

**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 any4 (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) What will be the penalty factor for a unit, if the incremental transmission loss is zero?  
(a) 0                                      (b) 1                                      (c) -1                                      (d) ∞.
- (ii) The rate of change of fuel cost with active power generation is called  
(a) Incremental Fuel Cost                                      (b) Incremental Transmission Loss  
(c) Base point                                      (d) Participation rate.
- (iii) 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.
- (iv) In the case of an HVDC system, there is  
(a) charging current but no skin effect  
(b) skin effect but no charging current  
(c) neither charging current nor skin effect  
(d) both charging current and skin effect.
- (v) A cable has inductance of 0.22 mH per km and capacitance of 0.202 μF per km. The surge impedance of the cable is  
(a) 28 ohm                                      (b) 33 ohm  
(c) 40 ohm                                      (d) 52 ohm.
- (vi) 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.
- (vii) Lightning arrester should be located  
(a) near the circuit breaker                                      (b) away from the circuit breaker  
(c) near the transformer                                      (d) away from the transformer.

- (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) The reflection coefficient of a short-circuited line is  
 (a) -1 (b) +1 (c) 0.5 (d) 0.
- (x) In Ferranti Effect the receiving end voltage  
 (a) Increases (b) Decreases  
 (c) Remains same (d) None of (a), (b) & (c).

*Fill in the blanks with the correct word*

- (xi) Automatic Voltage Regulator (AVR) controls the \_\_\_\_\_.
- (xii) HVDC Homopolar links uses one conductor of usually \_\_\_\_\_ polarity.
- (xiii) The velocity of travelling wave propagation in vacuum is \_\_\_\_\_.
- (xiv) In series compensation the maximum power that can be transmitted \_\_\_\_\_.
- (xv) The magnitude of transmitted voltage in open circuited condition of a transmission line is \_\_\_\_\_.

### Group - B

2. (a) Develop the condition for 'optimum generating scheduling' of thermal power plant including transmission losses. Hence define: (i) incremental transmission loss, (ii) penalty factor. [[CO1](Apply/IOCQ)]

- (b) Two units have the following cost curves:

$$C_1 = 0.05P_{G1}^2 + 22P_{G1} + 120 \text{ Rs/hr}$$

$$C_2 = 0.06P_{G2}^2 + 16P_{G2} + 120 \text{ Rs/hr}$$

Where PG is in MW. The limits of all the plants are as follows:

$$20 \text{ MW} \leq P_G \leq 100 \text{ MW}$$

Determine how will a load of (i) 80 MW and (ii) 120 MW and (iii) 200MW be shared? [[CO1](Evaluate/HOCQ)]

**6 + 6 = 12**

3. (a) Develop 'Transmission Loss Coefficients'. [[CO1](Apply/IOCQ)]

- (b) A power system has two generating plants and the power is being dispatched economically with  $P_1 = 150 \text{ MW}$  and  $P_2 = 275 \text{ MW}$ . The loss coefficients are:

$$B_{11} = 0.10 \times 10^{-2} \text{ MW}^{-1}$$

$$B_{12} = -0.01 \times 10^{-2} \text{ MW}^{-1}$$

$$B_{22} = 0.13 \times 10^{-2} \text{ MW}^{-1}$$

To raise the total load on the system by 1 MW will cost an additional Rs 200 per hour. Calculate (a) the penalty factor for plant 1, and (b) the additional cost per hour to increase the output of plant 1 by 1MW. [[CO1](Apply/IOCQ)]

**6 + 6 = 12**

## Group - C

4. (a) Explain the advantages and limitations of HVDC transmission system. [[CO2](Understand/LOCQ)]  
(b) Write short notes on the following:  
(i) Smoothing reactors (ii) Back to back HVDC station. [[CO2](Apply/IOCQ)]  
**5 + (3 + 4) = 12**
5. (a) Deduce the expressions of Refraction coefficients of voltage and current in case of travelling wave propagation. [[CO3](Evaluate/HOCQ)]  
(b) A surge of 15 kV magnitude travels along a cable towards its junction with an overhead line. The inductance and capacitance of the cable and overhead line are respectively 0.3 mH, 0.4  $\mu$ F and 1.5 mH, 0.012  $\mu$ F per km. Determine the voltage rise at the junction due to the surge. [[CO3](Evaluate/HOCQ)]  
(c) Define Ferranti Surge Absorber. [[CO3](Remember/LOCQ)]  
(d) Compare the Volt -Time Characteristics of Rod Gap and Expulsion Type surge diverter. [[CO3](Analyse/IOCQ)]  
(e) Define Infinite Line. [[CO3](Remember/LOCQ)]  
**4 + 3 + 2 + 2 + 1 = 12**

## Group - D

6. (a) Sketch the schematic diagram of speed governing system. [[CO4](Apply/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) Prove that in case of two generators connected in parallel their output is shared in the inverse ratio of their speed regulation. [[CO4](Evaluate/HOCQ)]  
(b) Sketch the block diagram representation of AVR. [[CO4](Apply/IOCQ)]  
(c) What are the types of Exciters of an alternator? [[CO4](Remember/LOCQ)]  
(d) Why do the AVR loop and ALFC loop work independently? [[CO4](Understand/LOCQ)]  
(e) Two generators rated 200 MW and 400 MW are operating in parallel. The droop characteristics of their governors are 4 % and 5%, respectively from no-load to full load. Assuming that the generators are operating at 50 Hz at no-load, how would a load of 600 MW be shared between them? Find the system frequency at this load? Assume free governor operation. [[CO4](Evaluate/HOCQ)]  
**3 + 2 + 1 + 2 + 4 = 12**

## Group - E

8. (a) Prove that the change of terminal voltage depends on the reactive power. [[CO5](Evaluate/HOCQ)]  
 (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](Evaluate/HOCQ)]  
 (e) Sketch the VI characteristics of TCR for different delay angles. [[CO5](Apply/IOCQ)]  
**3 + 2 + 3 + 2 + 2 = 12**
9. (a) Deduce the expression of surge impedance of a transmission line. [[CO5](Evaluate/HOCQ)]  
 (b) Justify that series compensation requires special protection schemes. [[CO5](Evaluate/HOCQ)]  
 (c) Compare any two features of series and shunt compensation. [[CO5](Analyse/IOCQ)]  
 (d) Sketch the circuit diagram and VI characteristics of FC-TCR. [[CO5](Apply/IOCQ)]  
 (e) An inductive load draws power of  $(2+j1)$  MVA at a receiving end bus of a radial three phase line. The receiving end bus voltage is 11 kV at 50 Hz and the system reactance is  $0.5 \Omega/\text{phase}$ . Determine (i) receiving end current (ii) voltage regulation (iii) sending end voltage and (iv) short capacity of the system. [[CO5](Evaluate/HOCQ)]  
**2 + 2 + 2 + 2 + 4 = 12**

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	16.67	44.80	38.53

### Course Outcome (CO):

After the completion of the course students will be able to

1. To understand the Economic Operation of Power Generation Systems
2. To learn about the components and operation of HVDC transmission system .
3. To learn about the power system transients and protection against overvoltage.
4. To understand and analyze the frequency Control in Power System.
5. To know about the basic principle of voltage control and operation of FACTS devices.

*\*LOCQ: Lower Order Cognitive Question; IOCQ: Intermediate Order Cognitive Question; HOCQ: Higher Order Cognitive Question.*