where p's are in megawatt. If there is an error of 1% in the representation of the input data, and the loss in operating economy for a load of 250 MW.	Understand	This would require the learner to understand economic operation of plant and recall the Coordination between different plants. Apply the formula to determine the load sharing among the power plants.	CO 2
3	A power System consists of two, 125 MW units whose input cost data are represented by the equations: $C1 = 0.04\ P_1^2 + 22\ P_1 + 800$ Rupees/hour	Understand	This would require the learner to understand economic operation of plant and recall the Coordination between different	CO 2

	$C2 = 0.045 P_2^2 + 15 P_2 + 1000$ Rupees/hour If the total received power $P_R = 200$ MW. Determine the load sharing between units for most economic operation.		plants. Apply the formula to determine the load sharing among the generating plants.	
4	100 MW, 150 MW and 280 MW are the ratings of three units located in a thermal power station. Their respective incremental costs are given by the following equations: dc1/dp1 = Rs (0.15p1 + 12); dc3/dp3 = Rs (0.21p3 + 13) dc2/dp2 = Rs (0.05p2 + 14) Where P1, P2 and P3 are the loads in MW. Determine the economical load allocation between the three units, when the total load on the station is 300 MW.	Understand	This would require the learner to understand economic operation of plant and recall the Coordination between different plants. Apply the formula to determine the load sharing among the generating plants.	CO 2
5	The incremental fuel cost in rupees per MWhr for a plant consisting of two units are dC1/dPG1 =0.20 PG1+40.0; dC2/dPG2 =0.25 PG2+30.0 Assume that both units are operating at all times and total load varies from 40 MW to 250 MW and maximum and minimum loads on each unit are to be 125 MW and 20MW respectively .How will the load be shared between the units as the system varies over full range? What are the plant incremental costs?	Understand	This would require the learner to understand economic operation of plant and recall the Coordination between different plants. Apply the formula to determine the load sharing among the generating plants.	CO 2
6	The fuel inputs per hour of plants 1 and 2 are given as $F1 = 0.2 P1^2 + 40 P1 + 120$ Rs per hr. $F2 = 0.25 P^2{}_2 + 30 P2 + 150$ Rs per hr. Determine the economic operating schedule and the corresponding cost of generation if the maximum and minimum loading on each unit is 100 MW and 25 MW, the demand is 180 MW and transmission losses are neglected. If the load is equally shared by both the units, determine the saving obtained by loading the units as per the incremental production cost.	Understand	This would require the learner to understand economic operation of plant and recall the Coordination between different plants. Apply the formula to determine the load sharing among the generating plants.	CO 2
7	Let us consider a generating station that contains a total number of three generating units. The fuel costs of these units are given by $F1 = (0.8/2) P_1^2 + 10 P_1 + 25$ Rs./hr $F2 = (0.7/2) P_2^2 + 5P_2 + 20$ Rs./hr $F3 = (0.95/2) P_3^2 + 15 P_3 + 35$ Rs./hr The generation limits of the units are 30 MW <= P1 <= 500 MW, 30 MW <= P2 <= 500 MW and 30 MW <= P3 <= 250 MW. The total load that these units supply varies between 90 MW and 1250 MW. Assuming that all the three units are operational all the time, Compute the economic operating settings as the load changes.	Understand	This would require the learner to understand economic operation of plant and recall the Coordination between different plants. Apply the formula to determine the load sharing among the generating plants.	CO 3
8	Consider two generating plant with same fuel cost and generation limits. These are given by $F1 = (0.8/2) Pi^2 + 10 Pi + 25$ Rs/hr; i = 1,2 and 100MW <= Pi <=500 MW	Understand	This would require the learner to understand economic operation of plant and recall the Coordination between different	CO 2

	For a particular time of a year, the total load in a day varies as shown in Fig. 5.2. Also an additional cost of Rs. 5,000 is incurred by switching of a unit during the off-peak hours and switching it back on during the during the peak hours. We have to determine whether it is economical to have both units operational all the time		plants. Apply the formula to determine the load sharing among the generating plants.	
9	The fuel inserts per all of plants I and II are given as $F_1= 0.1P^2_1 + 40\ P_1+120$ Rs/Hr $F_2= 0.25P^{\ 2}_2+30P_2+150$ Rs/Hr. Determine the economic operating schedule and corresponding cost of generation if the max and min loading on each unit is 100 MW and 25 MW and the demand is 180 MW and transmission losses are neglected. If the load is equally shared by the both the units, determine the saving obtained by loading the units as per equal incremental products and cost.	Understand	This would require the learner to understand economic operation of plant and recall the Coordination between different plants. Apply the formula to determine the load sharing among the generating plants.	CO 3
10	For the system shown in figure, with bus 1 as reference bus with a voltage of $1.0V<0^0$ pu, find the loss formula co-efficient if the branch currents and impedances are: Ia=1.00+j0.15 p.u; Za=0.02+j0.15 p.u, Ib=1.25+j0.20 p.u; Zb=0.03+j0.25pu, Ic =0.20-j0.05pu; Zc =0.02+0.25pu If the base is 100 MVA, what will be the magnitudes of B –coefficients in reciprocal MW? 	Understand	This would require the learner to understand economic operation of plant and recall the Coordination between different plants. Apply the formula to determine the load sharing among the generating plants.	CO 2
11	The fuel cost functions in Rs/hr for two thermal plants are given by $C_1 =420+9.2P_1+0.004P^2_2$; $C_2=350+8.5P_2+0.0029P^2_2$ Where P1, P2 are in MW. Determine the optimal scheduling of generation if the load is 640.82 MW. Estimate value of λ=12 Rs/MWhr. The transmission power loss is given by the expression P_L(p.u) $=0.0346P^2_1$(p.u) $+0.00643P^2_2$(p.u)	Understand	This would require the learner to understand economic operation of plant and recall the Coordination between different plants. Apply the formula to determine the load sharing among the generating plants.	CO 3
12	The IFC for two plants are $dC_1/dP_{G1}=0.075$ Pg1+18 Rs/hr; $dC2/dP_{G2}=0.08P_{G2}+16$ Rs/hr. The loss coefficients are given as B_{11}=0.0015/MW, B_{12}= -0.00004/ MW, B_{22} = 0.0032/ MW for λ=25 Rs/MWhr. Find the real power generations, total load demand, and the transmission power loss.	Understand	This would require the learner to understand economic operation of plant and recall the Coordination between different plants. Apply the formula to determine the load sharing among the generating plants.	CO 3
13	A system consists of two power plants connected by a transmission line. The total	Understand	This would require the learner to understand economic operation	CO 3

	load located at a plant-2 is as shown in below. Data of evaluating loss coefficients consists of information that a power transfer of 100 MW from station-1 to station-2 results in a total loss of 8 MW. Find the required generation at each station and power received by the load when λ of the system is Rs. 100/MWhr. The IFCs of the two plants are given by $dC_1/dP_{G1}=0.12P_{G1}+65$ Rs/MWhr; $dC_2/dP_{G2}=0.25P_{G2}+75$ Rs/MWhr		of plant and recall the Coordination between different plants. Apply the formula to determine the load sharing among the generating plants.	
14	Determine the incremental cost of received power and the penalty factor of the plant shown, if the incremental cost of production is $dC_1/dP_{G1}=0.1P_{G1}+3.0$ Rs/MWhr.	Understand	This would require the learner to understand economic operation of plant and recall the Coordination between different plants. Apply the formula to determine the load sharing among the generating plants.	CO 3
15	Assume that the fuel input in Btu per hour for units 1 and 2 are given by $C_1=(8P_{G1}+0.024P^2_{G2}+80)10^6$; $C_2=(6P_{G2}+0.04P^2_{G2}+120)10^6$ The maximum and min loads on the units are 100 and 10 MW, respectively. Determine the min cost of generation when the following load is supplied. The cost of fuel is Rs.2 per million Btu.	Understand	This would require the learner to understand economic operation of plant and recall the Coordination between different plants. Apply the formula to determine the load sharing among the generating plants.	CO 2
17	Two power plants are connected together by a transmission line and load at plant-2. When 100 MW is transmitted from plant-1, the transmission loss is 100 MW. The cost characteristics of two plants are $C_1=0.05P^2_{G1}+13P_{G1}$; $C_2=0.06P^2_{G2}+12P_{G2}$ Find the optimum generation for λ=22, λ=25 and λ=30.	Understand	This would require the learner to understand economic operation of plant and recall the Coordination between different plants. Apply the formula to determine the load sharing among the generating plants.	CO 2
18	A two-plant hydro-thermal system with negligible losses has the following characteristics. Fuel cost as a function of active power generated at the thermal plant is $F=(2p_1+0.01p_2^2)$ RS/hr. The optimal water conversion co-efficient is found to be 12.01RS/MCF. The load on the system is Duration (b) | 9 | 15 PD (MW) | 700 | 350 Compute the optimal active thermal and hydro power generations (in MW) in each of the subintervals and the allowable volume of water at the hydro plant	Understand	This would require the learner to understand economic operation of plant and recall the Coordination between different plants. Apply the formula to determine the load sharing among the generating plants.	CO 4
	UNIT-II			
	MODELING OF GOVERNOR, TURBINE AND EXCITATION SYSTEMS			
	Part – A (Short Answer Questions)			
1	Distinguish D.C excitation system and A.C excitation system.	Understand	This would require the learner to understand the concept of DC	CO 6

			and AC excitation system. Distinguish DC excitation system and AC excitation system	
2	What are the equations governing the movement of point C in “speed governor mechanism”?	Understand	This would require the learner to understand the working of speed governing system and develop mathematical model of it.	CO 5
3	What are the equations governing the movement of point D (i.e. hydraulic amplifier)?	Understand	This would require the learner to understand the working of speed governing system and develop mathematical model of it.	CO 5
4	Briefly explain the movement of point E (i.e., open or close the valve)	Understand	This would require the learner to understand the working of speed governing system and develop mathematical model of it.	CO 5
5	Define inertia constant	Remember	This would require the learner to Recall the concept of inertia constant which will be useful for droop characteristics.	CO 5
6	State any two necessities to put alternators in parallel	Understand	This would require the learner to understand the concept of parallel operation, this will help them for the analysis of droop characteristics.	CO 5
7	Give two conditions for proper synchronizing of alternators	Remember	This would require the learner to understand the concept of parallel operation, this will help them for the analysis of droop characteristics.	CO 5
9	Compare speed Governor and speed changer.	Understand	This would require the learner to understand the working of speed governing system and develop mathematical model of it.	CO 5
10	What are the various functions of excitation system?	Understand	This would require the learner to understand the concept of exciter and then explain the types with its components.	CO 6
11	Generalize the importance of Generator modeling?	Remember	This would require the learner to recall the concept of AVR and ALFC control loops of a generator and distinguish AVR and ALFC control loops of a generator.	CO 6
12	Compute the importance of Exciter modeling?	Remember	This would require the learner to recall the exciter and explain the working principle of excitation system with its modelling.	CO 6
13	Explain the importance of dynamic modeling of generators?	Understand	This would require the learner to understand the isolated power system and analyse the dynamic behavior of the system with step input.	CO 2
14	Derive Small signal transfer function?	Understand	This would require the learner to understand the incremental variations in the power system	CO 5

			constraints. The sudden changes could be modelled as small signal transfer function.	
15	What is the IEEE-I model?	Remember	This would require the learner to recall the excitation system and describe it with standard IEEE type I model.	CO 5
16	Write transfer function of modeling of excitation?	Remember	This would require the learner to recall the excitation unit and develop mathematical modeling.	CO 6
	Part - B (Long Answer Questions)			
1	Discuss the mechanical - hydraulic control and electro - hydraulic control speed governing system of steam turbine.	Understand	This would require the learner to understand the speed governing system of steam turbine. Also explain the mechanical - hydraulic control and electro – hydraulic control in detail.	CO 5
2	Derive the transfer function of overall excitation system?	Understand	This would require the learner to understand the concept of excitation system and the transfer function of excitation system of overall excitation system.	CO 6
3	Draw the block diagram of a power system showing the governor, turbine and Synchronous generator, indicating their transfer functions for a step disturbance of PD.	Understand	This would require the learner to understand the concept of governor, turbine and synchronous generator and understand their transfer functions then the block diagram for a step disturbance.	CO 5
4	Obtain the response of "increment in frequency", make suitable assumptions. (a) Without proportional plus integral controller and (b) With proportional plus integral control	Understand	This would require the learner to understand the concept of increment in frequency and discuss with and without proportional plus integral controller.	CO 5
5	Explain the classifications of excitation systems?	Understand	This would require the learner to understand the concept of excitation systems and explain the classification.	CO 6
6	Explain the various components of a block diagram representation of a general excitation system?	Understand	This would require the learner to understand the concept of excitation systems explain the operation and various components.	CO 6
7	Explain the different types of limiters and their role in speed- governing system modeling.	Understand	This would require the learner to understand the concept of speed-governing system modeling and explain the different limiters with its importance	CO 5
8	Explain the effect of varying excitation of a synchronous generator?	Understand	This would require the learner to understand the concept of excitation and explain the effect of varying excitation of a synchronous generator.	CO 5

10	Derive the mathematical modeling of Speed governing system.	Understand	This would require the learner to understand the concept of speed governing system and derive the mathematical modeling.	CO 5
11	Discuss the first order modeling of turbine with neat block diagram?	Understand	This would require the learner to understand the concept of excitation systems and explain the operation with neat diagram.	CO 5
12	Explain the methods of providing excitation systems.	Understand	This would require the learner to understand the concept of excitation system and explain in detail the necessity of it in the alternators**.**	CO 6
13	Outline the fundamental characteristics of excitation system?	Understand	This would require the learner to understand the fundamental characteristics of excitation unit from the basic principles.	CO 6
	Part - C (Problem Solving and Critical Thinking Questions)			
1	Determine the primary ALFC loop parameters for a control area with the following data: Total generation capacity = 2500 MW Normal operating load =1500 MW Inertia constant=5 kW-seconds per kVA; Load damping constant, B=1 %; frequency, f=50 Hz; and Speed regulation, R=2.5 Hz / p.u MW.	Understand	This would require the learner to understand the economic operation of plant and recall ALFC loop parameters. Apply those formulas to determine the primary ALFC loop parameters in a control area.	CO 5
2	A 100 MVA Synchronous generator operates at 50 Hz, runs at 3000 rpm under no- load. A load of 25 MW is suddenly applied to the machine. Due to the time lag in the governor system the turbine commences to open after 0.6 sec. Assuming inertia constant H= 5 MW- sec per MVA of generator capacity, calculate the frequency of the system before steam own commences to increase to meet the new load.	Understand	This would require the learner to understand the economic operation of plant and recall ALFC loop parameters. Apply those formulas to determine the primary ALFC loop parameters in a control area.	CO 5
3	Two generating stations 1 and 2 have full load capacities of 200 MW and 100 MW respectively at a generating frequency of 50 Hz. The two stations are interconnected by an induction motor and synchronous generator with a full load capacity of 25 MW. The speed regulation of station 1, station 2 and induction motor and synchronous generator sets are 4 %, 3.5% and 2.5% respectively. The load on respective bus bars is 75 MW and 50 MW respectively. Find the load taken by the motor generator set.	Understand	This would require the learner to understand the speed governing system and interconnected by an induction motor. Apply those formulas to determine load shared by the motor-generator set.	CO 5
4	Two turbo alternators rated for 110 MW and 220 MW have governor drop characteristics of 5% from no load to full load. They are connected in parallel to share a load of 250 MW. Determine the load shared by each machine assuming free governor action.	Understand	This would require the learner to understand the speed governing system and interconnected by an induction motor. Apply those formulas to determine load shared by the motor-generator set.	CO 5

5	Two generating stations 1 and 2 have full load capacities of 300 MW and 200 MW respectively at a generating frequency of 50 Hz. The two stations are interconnected by an induction motor and synchronous generator with a full load capacity of 50 MW. The speed regulation of station 1, station 2 and induction motor and synchronous generator sets are 45%, 4% and 3% respectively. The load on respective bus bars is 70 MW and 60 MW respectively. Find the load taken by the motor generator set.	Understand	This would require the learner to understand the speed governing system and interconnected by an induction motor. Apply those formulas to determine load shared by the motor-generator set.	CO 5
6	Two turbo alternators rated for 150 MW and 250 MW have governor drop characteristics of 8% from no load to full load. They are connected in parallel to share a load of 300 MW. Determine the load shared by each machine assuming free governor action.	Understand	This would require the learner to understand the speed governing system and interconnected by an induction motor. Apply those formulas to determine load shared by the motor-generator set.	CO 5
7	Two generators rated 200MW and 400MW are operating in parallel. Draw the 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 600MW is shared between them? What will be the system frequency at this load, assume free governor operation, repeat the problem if both governors have drop of 4%.	Understand	This would require the learner to understand the speed governing system and interconnected by an induction motor. Apply those formulas to determine load shared by the motor-generator set.	CO 5
8	Two generators rated 400MW and 700MW are operating in parallel. Draw the characteristics of their governors are 6% and 8% respectively from no load to full load. Assuming that the generators are operating at 50 Hz at no load, how would a load of 900MW be shared between them? What will be the system frequency at this load, assume free governor operation, repeat the problem if both governors have drop of 7%.	Understand	This would require the learner to understand the speed governing system and interconnected by an induction motor. Apply those formulas to determine load shared by the motor-generator set.	CO 5
9	Determine the primary ALFC loop parameters for a control area with the following data: Total generation capacity = 3500 MW Normal operating load =2500 MW Inertia constant=25 kW-seconds per kVA; Load damping constant, B=2 %; frequency, f=50 Hz; and Speed regulation, R=3.5 Hz / p.u MW	Understand	This would require the learner to understand the speed governing system and interconnected by an induction motor. Apply those formulas to determine load shared by the motor-generator set.	CO 5
10	A 400 MVA Synchronous generator operates at 50 Hz, runs at 3000 rpm under no- load. A load of 50 MW is suddenly applied to the machine. Due to the time lag in the governor system the turbine commences to open after 0.6 sec. Assuming inertia constant H= 9 MW- sec per MVA of generator capacity, calculate the	Understand	This would require the learner to understand the speed governing system and interconnected by an induction motor. Apply those formulas to determine load shared by the motor-generator set.	CO 5

	frequency of the system before steam own commences to increase to meet the new loa d.			
11	Two generating stations 1 and 2 have full lo ad capacities of 200 MW and 100 MW respectively at a generating frequency of 50 Hz. The two stations are interconnected by an induction motor and synchronous generator with a full load capacity of 25 MW. The speed regulation of station 1, station 2 and induction motor and synchronous generator sets are 4 %, 3.5% and 2.5% respectively. The load on respective bus bars is 75 MW and 50 MW respectively. Find the load taken by the motor generator set.	Understand	This would require the learner to understand the speed governing system and interconnected by an induction motor. Apply those formulas to determine load shared by the motor-generator set.	CO 5
12	Two turbo alternators rated for 110 MW and 220 MW have governor drop characteristics of 5% from no load to full load. They are connected in parallel to share a load of 250 MW. Determine the load shared by each machine assuming free governor action.	Understand	This would require the learner to understand the speed governing system and interconnected by an induction motor. Apply those formulas to determine load shared by the motor-generator set.	CO 5
13	Two generating stations 1 and 2 have full load capacities of 300 MW and 200 MW respectively at a generating frequency of 50 Hz. The two stations are interconnected by an induction motor and synchronous generator with a full load capacity of 50 MW. The speed regulation of station 1, station 2 and induction motor and synchronous generator sets are 45%, 4% and 3% respectively. The load on respective bus bars is 70 MW and 60 MW respectively. Find the load taken by the motor generator set.	Understand	This would require the learner to understand the speed governing system and interconnected by an induction motor. Apply those formulas to determine load shared by the motor-generator set.	CO 5
14	Two turbo alternators rated for 150 MW and 250 MW have governor drop characteristics of 8% from no load to full load. They are connected in parallel to share a load of 300 MW. Determine the load shared by each machine assuming free governor action.	Understand	This would require the learner to understand the speed governing system and interconnected by an induction motor. Apply those formulas to determine load shared by the motor-generator set.	CO 5
15	Two generators rated 200MW and 400MW are operating in parallel. Draw the 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 600MW is shared between them? What will be the system frequency at this load, assume free governor operation, repeat the problem if both governors have drop of 4%.	Understand	This would require the learner to understand the speed governing system and interconnected by an induction motor. Apply those formulas to determine load shared by the motor-generator set.	CO 6

UNIT -III

SINGLE AREA AND TWO AREA LOAD FREQUENCY CONTROL SYSTEMS

Part - A (Short Answer Questions)

1	Define control area.	Remember	This would require the learner to recall the concept of control area, explain it in detail	CO 7
2	Write Short notes on control area concept.	Remember	This would require the learner to recall the concept of control area with the basic properties and explain it in detail.	CO 7
3	Write Short notes on area control error.	Understand	This would require the learner to understand the concept of static response and explain it in detail in coherent area.	CO 7
4	What is tie line bias control?	Remember	This would require the learner to recall the concept of line bias control and explain it in detail.	CO 7
5	Define the static response.	Remember	This would require the learner to recall the concept of static response and explain it in detail.	CO 7
6	What is the function of Load Frequency Control	Understand	This would require the learner to understand the concept of load frequency control and explain its function in LFC loop.	CO 7
7	Identify the purpose power factor primary ALFC?	Understand	This would require the learner to understand the concept of ALFC, also discuss its purpose for power factor in primary ALFC loop.	CO 7
8	List out the various needs for frequency regulation in power system.	Remember	This would require the learner to recall the importance of frequency as constant.	CO 7
9	List out the various methods of voltage control in transmission system?	Understand	This would require the learner to understand the concept of voltage control techniques and explain them in detail.	CO 7
10	Define single area system	Understand	This would require the learner to understand the concept of single area and explain it in detail.	CO 7
11	Write expression for steady state response of a load frequency controller with integral control	Understand	This would require the learner to understand the concept of load frequency controller and derive its expression for steady state response with integral control.	CO 7
12	What are the merits of proportional plus integral?	Remember	This would require the learner to recall the concept of proportional plus integral and discuss its merits.	CO 7
13	Define control variables?	Remember	This would require the learner to recall the concept of control variables**.**	CO 7
14	State the basic role of ALFC?	Understand	This would require the learner to recall the concept of ALFC and discuss its importance.	CO 7

15	Define steady state response??	Remember	This would require the learner to recall the concept of steady state response and discuss it in detail.	CO 7
16	List out the methods to keep the frequency constant.	Remember	This would require the learner to recall the importance of frequency as constant.	CO 7
17	Compute the necessity of keeping the frequency constant in a power system	Understand	This would require the learner to understand the importance of frequency as constant.	CO 7
18	Define two Area load frequency control.	Remember	This would require the learner to recall the concept of two area and explain it in detail.	CO 7
19	Define dynamic response.	Remember	This would require the learner to recall the concept of static response and explain it in detail.	CO 7
20	Define pool operation?	Understand	This would require the learner to recall the concept of pool operation and explain it in detail with grid concept.	CO 7
Part - B (Long Answer Questions)				
1	Explain the state variable model of single area load frequency controller with integral action.	Understand	This would require the learner to understand the concept of single area load frequency controller and explain with its the state variable model.	CO 7
2	Discuss the importance of combined load frequency control and economic dispatch control with a neat block diagram	Understand	This would require the learner to understand the concept of single area load frequency controller, economic dispatch control and explain its importance.	CO 7
3	Discuss in detail the dynamic response of a single area system, without integral control following a step load disturbance	Understand	This would require the learner to understand the concept of single area load frequency controller and derive the expression for dynamic response with step input.	
4	Define control area. Obtain the transfer function model and explain ALFC of a single area of an isolated power system.	Understand	This would require the learner to understand the concept of single area load frequency controller and economic dispatch control and find transfer function.	CO 7
5	Describe the nature of the steady state response of the uncontrolled load frequency control of a single area?	Understand	This would require the learner to understand the concept of single area load frequency controller with its steady state response.	CO 7
6	List out the basic requirements of a closed loop control system employed for obtaining the frequency constant?	Understand	This would require the learner to understand the concept of closed loop control system and discuss the methods to obtain frequency constant.	CO 7
7	With a neat block diagram explain the load frequency control for a single area system.	Understand	This would require the learner to understand the concept of turbo-generator and discuss the response of the system for a	CO 7

			sudden change in load demand.	
8	Draw and explain complete block diagram representation of single area having a turbo-generator supplying an isolated load for load frequency problem. Discuss the response of the system for a sudden change in load demand	Understand	This would require the learner to understand the concept of turbo-generator and discuss the response of the system for a sudden change in load demand by developing its mathematical model.	CO 7
9	Explain the importance of flat tie-line and flat frequency control	Understand	This would require the learner to understand the tie line bias control for droop and load sharing.	CO 7
10	List out the requirements of control strategy in integral control? Explain the role played by the controller's gain setting in the frequency control.	Understand	This would require the learner to understand the concept of frequency control and discuss control strategy in integral control.	CO 7
11	Obtain an expression for steady state response of a load frequency controller with integral control. How it is different from without integral control.	Understand	This would require the learner to understand the steady state response of a load frequency controller with integral control.	CO 7
12	Discuss the merits of proportional plus integral load frequency control of a system with a neat block diagram.	Understand	This would require the learner to understand the proportional plus integral load frequency control and discuss the merits.	CO 7
13	State briefly how the time response of the frequency error depends upon the gain setting of the integral control	Understand	This would require the learner to understand the frequency control and discuss control strategy in integral control to minimize the error in frequency.	CO 7
14	Draw the block diagram of load frequency control of two- area control systems with gain blocks	Understand	This would require the learner to understand the frequency control in two area system with its blocks.	CO 7
15	Give a typical block diagram for a two-area system interconnected by a tie line and explain each block. Also deduce relations to determine the frequency of oscillations of tie line power and static frequency drop. List out assumptions made.	Understand	This would require the learner to understand the two area LFC system and also determine the oscillations in tie line. Also discuss the assumptions made.	CO 7
16	Describe the steady state analysis in controlled case and un-controlled case?	Understand	This would require the learner to understand the steady state analysis and discuss it in controlled and un-controlled case.	CO 7
17	Draw the transfer function block diagram for a two-area system provided with governor control and obtain the steady state frequency error following a step load change in both the areas.	Understand	This would require the learner to understand the two-area load frequency control systems block diagram and discuss control strategy in integral control.	CO 7

<table>
<tr><th colspan="5">Part – C (Problem Solving and Critical Thinking)</th></tr>
<tr><td>1</td><td>A 125 MVA turbo alternator operates on full load at 50 Hz. A load of 50MWis suddenly reduced on the machine. The steam valves to the turbine commence to close after 0.5 seconds due to the time lag in the governor system. Assuming inertia constant H= 6 kW -sec per kVA of generator capacity, calculate the change in frequency that occurs in this time.</td><td>Understand</td><td>This would require the learner to understand the load frequency controller and interconnected with an induction motor and synchronous generator. Apply the formulas to determine the change in frequency that occurs during the specified time.</td><td>CO 7</td></tr>
<tr><td>2</td><td>The single area control system has the following data: TP=10 sec, Tg = 0.3 sec, Tt=0.2 sec, KP =200 Hz/pu MW, R=6 Hz/pu MW, PD=0.5 pu MW, Ki=0.5. Compute the time error caused by a step disturbance of magnitude 0.5 pu (as given above). Prove, in particular, that the error is reduced by increasing the given Ki. Express the error in seconds and cycles if the system frequency is 50 Hz.</td><td>Understand</td><td>This would require the learner to understand the load frequency controller and interconnected with an induction motor and synchronous generator. Apply the formulas to determine the change in frequency that occurs during the specified time with its steady state error.</td><td>CO 7</td></tr>
<tr><td>3</td><td>A single area consists of two generators with the following parameters: Generator 1 = 1200 MVA; R=6 % (on machine base) Generator 2 = 1000 MVA; R=4 % (on machine base) The units are sharing 1800 MW at normal frequency 50 Hz. Unit supplies 1000 MW and unit 2 supplies 800 MW. The load now increased by 200 MW.
(a) Find steady state frequency and generation of each unit if B=0.
(b) Find steady state frequency and generation of each unit if B=1.5.</td><td>Understand</td><td>This would require the learner to recall the concept of single area load frequency controller and then understand the interconnected by an induction motor and synchronous generator. Apply the formula to determine the steady state frequency and generation by each unit.</td><td>CO 7</td></tr>
<tr><td>4</td><td>A single area consists of two generating units
<table><tr><th>unit</th><th>Rating in MVA</th><th>Speed regulation R (p.u on unit MVA base)</th></tr><tr><td>1</td><td>600</td><td>6%</td></tr><tr><td>2</td><td>500</td><td>4%</td></tr></table>with the following characteristics. The units are operating in parallel, sharing 900 MW at a nominal frequency. Unit 1 supplies 500 MW and unit 2 supplies 400 MW at 60 Hz. The load is increased by 90 MW.
(a) Assume there is no frequency dependent load i,e., B=0. Find the steady state frequency deviation and new generation on each unit.
(b) The load varies 1.5 % for every 1 % change in frequency i.e., B= 1.5. Find the steady state frequency deviation and new generation on each unit.</td><td>Understand</td><td>This would require the learner to recall the concept of single area load frequency controller and then understand the interconnected by an induction motor and synchronous generator. Apply the formula to determine the steady state frequency and generation by each unit.</td><td>CO 7</td></tr>
<tr><td>5</td><td>A Generator in single area load frequency control has the following parameters: Total generation capacity = 2500 MW Normal</td><td>Understand</td><td>This would require the learner to recall the concept of single area load frequency controller and</td><td>CO 7</td></tr>
</table>

	operating load =1500 MW Inertia constant=5 kW-seconds per kVA; Load damping constant, B=1 %; frequency, f=50 Hz; and Speed regulation, R=2.5 Hz / p.u MW. If there is a 1.5 % increase in the load, find the frequency drop (a) without governor control and (b) With governor control.		then understand the interconnected by an induction motor and synchronous generator. Apply the formula to determine the steady state frequency and generation by each unit.	
6	A250MVA synchronous generator is operating at 1500 rpm, 50 Hz. A load of 50 MW is suddenly applied to the machine and the station valve to the turbine opens only after 0.35 sec due to the time lag in the generator action. Calculate the frequency at which the generated voltage drops before the steam flow commences to increase to meet the new load. Given that the valve of H of the generator is 3.5 KW-s per KVA of the generator energy.	Understand	This would require the learner to recall the concept of single area load frequency controller and then understand the interconnected by an induction motor and synchronous generator. Apply the formula to determine the steady state frequency and generation by each unit.	CO 7
7	Two power systems, A and B, having capacities of 3000 and 2000 MW, respectively, are interconnected through a tie-line and both operate with frequency-bias-tie-line control. The frequency bias for each area is 1 % of the system capacity per 0.1 Hz frequency deviation. If the tie-line interchange for A is set at 100 MW and for B is set (incorrectly) at 200 MW, calculate the steady state change in frequency.	Understand	This would require the learner to recall the concept of single area load frequency controller and understand the interconnection with an induction motor and synchronous generator. Apply the formula to determine the tie-line power flow change.	CO 7
8	Two control areas have the following characteristics: Area-1: Speed regulation = 0.02 pu, Damping coefficient = 0.8 pu ,Rated MVA = 1500 Area-2: Speed regulation = 0.025 pu, Damping co-efficient = 0.9 pu, Rated MVA = 500 Determine the steady state frequency change and the changed frequency following a load change of 120MW occurs in area-1. Also find the tie-line power flow change.	Understand	This would require the learner to recall the concept of single area load frequency controller and understand the interconnection with an induction motor and synchronous generator. Apply the formula to determine the tie-line power flow change.	CO 7
9	The two area system has the following data: Capacity of area 1, Pr1 =1000 MW, Capacity of area 2, Pr2 =2000 MW, Nominal load of area 1, PD1=500 MW Nominal load of area 1, PD1=1500 MW Speed regulation of area 1=4% Speed regulation of area 2=3% Find the new steady state frequency and change in the line ow for a load change of area 2 by 125 MW. For both the areas each percent change in frequency causes 1 percent change in load. Find also the amount of additional frequency drop if the interconnection is lost due to certain reasons.	Understand	This would require the learner to recall the concept of single area load frequency controller and understand the interconnection with an induction motor and synchronous generator. Apply the formula to determine the tie-line power flow change.	CO 7
10	Explain the state variable model of two area load frequency controller with integral action.	Understand	This would require the learner to recall the concept of single area	CO 7

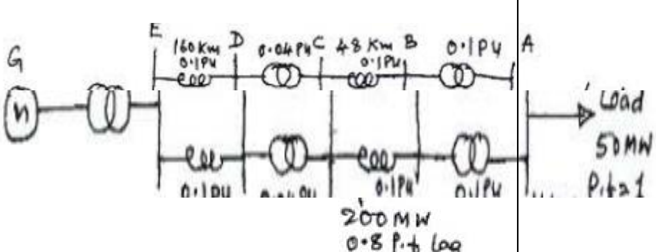
	Two control areas connected by a tie line have the following characteristics. Area 1 Area 2 R=0.01 pu R=0.02 pu ; D=0.8 pu D=1.0 pu Base MVA=2000 Base MVA=500 A load change of 100 MW (0.2 pu) occurs in area 1. What is the new steady state frequency and what is the change in the tie own? Assume both areas were at nominal frequency (60 Hz) to begin.		load frequency controller and understand the interconnection with an induction motor and synchronous generator. Apply the formula to determine the tie-line power flow change.	
11	Two generators rated 250 MW and 500 MW are operating in parallel. The droop characteristics are 4% and 6% respectively. Assuming that the generators are operating at 50 HZ at no load, how a load of 750 MW would be shared. What is the system frequency? Assume free governor action?	Understand	This would require the learner to recall the concept of single area load frequency controller and understand the interconnection with an induction motor and synchronous generator. Apply the formula to determine the tie-line power flow change.	CO 7
12	Two control areas have the following characteristics: Area-1: Speed regulation = 0.04 p.u, Damping coefficient = 0.6 p.u, Rated MVA = 1300 Area-2: Speed regulation = 0.03 p.u, Damping co-efficient = 0.85 p.u, Rated MVA = 500 Determine the steady state frequency change and the changed frequency following a load change of 150MW occurs in area-1. Also find the tie-line power flow change.	Understand	This would require the learner to recall the concept of single area load frequency controller and understand the interconnection with an induction motor and synchronous generator. Apply the formula to determine the tie-line power flow change.	CO 7
13	Two areas of a power system network are interconnected by a tie-line, whose capacity is 350MW, operating at a power angle of 450. If each area has a capacity of 3000 MW and the equal speed regulation of 6Hz/P.u MW, determine the frequency of oscillation of the power for step change in load. Assume that both areas have the same inertia constants of H = 5 sec. If a step load change of 120MW occurs in one of the areas determine the change in tie-line power.	Understand	This would require the learner to recall the concept of single area load frequency controller and understand the interconnection with an induction motor and synchronous generator. Apply the formula to determine the tie-line power flow change.	CO 7
14	Two Generating Stations A and B have full load capacities of 350 and 500MW, respectively. The interconnector connecting the two stations has an induction motor/synchronous generator of full load capacity 40 MW; percentage changes of speeds of A, B and C are 5, 4 and 2 respectively. Determine the load taken by plant C and indicate the direction of the power flow	Understand	This would require the learner to recall the concept of single area load frequency controller and understand the interconnection with an induction motor and synchronous generator. Apply the formula to determine the tie-line power flow change.	CO 7
	UNIT –IV			
COMPENSATION FOR POWER FACTOR IMPROVEMENT AND REACTIVE POWER CONTROL				
Part – A (Short Answer Questions)				
1	List out the disadvantages of low voltage and low power factor of the system.	Remember	This would require the learner to recall the concept of power	CO 9

			factor and discuss the disadvantages with low voltage and low power factors in the system.	
2	Write the importance of power factor correction	Remember	This would require the learner to recall the concept of power factor and discuss its importance and why the correction is necessary.	CO 9
3	List the financial benefits due to voltage improvement	Remember	This would require the learner to recall the concept of voltage improvement and discuss the financial benefits due to voltage improvement.	CO 8
4	Write advantages of series compensation.	Remember	This would require the learner to recall the concept of series compensation and discuss the advantages with this configuration in the system.	CO 8
5	List out the advantages of shunt compensation.	Understand	This would require the learner to recall the concept of shunt compensation and discuss its advantages.	CO 8
6	Define voltage regulation?	Remember	This would require the learner to recall the concept of automatic voltage booster and discuss its advantages and disadvantages.	CO 8
7	Define voltage drop?	Understand	This would require the learner to understand the concept of voltage drop and discuss the effects on the system.	CO 8
8	Define nominal voltage?	Understand	This would require the learner to understand the concept of nominal voltage and discuss the effects of it.	CO 8
9	Define rated voltage?	Understand	This would require the learner to understand the concept of rated voltage and discuss the importance of it.	CO 9
10	Define utilization voltage?	Understand	This would require the learner to understand the concept of utilization voltage and discuss the effects of it.	CO 9
11	What are the advantages and disadvantages of automatic voltage booster?	Remember	This would require the learner to recall the concept of automatic voltage booster and discuss its advantages and disadvantages.	CO 8
12	Write two applications of induction regulators.	Understand	This would require the learner to recall the concept of induction regulators and discuss some of its applications.	CO 8
13	Generalize how the generators act as VAR sources in a power network?	Understand	This would require the learner to recall the concept of VAR and discuss how the generators act as	CO 8

			VAR sources in a power network.	
14	Generalize how the voltage control is achieved by injection of power at nodes?	Understand	This would require the learner to recall the concept of injection of power and discuss how the generators act as VAR sources in a power system and how the voltage control is achieved by injection of power at nodes network.	CO 8
15	List out different sources of reactive power absorbers in a power system?	Remember	This would require the learner to recall the concept of reactive power absorbers discuss its different sources.	CO 8
16	Compute the need for voltage and frequency regulation in power system?	Understand	This would require the learner to understand the importance of voltage and frequency regulation in the power system.	CO 8
Part – B (Long Answer Questions)				
1	Discuss the effect of shunt compensation on distribution system.	Understand	This would require the learner to understand the concept of shunt compensation and discuss the effect of shunt compensation on distribution system.	CO 8
2	Compare and explain the role of shunt and series capacitors in power factor correction.	Understand	This would require the learner to understand the concept of power factor correction and explain the role of shunt and series capacitors in power factor correction.	CO 9
3	What are the differences between fixed and switched capacitors? What are their effects on distribution systems?	Understand	This would require the learner to understand the concept of fixed and switched capacitors and distinguish between them and also explain its effects on distribution systems.	CO 9
4	Discuss the procedure employed to determine the best capacitor location.	Understand	This would require the learner to understand the concept of capacitor location and explain the procedure for best capacitor location.	CO 9
5	Discuss how a series capacitor boosts the voltage with the help of a phasor diagram? What are the drawbacks of this method?	Understand	This would require the learner to recall the concept of series capacitor and explain how it boosts the voltage and list the drawbacks.	CO 8
6	Discuss different types of capacitors used in distribution network to improve power factor.	Understand	This would require the learner to understand the concept of power factor correction and explain different types of capacitors used in distribution network to improve power factor.	CO 8

7	Why the improvement of power factor is very important for both consumers and generating stations? List the various causes of low power factor and explain?	Understand	This would require the learner to recall the concept of power factor correction and explain the importance with causes for low power factor in the system.	CO 9
8	How economic power factor arrived at for a given distribution system with different loads?	Understand	This would require the learner to understand the concept of power factor correction and explain power factor at distribution system with different loads.	CO 9
9	Voltage control and p.f correction are necessary in power systems. Explain. What are the disadvantages of low voltage and low p.f of the system?	Understand	This would require the learner to understand the concept of power factor correction and explain the disadvantages of low voltage and low p.f in the system.	CO 9
10	Discuss how an overexcited synchronous machine improves power factor.	Understand	This would require the learner to understand the concept of power factor correction and explain the overexcited synchronous machine which improves power factor.	CO 9
11	How an AVR can control voltage? With the aid of suitable diagram, explain its function?	Understand	This would require the learner to understand the concept of AVR control strategy and explain with suitable diagram.	CO 8
12	Briefly explain the line drop compensation on voltage control?	Understand	This would require the learner to understand the concept of voltage compensation techniques.	CO 8
13	How do the shunt capacitors and reactors control the voltage? List the disadvantages of using a shunt capacitor for voltage control?	Understand	This would require the learner to understand the working of shunt reactors to control the voltage, discuss the merits and demerits.	CO 8
14	Discuss about the losses occurred due to VAR flow in power system?	Understand	This would require the learner to understand the concept of VAR flows with its losses in the power system.	CO 8
15	Describe the generators are acted as VAR sources in a power network?	Understand	This would require the learner to understand the concept of VAR sources with its working principles.	CO 8
16	Explain compensated and uncompensated transmission lines.	Understand	This would require the learner to understand the classification of transmission lines with compensation.	CO 8
17	Explain clearly what you mean by compensation of line and discuss briefly different methods of compensation.	Understand	This would require the learner to understand the classification of transmission lines with compensation.	CO 8
Part – C (Problem Solving and Critical Thinking)				
1	A 3-phase substation transformer has a name plate rating of 7500 kVA and a thermal capability of 125% of the name plate rating. If the connected load is 8816 kVA with a	Understand	This would require the learner to recall the concept of power factor correction and understand it is connected to the 3-phase	CO 8

	0.9power factor (lagging), determine the following: i. the kVAR rating of the shunt capacitor bank required to decrease the kVA load of the transformer to its capability level and ii. The power factor of the corrected level.		substation transformer. Apply the formula to determine the power factor at the corrected level.	
2	A 3phase transformer rated 7000kVA and has an overload capability of 125 % of the rating. If the connected load is 1150 kVA with a 0.8 p.f(lag), determine the following: i. The kVAR rating of shunt capacitor bank required to decrease the kVA load of the transformer to its capability level, ii. The kVAR raring of the shunt capacitor bank required to correct the load p.f. to unity and iii. The p.f. of the corrected level.	Understand	This would require the learner to recall the concept of shunt capacitor bank and then understand it is connected to a 3-phase substation transformer. Apply the formula to determine the power factor of the corrected level and the kVAR rating of shunt capacitor bank.	CO 8
3	A 440 V, 50 cycles three phase line delivers 250 KW at 0.7 p.f (lag). It is desired to bring the line p.f to unity by installing shunt capacitors. Calculate the capacitance if they are: i. star connected ii. delta connected	Understand	This would require the learner to recall the concept of shunt capacitor bank and then understand it is connected to a 3-phase substation transformer. Apply the formula to determine the capacitance in star connected and in delta connected.	CO 8
4	A 3 phase substation transformer has a name plate rating of 7250 KVA and a thermal capability of 120% of the name plate rating. If the connected load is is 8816 KVA with a 0.85 of lag p.f determine the following a. The KVAR rating of the shunt capacitor tank required to decrease the KVA load of the transformer to its capability level b. The power factor of the corrected level.	Understand	This would require the learner to recall the concept of shunt capacitor bank and then understand it is connected to a 3-phase substation transformer. Apply the formula to determine the power factor of the corrected level and the kVAR rating of shunt capacitor bank.	CO 8
5	A single-phase motor takes a current of 10 amps at a p.f. of 0.707 lagging from a 230V, 50 Hz supply. What value must a shunting capacitor have to raise the p.f. to unity	Understand	This would require the learner to recall the concept of shunt capacitor bank and then understand it is connected to a 3-phase substation transformer. Apply the formula to determine the capacitance in star connected and in delta connected.	CO 8
6	Discuss the computerized method to determine the economic power factor.	Understand	This would require the learner to recall the concept of shunt capacitor bank and then understand it is connected to a 3-phase substation transformer. Apply the formula to determine the capacitance in star connected and in delta connected.	CO 9
7	A 750 KVA load has a power factor of0.75 lag. It is derived to improve the power factor to 0.9 lag. Find the KVAR rating of the capacitor for	Understand	This would require the learner to recall the concept of shunt capacitor bank and then	CO 8

	the power factor improvement.		understand it is connected to a 3-phase substation transformer. Apply the formula to determine the capacitance in star connected and in delta connected.	
8	A synchronous motor having a power consumption of 40 KW is connected with a load of 150KW, a lag power factor of 0.8. if the combined load has a power factor of 0.9, what is the leading reactive KVA supplied by the motor and at what p.f is it working.	Understand	This would require the learner to recall the concept of shunt capacitor bank and then understand it is connected to a 3-phase substation transformer. Apply the formula to determine the capacitance in star connected and in delta connected.	CO 9
9	A 3 phase substation transformer has a name plate rating of 7000 KVA and a thermal capability of 125% of the name plate rating. If the connected load is is 1150 KVA with a 0.8 of lag p.f, determine the following a) The KVAR rating of the shunt capacitor tank required to decrease the KVA load of the transformer to its capability level b) The power factor of the corrected level.	Understand	This would require the learner to recall the concept of shunt capacitor bank and then understand it is connected to a 3-phase substation transformer. Apply the formula to determine the capacitance in star connected and in delta connected.	CO 9
10	A 400 V 50 cycles three phase line delivers 207KW at 0.8 p.f lag. It is desired to bring the line p.f to unity by installing shunt capacitors, calculate the capacitance if they are i. star connected ii. delta connected.	Understand	This would require the learner to recall the concept of shunt capacitor bank and then understand it is connected to a 3-phase substation transformer. Apply the formula to determine the capacitance in star connected and in delta connected.	CO 8
11	Briefly explain the different methods of reactive power injection in the power system. 10 In a radial transmission system shown in figure, all p.u values are referred to the voltage bases shown and 100 MVA. Determine the power factor at which the generator must operate. 	Understand	This would require the learner to recall the concept of shunt capacitor bank and then understand it is connected to a 3-phase substation transformer. Apply the formula to determine the capacitance in star connected and in delta connected.	CO 9
12	Find the rating of synchronous compensator connected to the tertiary winding of a 132kV star connected, 33 kV star connected, 11 kV delta connected three winding transformer to supply a load of 66 MW at 0.8 p.f. lagging at 33 kV across the secondary. The equivalent primary and secondary winding reactances are	Understand	This would require the learner to recall the concept of shunt capacitor bank and then understand it is connected to a 3-phase substation transformer. Apply the formula to determine the capacitance in star	CO 8

	32 ohms and 0.16 ohms respectively while the secondary winding reactance is negligible. Assume that the primary side voltage is essentially constant at 132 kV and maximum of nominal setting between transformer primary and secondary is1.1.		connected and in delta connected.	
13	A 3-phase single circuit, 220kV, line runs at no load. Voltage at the receiving end of the line is 205kV. Find the sending end voltage, if the line has resistance of 21.7ohms, reactance of 85.2ohms and the total susceptance of $5.32X10^{-4}$ mho. The transmission line is to be represented by Pie-model.	Understand	This would require the learner to recall the concept of shunt capacitor bank and then understand it is connected to a 3-phase substation transformer. Apply the formula to determine the capacitance in star connected and in delta connected.	CO 8
14	Design a static VAR compensator for a low voltage distribution system with the following specifications: System voltage = 440 V System frequency = 50 Hz Coil inductance, L=5.37 mH The inductor saturates at 950 A and settles to a value of 1.8 mH at 1800 A. Compensation is required over a range of -80 kVAR to +30 kVAR per phase.	Understand	This would require the learner to recall the concept of shunt capacitor bank and then understand it is connected to a 3-phase substation transformer. Apply the formula to determine the capacitance in star connected and in delta connected.	CO 8
15	The load at receiving end of a three-phase, overhead line is 25.5 MW, power factor 0.8 lagging, at a line voltage of 33 kV. A synchronous compensator is situated at receiving end and the voltage at both the ends of the line is maintained at 33 kV. Calculate the MVAR of the compensator. The line has a resistance of 4.5 ohms per phase and inductive reactance (line to neutral) of 20 ohms per phase.	Understand	This would require the learner to recall the concept of shunt capacitor bank and then understand it is connected to a 3-phase substation transformer. Apply the formula to determine the capacitance in star connected and in delta connected.	CO 8
	UNIT -V			
COMPENSATION FOR POWER FACTOR IMPROVEME NT AND REACTIVE POWER CONTROL				
Part - A (Short Answer Questions)				
1	Write short notes on load management functions	Understand	This would require the learner to recall the concept of load management functions and explain them in detail.	CO 10
2	Define demand?	Remember	This would require the learner to recall the concept of demand and explain in detail.	CO 10
3	Define coincidence Factor?	Understand	This would require the learner to recall the concept of coincidence factor and explain it in detail	CO 10
4	Define contribution factor.	Remember	This would require the learner to recall the concept contribution factor and explain it in detail.	CO 10
5	Define loss factor?	Remember	This would require the learner to	CO 10

			recall the concept of loss factor and explain it in detail.	
6	Define load factor?	Remember	This would require the learner to recall the concept of load factor and explain it in detail.	CO 10
7	Define load diversity factor?	Understand	This would require the learner to recall the concept of load diversity factor and explain it in detail.	CO 10
8	What is Maximum demand?	Understand	This would require the learner to recall the concept of maximum demand and explain it in detail.	CO 11
9	Define coincident demand?	Understand	This would require the learner to recall the concept of coincident demand and explain it in detail.	CO 11
10	Define Non-coincident demand?	Understand	This would require the learner to recall the concept of non-coincident demand and explain it in detail.	CO 11
11	What is meant by term load? How loads can be classified?	Remember	This would require the learner to recall the concept of term load and also explain the classifications of loads.	CO 11
12	Define distribution system?	Understand	This would require the learner to recall the concept of distribution system and explain it in detail.	CO 11
13	Define demand factor?	Remember	This would require the learner to recall the concept of demand factor and explain it in detail.	CO 10
14	Define load?	Understand	This would require the learner to recall the concept of load along with its characteristics.	CO 10
15	List out types of loads and give examples?	Remember	This would require the learner to recall the understand the types of loads with suitable examples.	CO 10
Part - B (Long Answer Questions)				
1	List out the various factors affecting the distribution system planning?	Understand	This would require the learner to recall the concept of distribution system and explain the various factors affecting the distribution system.	CO 11
2	Draw a block diagram in flow chart form for a typical distribution system planning process and explain the techniques for distribution planning.	Understand	This would require the learner to recall the concept of distribution system. Draw a typical distribution system planning process and explain the techniques for distribution planning.	CO 11
3	Explain briefly the classification of loads and modeling of load in distribution networks?	Understand	This would require the learner to recall the concept of distribution system and explain the classification of loads and modeling of loads in distribution networks.	CO 11

<table>
<tr><td>4</td><td>Obtain the relation between the load factor and loss factor.</td><td>Understand</td><td>This would require the learner to recall the concept of load factor and loss factor. Derive the relation between the load factor and loss factor.</td><td>CO 11</td></tr>
<tr><td>5</td><td>Discuss in detail about agriculture and industrial loads and their respective characteristics.</td><td>Understand</td><td>This would require the learner to recall the concept of load diversity factor and explain the agriculture and industrial loads with their respective characteristics.</td><td>CO 11</td></tr>
<tr><td>6</td><td>Differentiate between DC and AC systems?</td><td>Understand</td><td>This would require the learner to recall the concept of DC and AC systems and then differentiate between DC and AC systems.</td><td>CO 10</td></tr>
<tr><td>7</td><td>Explain residential and commercial loads and their characteristics?</td><td>Understand</td><td>This would require the learner to recall the concept of load diversity factor and explain the agriculture and industrial loads with their characteristics.</td><td>CO 11</td></tr>
<tr><td colspan="5">Part – C (Problem Solving and Critical Thinking)</td></tr>
<tr><td>1</td><td>At the end of a power distribution system, a certain feeder supplies three distribution transformer, each one supplying a group of customers whose connected loads are as under, if the diversity factor among the transformers is 1.3, find the maximum load on the feeder.
<table>
<tr><td>Transforme</td><td>Load</td><td>Demand Factor</td><td>Diversit y Factor</td></tr>
<tr><td>No.1</td><td>10kw</td><td>0.65</td><td>1.5</td></tr>
<tr><td>No 2</td><td>12kw</td><td>0.</td><td>3.5</td></tr>
<tr><td>No.3</td><td>15kw</td><td>0.7</td><td>1.5</td></tr>
</table></td><td>Understand</td><td>This would require the learner to recall the concept of power distribution system and understand it is connected to three distribution transformers. Apply the formula to determine the maximum load on the feeder.</td><td>CO 10</td></tr>
<tr><td>2</td><td>Distribution substation experiences an annual peak load of 3, 500 KW. The total annual energy supplied to the primary feeder circuits is 10^7 kwh. Find i) The annual average Factor ii) The annual Load Factor</td><td>Understand</td><td>This would require the learner to recall the concept of power distribution system and understand it is connected to three distribution transformers. Apply the formula to determine the maximum load on the feeder and annual load factor.</td><td>CO 10</td></tr>
<tr><td>3</td><td>Annual peak load input to a primary feeder is 2000kw at which the power loss is total copper loss at the time of peak load is $\sum I^2R$=100kw. The total annual energy supplied to the sending end of the feeder is $5.61*10^6$ kwh. Determine.
i) Annual loss factor and
ii) Total annual copper loss energy and its value Rs.1.50 per kwh</td><td>Understand</td><td>This would require the learner to recall the concept of power distribution system and understand it is connected to three distribution transformers. Apply the formula to determine annual loss factor and annual copper loss.</td><td>CO 11</td></tr>
<tr><td>4</td><td>Assume that load of 100kw is connected at the riverside substation, the 15 min. weekly maximum demand is given as 75 kw, and the weekly energy consumption is 4200 kwh.</td><td>Understand</td><td>This would require the learner to recall the concept of power distribution system and understand it is connected to</td><td>CO 11</td></tr>
</table>

	Assuming a week is 7 days; find the demand factor and the 15 min. weekly load factor of the substation.		three distribution transformers. Apply the formula to determine the maximum load on the feeder.	
5	Discuss how the maximum demand and average demand can be obtained from daily demand variation curve.	Understand	This would require the learner to recall the concept of power distribution system and understand it is connected to three distribution transformers. Apply the formula to determine the maximum load on the feeder.	CO 10
6	A 50 MW hydro generator delivers 320 million kwh during the year. Calculate the plant load factor.	Understand	This would require the learner to recall the concept of power distribution system and understand it is connected to three distribution transformers. Apply the formula to determine the maximum load on the feeder and annual load factor.	CO 11
7	Annual peak load input to a primary feeder is 2000kw at which the power loss is total copper loss at the time of peak load is $\sum I^2R$=100kw. The total annual energy supplied to the sending end of the feeder is $5.61*10^6$ kwh. Determine. I) Annual loss factor ii) Total annual copper loss energy and its value Rs 0.03 per kwh	Understand	This would require the learner to recall the concept of power distribution system and understand it is connected to three distribution transformers. Apply the formula to determine the annual loss factor and annual copper loss.	CO 11
8	Assume that the annual peak load of a primary feeder is 2000 kW, at which the power is 80 kw per three phase. Assuming an annual loss factor of 0.15, determine i) The average annual power loss. ii) The total annual energy loss due to the copper loss of the feeder.	Understand	This would require the learner to recall the concept of power distribution system and understand it is connected to three distribution transformers. Apply the formula to determine the maximum load on the feeder.	CO 11
9	A small city experiences an annual peak load of 3500 kw. The total annual energy supplied to the primary feeder's circuits is $10* 10^6$ kwh. The peak demand occurs in July/August and Is due to air Conditioning load. i) Find the annual average power demand ii) Find the annual load factor iii) Find the annual loss factor	Understand	This would require the learner to recall the concept of power distribution system and understand it is connected to three distribution transformers. Apply the formula to determine the maximum load on the feeder.	CO 10
10	The annual average load is 1241 kw and monthly peak load is 3600 kW. Find the load factor by using approximate formula.	Understand	This would require the learner to recall the concept of power distribution system and understand it is connected to three distribution transformers. Apply the formula to determine the maximum load on the feeder and annual Load factor.	CO 10

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