

**ADVANCED POWER SYSTEM
(ELEC 4131)**

Time Allotted : 3 hrs

Full Marks : 70

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 5 (five) from Group B to E, taking at least one from each group.

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

**Group – A
(Multiple Choice Type Questions)**

1. Choose the correct alternative for the following: **10 × 1 = 10**
- (i) 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.
- (ii) TCSC is
(a) shunt controller
(b) series controller
(c) both (a) and (b)
(d) none of these.
- (iii) Series compensation in transmission lines
(a) increases stability limit
(b) decreases stability limit
(c) has no effect on stability limit
(d) none of these.
- (iv) A cable has inductance of 0.22 mH per km and capacitance of 0.202 μ F per km. The surge impedance of the cable is
(a) 28 Ω (b) 33 Ω (c) 40 Ω (d) 52 Ω .
- (v) The reflection coefficient of a short-circuited line is
(a) -1 (b) +1 (c) 0.5 (d) zero.
- (vi) Which of the following is non-linear divider?
(a) Rod gap type arrester
(b) Valve type arrester
(c) Expulsion type arrester
(d) Electrolytic type arrester.
- (vii) Reactive power to HVDC system may be supplied from
(a) ac filters
(b) shunt capacitors
(c) SVS
(d) all of the above.
- (viii) What will be the penalty factor for a unit, if the incremental transmission loss is zero?
(a) 0 (b) 1 (c) -1 (d) ∞ .
- (ix) What is the unit of incremental fuel cost?
(a) Rs/MW (b) Rs/MWh (c) Unit less (d) Rs/MVA.

- (x) 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.

Group - B

2. (a) Develop the expression of the transmission loss in terms of transmission loss coefficients for a power system consisting of two generating plants.
 [(CO1)(Apply/IOCQ)]
- (b) In a two-plant system, the entire load is located at plant 2, which is connected to plant 1 by a transmission line. Plant 1 supplies 100 MW of power with a corresponding transmission loss of 5 MW. Determine the penalty factors for the two plants.
 [(CO1)(Evaluate/HOCQ)]
6 + 6 = 12

3. (a) Illustrate different constraints of unit commitment problem.
 [(CO1)(Understand/LOCQ)]
- (b) On the system consisting of two generating plants the incremental costs in rupees per MWh with P1 and P2 are in MW are

$$\frac{dC_1}{dP_1} = 0.15P_1 + 150; \quad \frac{dC_2}{dP_2} = 0.25P_2 + 175$$

The system is operating on economic dispatch with $P_1=P_2= 200\text{MW}$ and $\frac{dP_L}{dP_2} = 0.2$.
 Solve for penalty factors of both the plants.
 [(CO1)(Apply/IOCQ)]
6 + 6 = 12

Group - C

4. (a) An existing three-phase, double-circuit AC line is to be converted to three circuit DC line.
 Assuming the same insulation level and unity power factor in the ac systems, prove that (i) the ratio of power transmitted by DC to that by AC is equal to $\sqrt{2}$ and (ii) the ratio of percentage loss by DC to that by AC is equal to $1/\sqrt{2}$.
 [(CO2)(Evaluate/HOCQ)]
- (b) Examine the effect of travelling wave on a terminal inductor. [(CO3)(Analyse/IOCQ)]
6 + 6 = 12
5. (a) Explain the advantages and limitations of HVDC transmission system.
 [(CO2)(Understand/LOCQ)]
- (b) What is basic impulse level? [(CO3)(Understand/LOCQ)]
- (c) Develop the expression for reflection and refraction coefficients for voltage and current travelling waves.
 [(CO3)(Analyze/IOCQ)]
4 + 2 + 6 = 12

Group - D

6. (a) Explain the necessity of keeping frequency constant in power system. [(CO4)(Understand/LOCQ)]
 (b) Justify that supplementary control is slower than the governor control. [(CO4)(Evaluate/HOCQ)]
 (c) A 200 MVA synchronous generator operates on 80% loading condition with unity power factor load. The speed governor of the generator has a regulation of 4% and the no load operating frequency is 50 Hz. The load on the generator is suddenly reduced by 30 MW. Due to time lag in the governing system, the steam valve begins to close after 0.5 sec. Determine the change in frequency during this time. Inertia constant of the generator is 5 MW-s/MVA. [(CO4)(Evaluate/HOCQ)]
4 + 3 + 5 = 12
7. (a) What is an exciter? [(CO4)(Remember/LOCQ)]
 (b) What is its role in AVR loop? [(CO4)(Understand/LOCQ)]
 (c) Build the complete block diagram of an AVR loop taking into account modern static excitation system of the alternator. [(CO4)(Apply/IOCQ)]
3 + 2 + 7 = 12

Group - E

8. (a) What is STATCOM? [(CO5)(Remember/LOCQ)]
 (b) Compare the performance and operation of SVC with that of STATCOM. [(CO5)(Analyze/IOCQ)]
 (c) 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) Maximum power transfer capability of the system. Assume lossless system. [(CO5)(Evaluate/HOCQ)]
2 + 5 + 5 = 12
9. (a) Define Sub-Synchronous Resonance (SSR). [(CO5)(Remember/LOCQ)]
 (b) Deduce the following relation in case of series and shunt compensation in a power system.

$$Z'_c = \sqrt{\frac{j\omega L'}{j\omega C'}} = Z_c \sqrt{\frac{1-\gamma_{se}}{1-\gamma_{sh}}}$$
 [(CO5)(Evaluate/HOCQ)]
 (c) Compare the advantages of Static Synchronous Series Compensator (SSSC) with respect to Thyristor Controlled Series Capacitor (TCSC). [(CO5)(Analyze/IOCQ)]
2 + 6 + 4 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	26.04	41.66	32.29

Course Outcome (CO):

After the completion of the course students will be able to

C01: understand the Economic Operation of Power Generation Systems

C02: learn about the components and operation of HVDC transmission system.

C03: learn about the power system transients and protection against overvoltage.

C04: understand and analyze the frequency Control in Power System.

C05: 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