2023

ELECTRICAL ENGINEERING

PAPER-II

*Time Allowed — 3 Hours* *Full Marks — 200*

*If the questions attempted are in excess of the prescribed number, only the questions attempted first up to the prescribed number shall be valued and the remaining ones ignored.*

*Answer may be given either in* ***English*** *or in* ***Bengali*** *but all answers must be in one and the same language.*

*All symbols have their usual significance.*

Answer *any five* questions.

1. (a) Derive the optimal division of load between two generators and extend the idea for $n$-number of generators in power system for economic operation.

(b) The incremental cost curves in Rs/MWhr for two generators supplying a common load of 700 MW are shown in figure (Fig. 1). The maximum and minimum generation limits are also indicated. Find the optimum generation schedule.

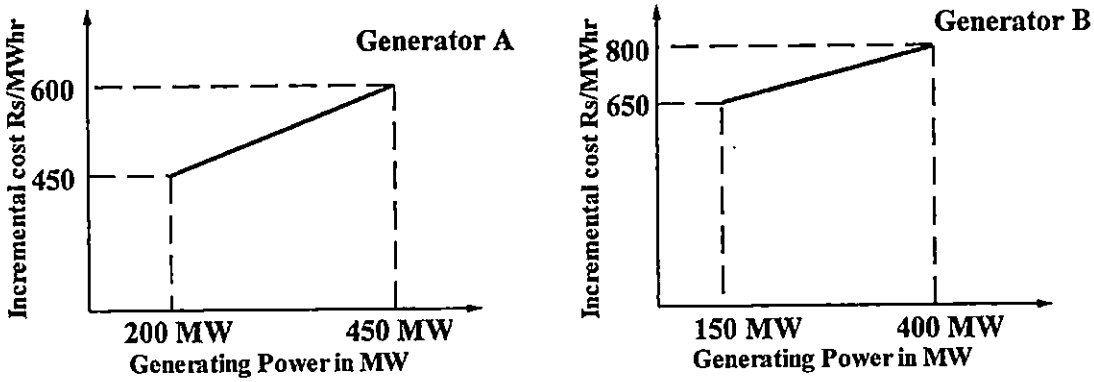


Fig. 1

(c) The incremental cost characteristic of two generators delivering 200 MW are as follows:

$$\frac{dF_1}{dP_1} = 0{\cdot}10P_1 + 20$$

$$\frac{dF_2}{dP_2} = 0{\cdot}20P_{G_2} + 16$$

For economic operation, find the values of power generations from both the generators $P_1$ and $P_2$. 10+10+20

2. (a) A lossless transmission line having surge impedance loading (SIL) of 2280 MW is provided with a uniformly distributed series capacitive compensation of 30%. Then, find the SIL of the compensated transmission line.

(b) An isolated 50 Hz synchronous generator is rated at 15 MW which is also the maximum continuous power limit of its prime mover. It is equipped with a speed governor with 5% droop. Initially, the generator is feeding three loads of 4 MW each at 50 Hz. One of these loads is programmed to trip permanently if the frequency falls below 48 Hz. If an additional load of 3·5 MW is connected then the frequency will settle down at which value?

(c) A round rotor generator with internal voltage $E_1 = 2{\cdot}0$ *pu* and $X = 1{\cdot}1$ *pu* are connected to a round rotor synchronous motor with internal voltage $E_2 = 1{\cdot}3$ *pu* and $X = 1{\cdot}2$ *pu*. The reactance of the line connecting the generator to the motor is 0·5 *pu*. When the generator supplies 0·5 *pu* power, find the rotor angle difference between the two machines. 10+10+20

3. (a) A generator with constant 1·0 *pu* terminal voltage supplies power through a step-up transformer of 0·12 *pu* reactance and a double circuit line to an infinite bus bar as shown in figure (Fig. 2). The infinite bus voltage is maintained at 1·0 *pu*. Neglecting the resistances and susceptances of the system, the steady state stability power limit of the system is 6·25 *pu*. If one of the double circuit is tripped, find the resulting steady state stability power limit in *pu*.

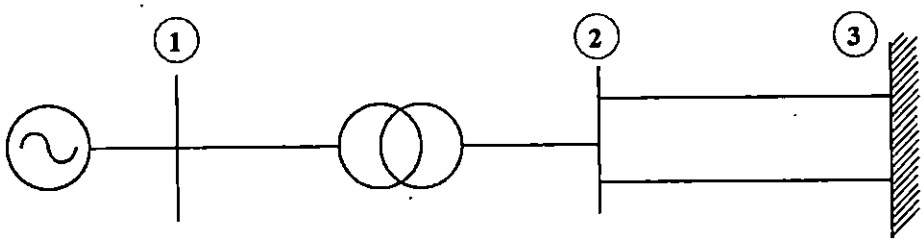


Fig. 2

(b) The *ABCD* parameters of a 3-phase overhead transmission line are $A = D = 0{\cdot}9\ \angle 0°$, $B = 200\ \angle 90°\ \Omega$ and $C = 0{\cdot}95 \times 10^{-3}\ \angle 90°\ S$. At no load condition and shunt inductive, reactor is connected at the receiving end of the line to limit the receiving-end voltage to equal to the sending-end voltage. Calculate the ohomic value of the reactor.

(c) A 20 MVA, 6·6 kV, 3-phase alternator is connected to a 3-phase transmission line. The per unit positive sequence and zero-sequence impedances of the alternator are $j\ 0{\cdot}1$, $j\ 0{\cdot}1$ and $j\ 0{\cdot}4$ respectively. The neutral of the alternator is connected to ground through and inductive reactor of $j\ 0{\cdot}05$ *pu*. The per unit positive, negative and zero-sequence impedances of the transmission line are $j\ 0{\cdot}1$, $j\ 0{\cdot}1$ and $j\ 0{\cdot}3$ respectively. All per unit values are based on the machine ratings. A solid ground fault occurs at one phase of the far end of the transmission line. Find the voltage of the alternator neutral with respect to ground during the fault.

10+10+20

4. (a) Explain the operation of single-phase induction motor by

(i) double revolving field theory and

(ii) cross-field theory.

(b) A 230 V, 50 Hz, 4-pole, single phase induction motor is rotating in the clockwise (forward) direction at a speed of 1425 rpm. If the rotor resistance at standstill is 7·8 Ω, then calculate the effective rotor resistance in the backward branch of the equivalent circuit. 25+15

5. (a) The armature resistance of a permanent magnet dc motor is 0·8 Ω. At no load, the motor draws 1·5 A from a supply voltage 25 V and runs at 1500 rpm. Calculate the efficiency of the motor while it is operating on load at 1500 rpm drawing a current of 3·5 A from the same source.

(b) A 50 kVA, 3300/230 V single phase transformer is connected as an auto-transformer shown in figure (Fig. 3), Find the nominal rating of the auto-transformer. 20+20

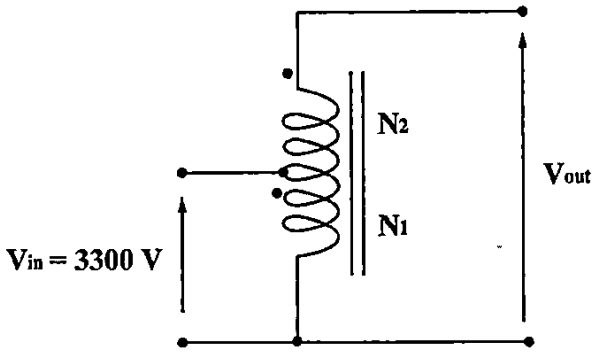


Fig. 3

6. (a) The following circuit (Fig. 4) has R = 10 kΩ, C = 10 μF. The input voltage is a sinusoidal at 50 Hz with an rms value of 10 V. Under ideal conditions, find the current $I_S$ from the source.

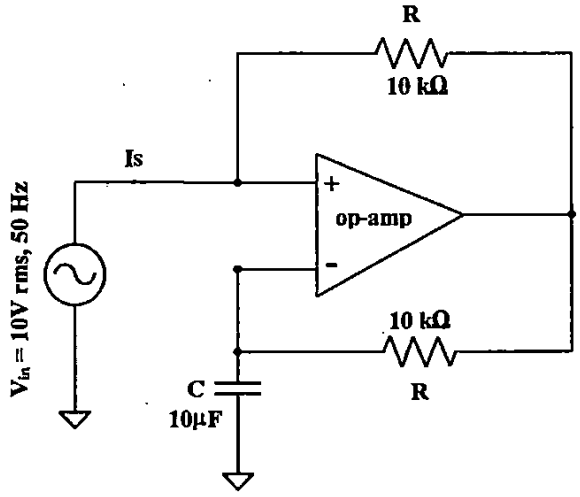


Fig. 4

(b) For the circuit of figure (Fig. 5) with an ideal operational amplifier, find the maximum phase shift of the output $V_{out}$ with reference to the input $V_{in}$. 20+20

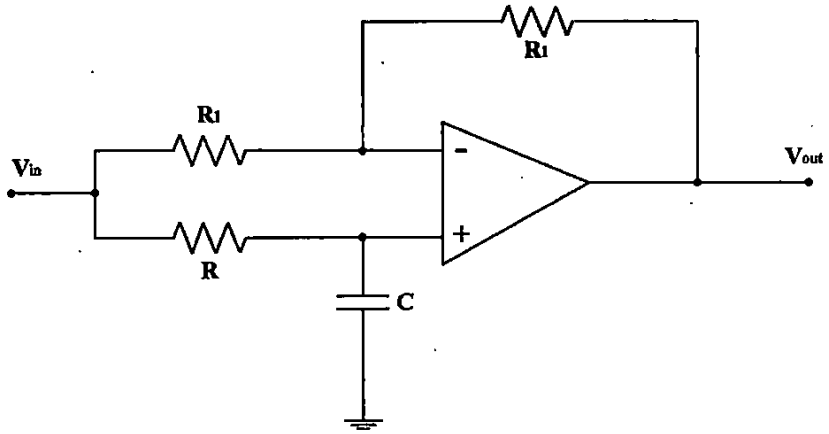


Fig. 5

7. (a) A 4-pole, 50 Hz, synchronous generator has 48 slots in which a double layer winding is housed. Each coil has 10 turns and is short pitched by an angle to 36° electrical. The fundamental flux per pole is 0·025 Wb. Find the line-to-line induced emf (in volts), for a three-phase star connection.

(b) The state variable description of a liner autonomous system is $\dot{X} = AX$, where $\dot{X}$ is the two-dimensional state vector and $A$ is the system matrix given by $A = \begin{bmatrix} 0 & 2 \\ 2 & 0 \end{bmatrix}$. Find the roots of the characteristics equation. 20+20

8. Write short notes on the following: 10×4=40

(a) Application of Maximum Power Transfer Theorem

(b) Equal area criteria in power system stability analysis

(c) Lag-lead compensator

(d) Pitch factor and its advantages