ADVANCED POWER SYSTEM
(ELEC 4131)

Time Allotted : 2½ hrs **Full Marks : 60**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 4 (four) from Group B to E, taking one from each group.

Candidates are required to give answer in their own words as far as practicable.

Group – A

1. Answer any twelve: **12 × 1 = 12**

Choose the correct alternative for the following

(i) If the penalty factor of a plant is unity, the incremental transmission loss is
(a) 0 (b) -1 (c) 1 (d) 2.

(ii) Which of the following power plants can be employed for supplying peak loads?
(a) Diesel power plant (b) Hydroelectric power plant
(c) Thermal power plant (d) Nuclear power plant.

(iii) The unit of transmission loss coefficient is
(a) unit less (b) MW^{-1} (c) MW (d) Watt.

(iv) Reactive power to HVDC system may be supplied from
(a) ac filters (b) shunt capacitors
(c) SVS (d) all of the above

(v) The main objective of the smoothing reactor
(a) to reduce the risk of commutation failure
(b) to prevent the resonance in the DC circuit
(c) to smooth the ripple current in DC
(d) all of the above

(vi) In a power system, frequency is primarily controlled by adjusting which of the following?
(a) Voltage (b) Reactive power
(c) Generator output (active power) (d) Transformer taps.

(vii) What is the purpose of the governor in the Load Frequency Control of a generator?
(a) Control the voltage output (b) Adjust the active power output
(c) Measure the load demand (d) Increase the reactive power.

(viii) Which of the following is non-linear diverter?
(a) Rod gap type arrester (b) Valve type arrester
(c) Expulsion type arrester (d) Electrolytic type arrester.

(ix) Due to series compensation, Ferranti Effect
(a) reduces (b) aggravates
(c) unaffected (d) none of these.

(x) What is the effect of series compensation on power transfer capability?
(a) Decreases it (b) Does not affect it
(c) Increases it (d) Reverses the power flow.

Fill in the blanks with the correct word

(xi) In a power plant, a reserve generating capacity which is in operation but not in service, is called the _____.

(xii) The velocity of travelling wave propagation in vacuum is _____.

(xiii) A transmission line terminated with a load impedance equal to the characteristic impedance will result in _____ reflection.

(xiv) An increase in reactive power can lead to a decrease in the _____ factor, making the system less efficient.

(xv) In series compensation the maximum power that can be transmitted is _____.

Group - B

2. (a) Develop the condition for 'optimum generating scheduling' of thermal power plant neglecting transmission losses. *[(CO1)(Apply/IOCQ)]*

(b) On the system consisting of two generating plants the incremental costs in rupees per MWh with P1 and P2 are in MW are

$$\frac{dC_1}{dP_1} = 0.15P_1 + 150 \text{ Rs/ MWh}$$

$$\frac{dC_2}{dP_2} = 0.25P_2 + 175 \text{ Rs/ MWh}$$

The system is operating on economic dispatch with $P_1 = P_2 = 200$MW and $\frac{\partial P_L}{\partial P_2} = 0.2$. Find penalty factor of plant1. *[(CO1)(Apply/IOCQ)]*

6 + 6 = 12

3. (a) Discuss the reason to keep reserve power in power system. What are the different kinds of power reserve? *[(CO1)(Understand/LOCQ)]*

(b) A steam station and a hydro station feed an area jointly. The hydro station is run for 14 hours daily and steam station runs for all 24 hours. The production cost characteristic of steam station is:

$C = 5 + 8P_s + 0.05P_s^2$ Rs/hour

If the load on the steam station, when both plants are in operation, is 250 MW, the incremental water rate of hydro plant is $\frac{dW}{dP_h} = 30 + 0.05P_h \quad m^3/MW -$ seconds.

The total quantity of water used during 14 hours is 500 million cubic metres. Find the load on hydro plant and cost of water use. Assume that the load on hydro plant is constant for the 14 hour period. *[(CO1)(Analyse/HOCQ)]*

(3 + 2) + 7 = 12

Group - C

4. (a) Explain with necessary diagrams kinds of HVDC links used in HVDC systems. *[(CO2)(Remember/LOCQ)]*

   (b) A new bipolar DC transmission system is compared with a three phase AC system. Obtain the ratio of the DC insulation level to AC insulation level if both the system transmit the same amount of power and have the same size of conductor. Assume unity power factor of the AC system. *[(CO2)(Apply/IOCQ)]*

6 + 6 = 12

5. (a) Sketch the waveform of an impulse voltage with proper labelling. *[(CO3)(Apply/IOCQ)]*

   (b) What are the two types of over-voltages? *[(CO3)(Remember/LOCQ)]*

   (c) 220 kV surge travels on a line of 400 Ω surge impedance and reaches a junction where two branch lines of surge impedances 550 Ω and 350 Ω, respectively are connected with the transmission line. Calculate the surge voltage and current transmitted into each branch line. *[(CO3)(Evaluate/HOCQ)]*

   (d) What are the advantages of Expulsion Type Surge Arrester? *[(CO3)(Remember/LOCQ)]*

   (e) Compare the VI Characteristics of ZnO and SiC elements. *[(CO3)(Analyse/IOCQ)]*

2 + 2 + 4 + 2 + 2 = 12

Group - D

6. (a) Sketch the schematic diagram of speed governing system. *[(CO4)(Analyse/IOCQ)]*

   (b) Sketch the block diagram representation of ALFC. *[(CO4)(Apply/IOCQ)]*

   (c) What is the purpose of AGC? *[(CO4)(Remember/LOCQ)]*

   (d) What is the function of AVR? *[(CO4)(Remember/LOCQ)]*

   (e) A 100 MVA synchronous generator operates on full load at frequency of 50 Hz. The load is suddenly reduced to 50 MW. Due to time lag in governor system, the steam valve begins to close after 0.4 seconds. Determine the change in frequency that occurs in this time. Given H = 5 kW-sec / kVA of generator capacity. *[(CO4)(Evaluate/HOCQ)]*

3 + 2 + 2 + 1 + 4 = 12

7. (a) A 60 Hz system has two generators with droop characteristics. Generator G1 has a droop of 4%, and G2 has a droop of 5%. If the total load increases by 30 MW, calculate the power each generator will supply. *[(CO4)(Evaluate/HOCQ)]*

   (b) Define stiffness of a power system (β). *[(CO4)(Remember/LOCQ)]*

   (c) Prove that stiffness (β) of a power system is given by $\beta = \frac{1}{R_{eq}} + D$, where, D is the load damping coefficient and $\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \ldots\ldots\frac{1}{R_n}$, where R is the speed regulation. *[(CO4)(Evaluate/HOCQ)]*

   (d) Two generators G1and G2 are operating in parallel. The total load on the system is 500 kW. The ratings of the generators are: G1 = 300 kW, G2 = 400 kW. If the droop characteristics of both generators are such that they share load proportionally to their ratings, calculate the power supplied by each generator. *[(CO4)(Evaluate/HOCQ)]*

3 + 2 + 4 + 3 = 12

Group - E

8. (a) Prove that the change of terminal voltage depends on the reactive power. *[(CO5)(Analyse/IOCQ)]*

(b) Define natural loading of a transmission line. *[(CO5)(Remember/LOCQ)]*

(c) Classify the FACTS controllers. *[(CO5)(Analyse/IOCQ)]*

(d) Justify the performance of a capacitor will be poor under low voltage conditions. *[(CO5)(Analyse/IOCQ)]*

(e) Sketch the VI characteristics of TCR for different delay angles. *[(CO5)(Apply/IOCQ)]*

3 + 2 + 3 + 2 + 2 = 12

9. (a) Show that a synchronous compensator is self regulating. *[(CO5)(Analyse/IOCQ)]*

(b) How does shunt compensation help in compensating the load power factor. *[(CO5)(Understand/LOCQ)]*

(c) A transmission line has a sending end voltage of 220 kV and a receiving end voltage of 210 kV under a lagging load. To improve the voltage at the receiving end, a 25 MVAR shunt capacitor is installed. Determine the new receiving end voltage assuming the system impedance is 30 ohms. *[(CO5)(Evaluate/HOCQ)]*

(d) Write three demerits of Ferranti Effect. *[(CO5)(Understand/LOCQ)]*

3 + 2 + 4 + 3 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	28.12	41.66	30.22