PS7102 POWER SYSTEM OPERATION AND CONTROL

UNIT I: INTRODUCTION

PART A:

1. Define spinning reserve.
2. What is meant by load frequency control?
3. What are the advantages of pool operation with respect to LFC?
4. What is the use of secondary loop in ALFC system?
5. Define connected load?
6. What is the role of computers in the operation and control of power system?
7. What is load curve?
8. What is base load?
9. Define load factor.
10. What is the need for load forecasting?
11. What is the need for voltage regulation in power systems?
12. Define diversity factor.
13. What is the effect of load factor on the cost of generation?
14. Define the term average load.
15. What is system level control
16. What are the effects of variable load in power system
17. What is the objective of power system control
18. What is the difference between load curve and load duration curve.
19. What are the different types of load
20. What is the significance of load factor and diversity factor.

PART B:

1. i) Define the following: (1) Hot reserve (2) Cold reserve (3) diversity factor
   ii)A generating station has the following daily load cycle:

Time in (hrs)	0-6	6-10	10-12	12-16	16-20	20-24
Load(MW)	20	25	30	25	35	20

   Draw the load curve and calculate maximum demand, units generated per day, average load, load factor.
2. Explain the following: (i) Load forecasting (ii) Economic dispatch control.
3. (i) Explain the following terms: Installed reserve, spinning reserve, cold reserve, hot reserve.
   (ii)A power station has to meet the following demand:
   Group A:200KW between 8 A.M and 6 P.M
   Group B:100KW between 6 A.M and 10 A.M
   Group C:50KW between 6 A.M and 10 A.M
   Group D:100KW between 10 A.M and 6 P.M and then between 6 P.M and 6 A.M. Plot the daily load curve and determine diversity factor, units generated per day and load factor.

4. (i)Discuss about the recent trends in real time control of power systems.
   (ii) Write short notes on load forecasting.
5. i)What is meant by chronological load curve? Give the information obtained from load curves.
   ii)Explain the advantages and different types of computer control system.
6. Describe briefly about plant level and system level control.
7. i) what are the information obtained from load curve and load duration curve?
   ii) Briefly describe the importance of load forecasting and explain the method of least square fit forecasting the base load.
8. What are objectives of modern trend in real time control of power system? Explain the significant features of computer control in power system.
9. i) with neat sketch describe the p-f and Q-V control structure.
   ii) Explain the following terms
   i. Maximum Demand
   ii. Plant use factor
   iii. Plant capacity factor
   iv. Reserve capacity
10. (i) Explain the need for voltage and frequency regulation in power system
    (ii) A generating station has maximum demand of 400 MW. The annual load factor is 65% and capacity factor is 50% find the reserve capacity of the plant.
11. Draw load curve and load duration curve. Explain the importance of these curves in connection with economic operation of power system
12. A generating station has maximum demand of 20 MW, load factor is 60% and capacity factor is 50% find the reserve capacity of the plant, daily energy produced, maximum energy that could be produced daily if the plant were running all the time and maximum energy that could be produced if the plant when running(acc. To operating schedule) were fully loaded.
13. A generating station has a maximum demand of 50,000 KW.calculate the cost per unit generated from the following data.

Capital Cost	=	Rs95 x 10^6
Annual load factor	=	40%
Annual cost of fuel and oil	=	Rs9 x 10^6
Taxes, wages and salaries etc.	=	Rs7.5 x 10^6
Interest and depreciation	=	12%

UNIT II: REAL POWER- FREQUENCY CONTROL

PART A:

1. State the advantages of state variable model.
2. What is AGC?
3. What are the conditions necessary for sharing load operating in parallel between the two synchronous machines?
4. Define area control error.
5. What are the classification of system load?
6. What is meant by load frequency control.
7. Why the frequency and voltage to be regulated in a power system?
8. Compare the functions of "speed Governor" and " speed changer" in a speed governing systems of a turbine generator set.
9. What do you understand by coherent group of generators?
10. A speed governor system cannot completely eliminate frequency error caused by a step load change in power system. Justify this statement.
11. How is the real power in power system controlled?
12. What is meant by free governor operation?
13. What is the function of load frequency control on a power system?
14. Define speed droop.
15. Draw the dynamic responses of change in frequency for a step load change for single area system
16. What is the use of secondary loop in ALFC system?
17. What is meant AFRC
18. State whether changes in AVR loop will be reflected in ALFC loop.
19. List the advantages of multi area operation.
20. Explain the principle of tie line bias control.

PART B:

1. Two synchronous generators operating in parallel. Their capacities are 300MW and 400MW. The droop characteristics of their governors are 4% and 5% from no load to full load. Assuming that the generators are operating at 50HZ at no load , how would be a load of 600MW shared between them. What will be the system frequency at this load? Assume free governor action.
2. Develop the state variable model of a two area system and state the advantages of the model.
3. Draw the block diagram of uncontrolled two area load frequency control system and explain the salient features under static condition.
4. How is speed governor mechanism modeled? Explain its operations with the speed load characteristics.
5. Derive the transfer function model and draw the block diagram for single control area provided with governor system. From the transfer function derive the expression for steady state frequency error for a step load change.
6. What are the components of speed governor system of an alternator? Derive its transfer function with an aid of a block diagram.

7. Explain the dynamic response of single area load frequency control.
8. Two 1000KW alternators operate in parallel. The speed regulation of first alternator is 100% to 103% from full load to no load and that of other 100% to 105%. How will the two alternators share load of 1200KW and at what will one machine cease to supply any portion of the load.
9. For a system regulation =4Hz/p.u.MW,K_p=150 T_p=18sec,ΔP_0=0.01p.u.Find the dynamic response of uncontrolled case. Also derive the equation used.
10. Derive the expression for steady state frequency change for single area system with the following cases.
    (i)Changes in load with fixed speed

    (ii)changes in speed with fixed demand
11. i) Determine the primary ALFC loop parameters for a control area having the following data.
    Total rated area capacity Pr=2000MW.
    Normal operating load Pd=1000MW.
    Inertia constant H=5.0
    Regulation R=2.40 Hz/pu MW (all area generators)
    We shall assume that the load frequency dependency as linear meaning that the old load would increase 1% for 1% frequency increase.
    ii) Highly brief the importance of regulating frequency and voltage of the power system.

12. Explain the static and dynamic characteristics of single area control system.

Unit-3

HYDROTHERMAL SCHEDULING PROBLEM

Part-A

1. State Hydro thermal co-ordination with necessary equations.
2. Different methods for solving hydro thermal scheduling.
3. Define in detail cost curve of thermal stations.
4. Draw input - output characteristics of thermal power stations. What is minimum up and minimum down time in unit commitment problem?
5. Define participation factor.
6. What is participation factor with respect to economic load dispatch
7. Write the co-ordination equation taking losses into account.
8. What is meant by incremental cost curve?
9. Compare with unit commitment and Economic load dispatch
10. Define penalty factor
11. List the few constraints that are accounted in hydro unit commitment problem.
12. What is meant by priority list method for hydro thermal.
13. Mention the assumption made in the formation of loss formula matrix B.
14. What are the advantages of using forward dynamic programming method
15. State unit commitment problem.
16. Define incremental efficiency.
17. What are loss coefficients?
18. Explain the penalty factor.
19. How can the economic controller be added as the tertiary loop of LFC control?
20. What are the assumption for deriving loss coefficients?

Part-B

1.a) Explain the short term Hydro-thermal scheduling problem with necessary expressions.

b) Discuss the optimal power flow with inequality constraints. [16]

2. (a) Explain input - output characteristics of thermal power stations.

(b) Define in detail cost curve of thermal stations. [8+8]

3. Discuss the combined hydro- electric and steam station operation. [16]

4. In a two plant operation system, the Hydro plant is operate for 12 hrs. during

each day and the hydro plant is operate all over the day. The characteristics of the steam and hydro plants are

$C_T = 0.3\ P_{GT}^2 + 20\ PGT + 5$ Rs/hr

$W_H = 0.4 P_{GH}^2 + 20\ PGH$ $m^3/$ sec

When both plants are running, the power flow from steam plant to load is 300 MW and the total quantity of water is used for the hydro plant operation during 12 hrs is 180×10^6 m^3. Determine the generation of hydro plant and cost of water used. [16]

5. Describe different methods for solving hydro thermal scheduling. [16]

6. Explain about Hydro thermal co-ordination with necessary equations. [16]

7. In a two plant operation system, the hydro plant is operation for 10 hrs, during each day and the steam plant is to operate all over the day. The characteristics of the steam and hydro plants are

$C_T = 0.04\ P_{GT}^2 + 30\ P_{GT} + 10$ Rs/hr

$WH = 0.12\ P_{GH}^2 + 30\ PGH$ $m^3/$ sec

When both plants are running, the power flow from steam plant to load is 150 MW and the total quantity of water is used for the hydro plant operation during 10 hrs is 150×10^6 m^3. Determine the generation of hydro plant and cost of water used. Neglect the transmission losses. [16]

8. In a two plant operation system, the hydro plant is operate for 8 hrs. During each day and the steam plant is operate all over the day. The characteristics of the steam and hydro plants are

$C_T = 0.04\ P_{GT}^2 + 30\ P_{GT} + 20$ Rs/hr

$W_H = 0.0012\ P_{GH}^2 + 7.5\ PGH$ $m^3/$ sec

When both plants are running, the power flow from steam plant to load is 190 MW and the total quantity of water is used for the hydro plant operation during 8 hrs is 220×10^6 m^3. Determine the generation of hydro plant and cost of water used. Neglect the transmission losses. [16]

9. Consider a system of one hydro and one thermal unit

$F = 700 + 4.8 P_S + 0.0005 P_S^2$ Rs/hr

200 MW<=PS<=1200 MW

Q=260+10PH acre ft/hr for PH>0

0<=PH<=200 MW

Storage volume limits are 6000 and 18000 acre ft.

Initial and final volume is 10000 acre ft.

Inflow of water is 1000 acre ft/hr .

Load for first and second time period are 600 and 1000.

Use DP.

10. Explain pumped storage hydro scheduling with a lemta gamma iteration method.

Unit-4

UNIT COMMITMENT AND ECONOMIC DISPATCH

Part-A

1. What is meant by FLAC?
2. Write the condition for the optimal power dispatch in a lossless system.
3. Draw the incremental fuel cost curve.
4. What is meant by spinning reserve?
5. Write the significance of Unit Commitment.
6. Draw the incremental cost curve of a thermal power plant.
7. Write the equality and inequality constraints considered in the economic dispatch problem.
8. Define spinning reserve constraint in unit commitment problem.
9. What is minimum up and minimum down time in unit commitment problem?
10. Define participation factor.
11. What is participation factor with respect to economic load dispatch
12. Write the co-ordination equation taking losses into account.
13. What is meant by incremental cost curve?
14. Compare with unit commitment and Economic load dispatch
15. List the few constraints that are accounted in unit commitment problem
16. What is meant by priority list method
17. Mention the assumption made in the formation of loss formula matrix B.
18. What are the advantages of using forward dynamic programming method
19. State unit commitment problem.
20. What is difference between load frequency controller and economic dispatch controller

Part-B

1. State the unit commitment problem. With the help of a flow chart, explain forward dynamic programming solution method of unit commitment problem.
2. The fuel inputs per hour of plants 1 and 2 are given as
   $F_1 = 0.2P_1^2 + 40P_1 + 120$Rs/hr
   $F_2 = 0.25P_2^2 + 30P_2 + 150$Rs/hr
   Determine the economic operating schedule and the corresponding cost of generation. The maximum and the minimum loading on each unit are 100MW and 25MW. Assume the transmission losses are ignored and the total demand is

180MW. Also determine the saving obtained if the load is equally shared by both the units.

3. (i) With the help of Flow chart explain Economic dispatch by λ Iteration method without loss.

   (ii) The fuel cost of two units are given by

   $F_1=F_1\ (P_{G1}) = 1.5+20P_{G1}+0.1P_{G1}^2$ Rs\hr

   $F_2=F_2\ (P_{G2}) = 1.9+30P_{G2}+0.1P_{G2}^2$Rs\hr

   If the total demand on the generator is 200 MW. Find the economic load scheduling of the two units.

   (iii) What is the significance of equality and inequality constraints in the formulation of optimum dispatch problem?

4. (i) What is unit commitment problem? Discuss the constraints that are to be accounted in unit commitment problem.

   (ii) Obtain the priority list of unit commitment using full load average production cost for the given data:

   Heat rate of unit1 $H_1= 510+7.2P_{G1}+0.00142\ P_{G1}^2$MW\hr

   Heat rate of unit2 $H_2= 310+7.85P_{G2}+0.00194P_{G2}^2$MW\hr

   Heat rate of unit3 $H_3= 78+7.97P_{G3}+0.00482P_{G3}^2$MW\hr. P_D=500MW

Unit	Mm(MW)	Max(MW)	Fuel Cost (K)
1	150	600	1.1
2	100	400	1.0
3	50	200	1.2

5. (i) Explain the unit commitment problem using priority ordering load dispatch.

   (ii) Explain the term 'Incremental Operating Cost' of power system related with economic dispatch.

6. The fuel inputs per hour of plants 1 and 2 are given as

   $F_1= 0.2P_1^2+40P_1+120$ Rs/hr

   $F_2=0.25P_2^2+30P_2+150$Rs/hr

   Determine the economic operating schedule and the corresponding cost of generation if the maximum and minimum loading on each unit is 100MW and 25MW.Assume the transmission losses are ignored and the total demand is 180 MW. Also determine the saving obtained if the load is equally shared by both the units.

7. Explain various constraints in UC and indicate the steps involved in solving UC by DP method.

8. Formulate the coordination equations with losses neglected and also explain the algorithmic steps of iterative method to find the solution of coordination equations.

9. (i)Explain the priority list method of solving unit commitment Problem. State merits and limitations of this method.

10. The fuel cost functions for three thermal plants in $/h are given

by

$F_1=0.004P_{g1}^2+5.3P_{g1}+500$

$F_2=0.006P_{g2}^2+5.5P_{g2}+400$

$F_3=0.009P_{g3}^2+5.8P_{g3}+200$ where P_{g1},P_{g2},P_{g3} are in MW.

Find the optimal dispatch and the total cost when the total load is 925 MW with the following generator limits.

$100MW \le P_{g1} \le 450MW$,

$100MW \le P_{g2} \le 350MW$,

$100MW \le P_{g3} \le 225MW$

11. (i)Explain the forward dynamic programming method of solving unit commitment problem.

    (ii)Develop an iterative algorithm for solving the optimum dispatch equation of an 'n' bus power system taking into account the effects of system losses.

12. (i)Construct the priority list for the units given below.

    $H_1=510+7.20P_1+0.00142P_1^2$.$P_{min}=150MW$.$P_{max}=600MW$.
    Fuel cost=1.1Rs/MBtu.
    $H_2=310+7.85P_2+0.00194P_2^2$.$P_{min}=100MW$.$P_{max}=400MW$.
    Fuel cost=1.0Rs/MBtu
    $H_3=78+7.97P_3+0.00482P_3^2$.$P_{min}=50MW$.$P_{max}=200MW$.
    Fuel cost=1.2Rs/MBtu

ii)Derive the co ordination equation with losses neglected.

13. (i) The cost characteristics of three plants of a system are

    $C_1=0.05P_1^2+17.0P_1+160$ Rs/hour
    $C_2=0.06P_2^2+14.4P_2+200$ Rs/hour
    $C_3=0.08P_3^2+9.0P_3+240$ Rs/hour Where P_1,P_2,P_3 are in MW.

The incremental transmission losses for the network with respect to plants 1,2 and 3 are 0.05,0.10 and 0.15 MW per MW of generation. Find the optimal dispatch for a total load of 100MW and also its incremental cost of received power.

ii) The input output curve characteristics of three units are

$F_1=750+6.49P_{g1}+0.0035P_{g1}^2$.

$F_2=870+5.75P_{g2}+0.0015P_{g2}^2$.

$F_3=620+8.56P_{g3}+0.001P_{g3}^2$. The fuel cost of unit 1 is 1.0 Rs/MBtu, 1.0 Rs/MBtu for unit 2 and 1.0 Rs/MBtu for unit 3. Total load is 800MW. Use the participation factor method to calculate the dispatch for a load is increased to 880MW?

14. With a neat flow chart explain the iterative algorithm for solving the economic dispatch equation of N bus power system taking into account the effects of system losses.

15. The fuel-cost functions for three thermal plants are given by

$F_1=0.004P_{g1}^2+5.3P_{g1}+500$ \$/hr

$F_2=0.006P_{g2}^2+5.5P_{g2}+400$ \$/hr

$F_3=0.009P_{g3}^2+5.8P_{g3}+200\$/hr$

Where P_{g1},$P_{g2}$and P_{g3} are in MW.Find the optimum scheduling and the total cost per hour for a total load of 975 MW with the following generator limits.

$100MW \leq P_{g1} \leq 450MW$

$100MW \leq P_{g2} \leq 350MW$

$100MW \leq P_{g3} \leq 225MW$

16. In power system having two units, the loss co-efficient are

$B_{11}=0.0015MW^{-1}$, $B_{12}=-0.0006MW^{-1}$

$B_{21}=0.0006MW^{-1}$,$B_{22}=0.0024MW^{-1}$

The incremental production costs of the units are

$\frac{dF1}{dPG1}=0.08P_{G1}+20$ Rs/MWhr

$\frac{dF2}{dPG2}=0.09P_{G2}+16$Rs/MWhr

Find the generation schedule for λ=20 and 25. Find also change in transmission loss between two schedules.

17. Explain the Forward Dynamic Programming method of solving unit commitment problem with neat flow chart.

(ii) Explain briefly various constraints on unit commitment problem.

18. The input output curve characteristics of three units are

$F_1=940+5.46PG1+0.0016PG1^2$

$F_2=820+5.35PG2+0.0019PG2^2$

$F_3=99+5.65PG3+0.0032PG3^2$. Total load 600MW. Use the participating factor method to calculate dispatch for a load is reduced to 550MW

Unit-5

COMPUTER CONTROL OF POWER SYSTEMS

Part-A

1. What are the functions of SCADA?
2. Define state estimation.
3. What is “SCADA”?
4. Write any two functions of Load Dispatch Center.
5. Define network topology in power system.
6. What are the different operating states in power system.
7. Distinguish between reliability and security of power system.
8. What are the EMS functions?
9. List out the conditions for normal operations of a power system.
10. What do you understand by security constraints?
11. What is contingency analysis program
12. List the factors that affects the power system security
13. What are the typical sensors used in power system application
14. When is power system considered to be secured?
15. What are the tasks of energy control center?
16. What are the important types of relay used for protection,
17. Denote the hierarchical levels used in EMS.
18. Write the importance of state estimation in power system.
19. List out the conditions for normal operation of power system.
20. What are the functions of load control centre?

Part-B

1. Briefly explain various functions of SCADA with neat diagram. Also list some of the common features of all SCADA systems
2. Discuss the various functions, system monitoring and control of load dispatch center.
3. (i) What is EMS? What are its major functions in power system operation and control?
   (ii) Draw the block diagram to show the hardware configuration of a SCADA system for a power system and explain the application of SCADA in monitoring and control of power system
4. Explain the security monitoring using state estimation with necessary diagrams.
5. (i)Explain need of computer control of power system.
   (ii) Explain the major functions of system security control.
6. Explain various state transitions and control strategies using state transition diagram.

7. Briefly discuss the various functions of energy control centre.
8. List the various contingencies that are generally considered for steady sate security analysis. Explain the major functions of system security control.
9. Write short notes on energy control centre EMS and its functions.
10. Explain the state estimation method in power system.
11. (i) Explain the network topology determination method with the factors involved in it.
    (ii) Explain the power system security and control with neat flow chart.