(c) A 415 V, 50 Hz, 3 phase system delivers 500 kW at 0.8 power factor lag. Shunt capacitors are installed to raise the power factor to 0.92. Determine the kVAr rating per phase and the capacitance per phase needed if a delta connected capacitor bank is used.

**3 + 5 + (2 + 2) = 12**

9. (a) What are static var systems (SVS)?

(b) Describe the different SVS schemes commonly used in EHV/UHV transmission for voltage compensation.

(c) Write the advantages of SVS.

**2 + 8 + 2 = 12**





# ADVANCED POWER SYSTEM
# (ELEC 4161)

**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) If the penalty factor of a plant is unity, the incremental transmission loss is
(a) 1.0 (b) -1.0 (c) zero (d) 2.

(ii) What is the unit of transmission loss coefficient?
(a) MW (b) $(MW)^{-1}$ (c) Unit less (d) $(MW)^2$.

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

(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) The insulation level of a 400kV EHV overhead transmission line is decided on the basis of
(a) lightning over-voltage (b) switching over-voltage
(c) corona inception voltage (d) radio and TV interference.

(vi) A 100 MW alternator is connected to an infinite bus and its excitation is increased, then the terminal voltage of the alternator will
(a) rise (b) fall (c) remain unaltered (d) fall to 0.

(vii) Shunt compensation in an EHV line is used to
(a) improve stability (b) reduce fault level
(c) improve voltage profile (d) skin effect.

(viii) Overhead ground wires are used to protect a transmission line against
(a) line-to-ground faults
(b) arcing earths
(c) voltage surges due to direct lightning stroke
(d) high voltage oscillations due to switching.

(ix) In an Automatic load frequency control (ALFC) loop, $\Delta f$ can be reduced by using _____ controller.
(a) differential (b) integral
(c) proportional (d) none of (a), (b), (c).

(x) Under over excitation synchronous phase modifier works as
(a) shunt capacitor (b) series capacitor
(c) shunt reactor (d) series resistance.

## Group – B

2. (a) Derive the condition for economic load scheduling of thermal power plants considering transmission losses. Hence define: (i) incremental transmission loss, (ii) penalty factor.

(b) A power system has two generating plants and the power is being dispatched economically with $P_1$ = 150 MW and $P_2$ = 275 MW. The loss coefficients are:
$B_{11} = 0.10 \times 10^{-2}$ MW$^{-1}$
$B_{12} = -0.10 \times 10^{-2}$ MW$^{-1}$
$B_{22} = 0.13 \times 10^{-2}$ MW$^{-1}$
To raise the total load on the system by 1 MW, an additional cost of Rs.200 per hour is incurred. Find (i) the penalty factor for plant 1, and (ii) the additional cost per hour to increase the output of plant 1 by 1 MW.

**(4 + 1 + 1) + (3 + 3) = 12**

3. (a) Discuss different constraints of the unit commitment problem.

(b) Two units have the following cost curves:
$F_1 = 0.05P_{G1}^2 + 22P_{G1} + 120$ **Rs/hr**
$F_2 = 0.06P_{G2}^2 + 16P_{G2} + 120$ **Rs/hr**
Where $P_{G1}$ *and* $P_{G2}$ are in MW. The limits of all the plants are as follows:
**20 MW** $\leq P_G \leq 100$ *MW*
How will a load of (i) 80 MW and (ii) 120 MW be shared?

**6 + 6 = 12**

## Group – C

4. (a) Discuss the advantages and limitations of HVDC systems.





(b) Explain the following:
(i) Prospects of MTDC systems
(ii) Role of Harmonic filters in HVDC system.

**5 + (4 + 3) = 12**

5. (a) What is Bewley lattice diagram? Explain its utility in the study of traveling waves.

(b) An overhead transmission line having a surge impedance of 500 Ω branches into two lines having a surge impedance of 40 Ω and 60 Ω respectively. If a travelling wave of vertical front and magnitude 100 kV travels along the overhead line, calculate the magnitude of voltage and current in the overhead line and in the two branches immediately after the travelling wave has reached the fork.

**5 + 7 = 12**

## Group – D

6. (a) Explain the Basic Working Principle of AVR.

(b) "Load Frequency Control could not affect the operation of Excitation Voltage Control". Justify the statement.

(c) A 125 MVA turbo-alternator operates on full load at 50 Hz frequency. The load is suddenly reduced to 50 MW. The steam valves of the turbine commence to close after 0.5 seconds due to the time lag in the governor system. Assume the inertia constant, H = 6 kW-sec per kVA of generator capacity. Calculate the change in frequency that occurs in this time.

**6 + 2 + 4 = 12**

7. (a) Obtain the mathematical model and block diagram of generator and load for frequency control analysis.

(b) 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 500 MW be shared between them? What would be the system frequency at this load? Assume free governor operation.

**6 + 6 = 12**

## Group – E

8. (a) Show that the voltage control and reactive power control are interrelated.

(b) Compare the performances of series and shunt capacitors in power system.