B.Tech.

Fifth Semester Examination

Power Systems-I (EE-315F)

Q.1. (a) A 3-ϕ circuit breaker is rated at 2000 mVA 33 kV. Find it making current.

Ans. Breaking current $= \frac{2000}{\sqrt{3} \times 33} = 34.99\,\text{kA}$

Making current $= 2.55 \times 34.99$

$= 89.22\,\text{kA}$

$= 90\,\text{kA}$

Q. 1. (b) Why is one of the buses taken as slack bus in load flow studies?

Ans. In power system there are mainly two types buses. For these buses we specified the real power P injection. Now $\sum_{i=1}^{n} p_i$ = Real power loss P_L.

Where, p_i is the power injection at the buses which is + ve for generator buses.

Q. 1. (c) List advantages of using per unit values in power system calculation.

Ans. Advantages given below :

(i) It minimise calculation of power system.

(ii) Analysis become easier as continuous as like in both sides of transformer.

Q. 1. (d) Write expression for per unit Impedance (Z_{pu}) in a 3-phase system.

Ans. $Z_{pu} = \frac{Z_{\text{OHM}} \times (\text{MVA})_B}{(\text{kV})_B^2}$

Q. 1. (e) Explain in brief about Plant Capacity Factor.

Ans. Plant Capacity Factor : The plant capacity factor give an idea about the reserve capacity requirements of a power system.

Q. 1. (f) Write main role of plant in a large connected Power System.

Ans. Role of Plant in Large Connected Power System :

(a) Increased reliability of power system.

(b) Reduction in total installed capacity.

(c) Economic operation.

Q. 1. (g) Write Gauss-Siedel Iterative Formula for solving load flow equation.

Ans. $$V_k^{k+1} = \frac{1}{Y_{PP}}\left[\frac{P_p - jQ_p}{(V_p^x)^*} - \sum_{q=1}^{p-1} Y_{PQ} V_q^{k+1} - \sum_{q=p+1}^{n} Y_{pp} V_q^k\right]$$

Q. 1. (h) What do you know about swing equation ?

Ans. The equation describe the relative motion of rotor, with respect to stator field is known as power system stability.

Q. 1. (i) What is Diversitive Factor?

Ans. Diversitive factor is defined as ratio of sum of individual maximum demand to simultaneous maximum demand.

Q. 1. (j) What is load factor ?

Ans. Load factor is defined as average load to maximum load ratio.

Section—(A)

Q. 2. (a) Classification of Hydro electrical plants and explain it in details.

Ans. Based on Quantity of Water Available :

(i) Run-off River Plants without Pondage : These plant does not store water so that they remain functional only when water is available also there generation capacity depends upon availability of water.

(ii) Run-off River Plants with Pondage : The utility of run off river plant can be increase without storage of water. This storage of water, can be utilized during peak period.

(iii) Reserving Plants : In this plant a large reservoir stores water, from wet seasons to next dry session. This plant can operate on any part of load flow.

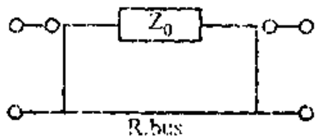
Q. 2. (b) Draw the zero sequence equivalent circuit of 3-ϕ transformer with following connection of windings :

(a) Δ / Δ (b) Δ / Y (c) Δ / Y⏚

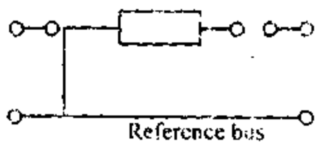
(d) Δ / Y⏚ (e) Y / Y

Ans. Connection **Zero sequence equivalent circuit**

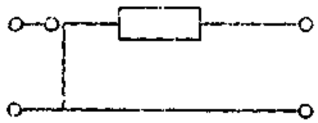
(a) Δ / Δ



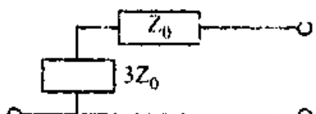
(b) Δ / Y



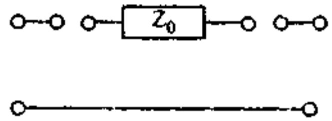
(c) Δ / Y⏚



(d) Δ / Y⏚



(e) Y / Y



Q. 3. Draw reactance diagram of power system whose admittance matrix is given below. First, second, third, fourth row refer to buses 1, 2, 3, 4 respectively.

$$Y_{Bus} = j\begin{bmatrix} -3.78 & 1.25 & 2.50 & 0 \\ 1.25 & -3.42 & 1.11 & 1.00 \\ 2.50 & 1.11 & -4.89 & 1.25 \\ 0 & 1.00 & 1.25 & -2.31 \end{bmatrix}$$

Ans.

$$Y_{12} = -Y_{12} = j\,1.25 = Y_{21}$$

$$Y_{12} = -j\,1.25$$

$$Z_{12} = \frac{1}{Y_{12}} = -\frac{1}{j1.25} = j\,0.8$$

$$Y_{13} = -Y_{13} = +j\,2.5$$

$$Z_{13} = -\frac{1}{j\,2.5} = j\,0.4$$

$$Y_{14} = -Y_{14} = 0$$

$$Z_{14} = 0$$

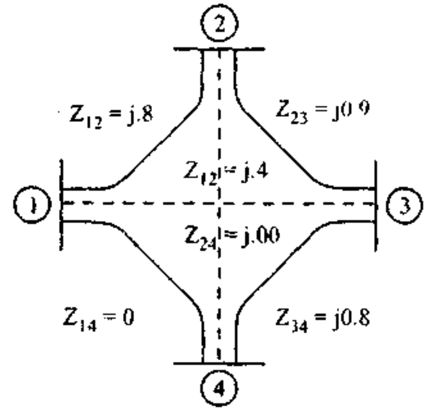
$$Z_{23} = -Y_{23} = j\,1.11$$

$$Z_{23} = -\frac{1}{j1.11} = j\,0.9$$

$$Y_{24} = -Y_{24} = j\,1.00$$

$$Z_{24} = j\,1.00$$

$$Z_{34} = +j\,0.8$$



Section—(B)

Q. 4. Derive expression for 3-ϕ system in term of symmetrical components.

Ans. Expression for Total 3-phase System :

We know that reference phaser

$$V_a = V_{a_1} + V_{a_2} + V_{a0}$$

$$V_b = \alpha^2 V_{a_1} + \alpha V_{a_2} + V_{a0}$$

$$V_c = \alpha V_{a_1} + \alpha^2 V_{a_2} + V_{a0}$$

$$\begin{bmatrix} V_a \\ V_b \\ V_c \end{bmatrix} = \begin{bmatrix} 1 & 1 & 1 \\ \alpha^2 & \alpha & 1 \\ \alpha & \alpha^2 & 1 \end{bmatrix} \begin{bmatrix} V_{a_1} \\ V_{a_2} \\ V_{a_3} \end{bmatrix}$$

$$V_b = AU_S$$

$$V_p = \begin{bmatrix} V_a \\ V_b \\ V_c \end{bmatrix}$$

$$V_S = \begin{bmatrix} V_{a_1} \\ V_{a_2} \\ V_{a_3} \end{bmatrix}$$

$$A^{-1} = \frac{1}{3} \begin{bmatrix} 1 & \alpha & \alpha^2 \\ 1 & \alpha^2 & \alpha \\ 1 & 1 & 1 \end{bmatrix}$$

$$S = V_P^T \cdot I_P^*$$

$$S = 3V_S^T \cup I_S^*$$

$$\boxed{S = 3 V_S^T \cdot I_S^*}$$

Q. 5. By choosing 3-ϕ power and live voltage as base values for a 3-ϕ system. Demonstrate how the per unit method performs power system calculation on single phase basis ?

Ans. For a single phase system base impedance is

$$Z_b I\phi = \frac{kV_{I\phi}^2}{\text{mVA}_{1\phi}} \ \Omega/\text{phase}$$

For 3 phase line to line voltage :

$$Z_{3\phi} = \frac{\text{KV}_{\text{Line}}^2}{\text{mVA}_{3\phi}}$$

As the system is assumed to be star-connected

$$\text{kV line} = \sqrt{3} \times \text{kV Phase}$$

$$= \sqrt{3} \times \text{kV}_{1\phi}$$

$$\text{mVA}_{3\phi} = 3 \times \text{mVA}_{1\phi}$$

$$Z_{b3\phi} = \frac{(\sqrt{3} \times \text{kV}_{1\phi})^2}{3 \times \text{mVA}_{1\phi}} = \frac{\text{kV}_{1\phi}^2}{\text{mVA}_{1\phi}} = Z_{b1\phi}$$

$$\boxed{Z_{b3\phi} = Z_{b1\phi}}$$

Section—(C)

Q. 6. Three faults simulated on a power system give the following results :

$I_{f,3\phi} = 1700$ **Å,** $I_{f,ZL} = 1500$ **Å**

$I_{f,SLG} = 2000$ **Å**

The base values at fault equation are : 1000 MVA, 132 kV. Find Pu values of all sequence impedance of Thevenin Equivalent Network.

Ans.
$$I_{f3\phi} = \frac{\text{per fault phase voltage IPu}}{Z_1}$$

E at the fault location
$$= \frac{11}{\sqrt{3}} = 6.35\,\text{kV}$$
$$= 6350\,\text{volt}$$
$$I_{f3\phi} = 1700\text{ A} = \frac{6.350}{Z_1}$$

E at fault location
$$= \frac{11}{\sqrt{3}} = 6.35\,\text{kV}$$
$$I_{f3\phi} = 1700\text{ A} = \frac{6350}{Z_1}$$
$$I_{fLL} = \frac{\sqrt{3}F}{(Z_1 + Z_2)}$$
$$Z_1 + Z_2 = 7.333\,\Omega \Rightarrow 1500 = \frac{\sqrt{3} \times 6350}{(Z_1 + Z_2)}$$
$$Z_2 = 7.333 - 3.735$$
$$Z_2 = 3.598\,\Omega$$
$$I_{f,SLG} = \frac{3E}{(Z_1 + Z_2 + Z_0)} = \frac{3 \times 6350}{Z_1 + Z_2 + Z_0} = 2000\text{ A}$$
$$Z_1 + Z_2 + Z_0 = 9.525\,\Omega$$
$$Z_0 = 9.525 - 7.33 = \mathbf{2.192}\,\Omega$$
$$Z_1 = 3.735\,\Omega$$

Q. 7. A three phase generator is solidly grounded neutral the sequence impedance of alternator are

$\mathbf{Z_1 = j\,0.4, Z_2 = j\,0.35, Z_0 = j\,0.05}$ **p.u. resistance are negligible. What is value of reactance?**

Ans. Taking equipment rating as base, the generator rated current

$$= \frac{10 \times 10^6}{\sqrt{3} \times 11 \times 10^3} = 524.89 \text{ A}$$

Base impedance $= \frac{11^2}{10} = 1.21\Omega$

1 p.u. current $= 524.87$ A

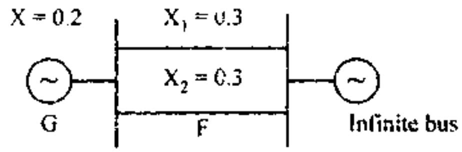
$$I_{f\,SLG} = 1 \text{ p.u.} = \frac{3E}{Z_1 + Z_2 + Z_0 + 3Z_4}$$

$$1 \text{ p.u} = \frac{3 \times 1}{(j0.4 + j0.35 + j0.05 + 3j0.4)}$$

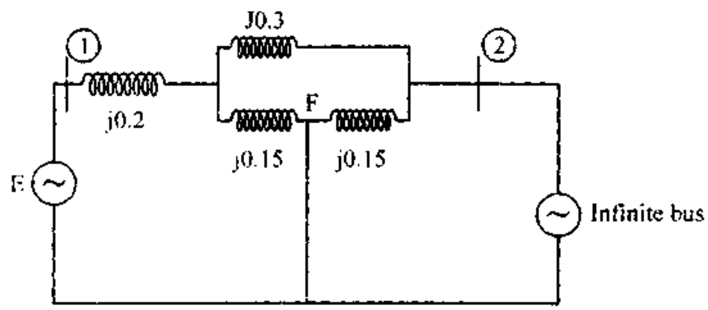
$$\boxed{\alpha_y = 0.733 \text{ p.u.}}$$

Section—(D)

Q. 8. A 3-ϕ fault occur at middle point *F* on the transmission line as shown in figure below. Determine transfer reactance between generator and infinite bus.



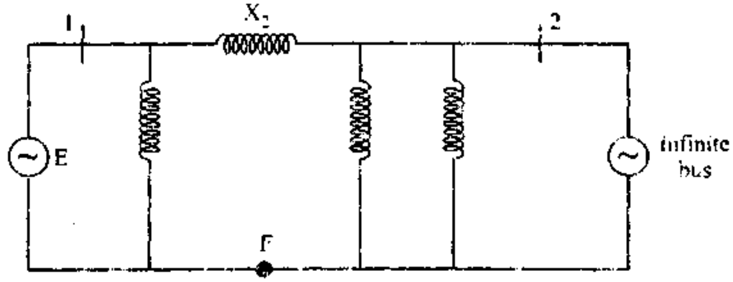
Ans.



It is required to determine the reactance diagram that appears between generator and infinite bus. Hence, the star connected network consisting of generator reactance 0.2, line-I reactance 0.3 and faulted line Half-reactance 0.15 p.u. is converted into equivalent delta network :

Transfer $X_{12} = j0.2 + j0.3 + \frac{j0.2 \times j0.3}{j0.15}$

$$= j0.9 \text{p.u.}$$



Q. 9. Determine economic operated schedule and the corresponding cost of generation. If maximum and minimum loading of each machine is 100 mW and 25 mW. The demand is 180 mW the transmission losses are neglected determines powers.

$$F_1 = 0.2\,P_1^2 + 40P_1 + 120 \text{ Rs/hr}$$

$$F_2 = 0.25\,P_2^2 + 30P_2 + 150 \text{ Rs/hr}$$

Ans. Incremental production cost of both unit are :

$$\frac{dF_1}{dP_1} = 0.9P_1 + 40 \text{ Rs./mWhr}$$

$$\frac{dF_2}{dP_2} = 0.5P_2 + 30 \text{ Rs./mWhr}$$

Now economic operation of units

$$\frac{dF_1}{dP_1} = \frac{dF_2}{dP_2}$$

i.e., $$0.9P_1 + 40 = 0.5P_2 + 30$$

$$0.9P_1 - 0.5P_2 = -10$$

$$P_1 = \frac{80}{0.9} = 88.88 \text{ mW}$$

$$P_2 = 91.11 \text{ mW}$$ **Ans.**