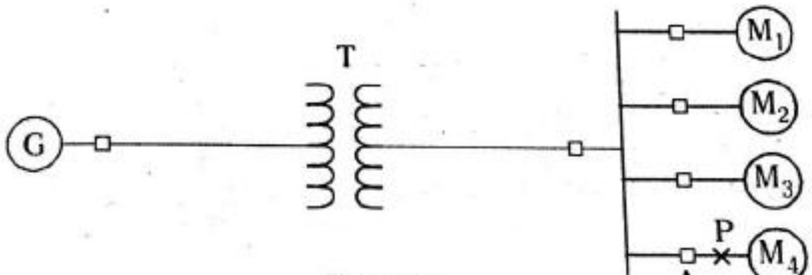
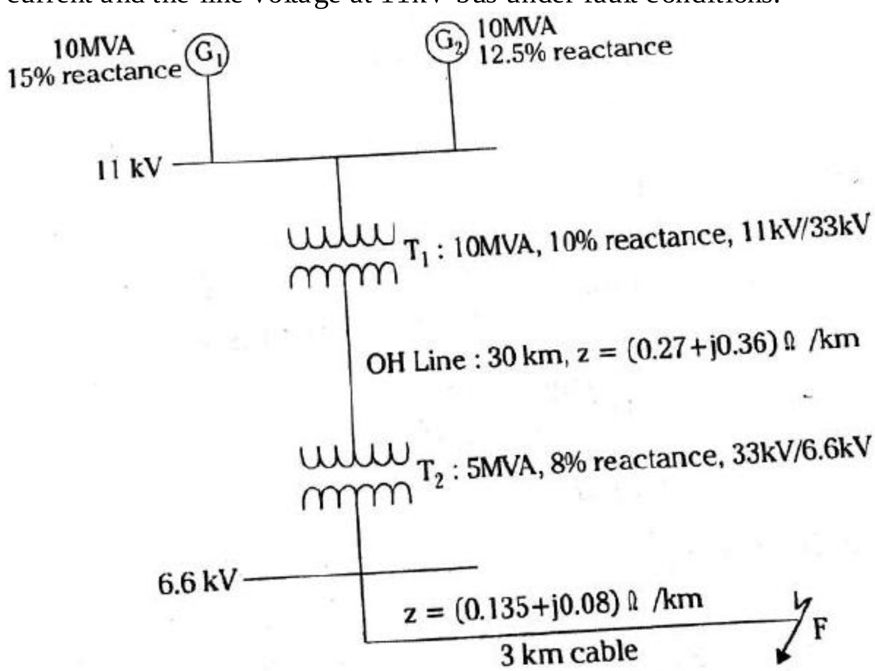
CMR INSTITUTE OF TECHNOLOGY

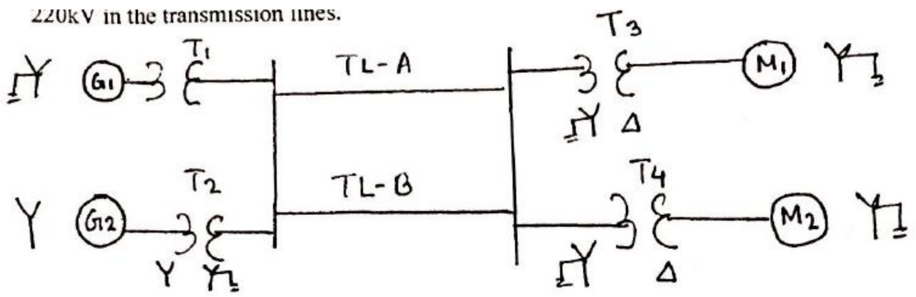
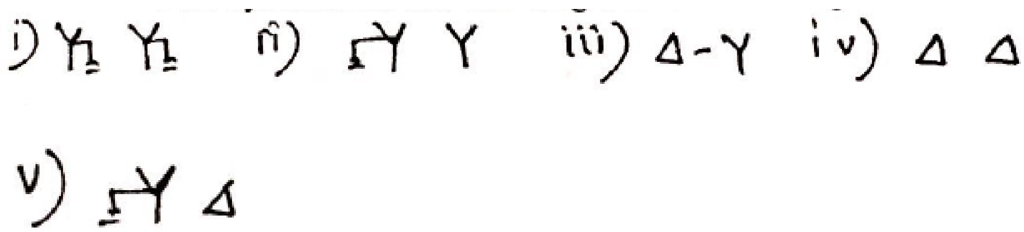
USN

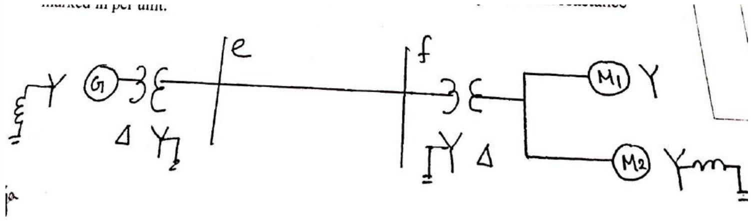
Internal Test 2 –April 2019

Sub:	Power System Analysis-1							Code:	15EE62/10EE61
Date:	15/04 /2019	Duration:	90 mins	Max Marks:	50	Sem:	VI	Branch:	EEE

Note: Answer any FIVE full questions with neat diagram wherever necessary.

		Marks	OBE CO	OBE RBT
1.	A 25 MVA, 13.8kV generator with Xd"=15% is connected through a transformer to a bus that supplies four identical motors as shown in figure. Each motor has Xd"=20% and Xd'=30% on a base of 5 MVA, 6.9kV. With a leakage reactance at the point P. For the fault specified determine: a) The sub transient current in the fault. b)The sub transient current in the breaker A. c)The momentary current in breaker A. d) The current to be interrupted by breaker A in 5 cycles. Leakage reactance of transformer is 10%.  Fig. 2.28 .	[10]	CO2	L3
2.	For the radial network shown in figure, a three phase fault occurs at F. Determine the fault current and the line voltage at 11kV bus under fault conditions. 	[10]	CO2	L3
3a.	Obtain an expression for power in terms of sequence components of line to neutral voltages and line currents.	[5]	CO3	L1
3b.	In a three phase system, the sequence quantities are V_{a1}=(0.9 + j0.2) p.u., V_{a2}= (0.2 + j0.1) p.u., V_{a0}=(0.1 + j0.05) p.u. and I_{a1}=(0.9 - j0.1) p.u., Ia2=(0.2 - j0.1) p.u., I_{a0}=(0.05 - j0.02) p.u. Find the three phase complex power in p.u and in MVA on a base of 100 MVA. Also compute the active and reactive power.	[5]	CO3	L2

4a.	Obtain the relationship between line and phase sequence components of voltages in star connection. Draw the relevant phasor diagram. **P.T.O**	[5]	CO3	L1
4b.	The positive and negative sequence components of phase voltages of a three phase system are Va1= 230∠30° V, Va2=60∠60° V,. Determine the [positive and negative sequence of components of line voltage and hence the line voltages.	[5]	CO3	L2
5.	The one line diagram of a power system is shown in figure. The ratings of the devices are as follows:G1 & G2 : 104 MVA, 11.8 kV, X1=X2=0.2 p.u., X0=0.1 p.u. T1 and T2: 125 MVA, 11Y-220Y kV, X1=X2= X0=0.1 p.u. T3 and T4 : 120 MVA, 230Y-6.9YkV, X1=X2=X0=0.12 p.u M1: 175 MVA, 6.6 kV, X1=X2=0.3 p.u., X0=0.15p.u. M2 :50 MVA, 6.9 kV, X1=X2=0.3 p.u, X0=0.1 p.u. Transmission line reactances : X1=X2=30Ω, X0=60Ω. Draw the sequence diagram in p.u. on a base of 200 MVA, 220kV in the transmission lines. 	[10]	CO3	L3
6a.	Draw zero sequence equivalent circuits of three phase transformer banks, together with diagram of connections and the symbols for one line diagram for following configuration. 	[5]	CO3	L1
6b	A single phase resistive load of 100kVA is connected across lines **bc** of a balanced supply of 3 kV, compute the symmetrical components of line currents.	[5]	CO3	L2
7.	25 MVA, 11kV, three phase generator has a subtransient reactance of 20%. The generator supplies two motors over a transmission line with transformers at both ends as shown in One Line Diagram. The motors have rated inputs of 15MVA and 7.5MVA, both 10 kV with 25% subtransient reactance. The three phase transformers are both rated 30MVA, 10.8/121kV, connection Δ-Y with leakage reactance of 10% each. The series reactance of line is 100Ω. Assume zero sequence reactance for the generators and motors of 0.06pu and current limiting reactors of 2.5 Ω each are connected in the neutral of the generator and motor no. 2. The zero sequence reactance of transmission line is 300Ω. Choose base of 25MVA and 11kV in the generator circuit. Assume that negative sequence reactance of each machine is equal to its subtransient reactance. Draw the positive, negative and zero sequence networks of the systemwith reactance marked in per unit.	[10]	CO3	L3



1.

Solution Base values

Let $(MVA)_B = 25$ MVA, and bar voltage be 13.8 kV in the generator circuit.

Base voltage on the motor side $= 13.8 \times \frac{6.9}{13.8}$
$= 6.9$ kV.

Reactance of generator G:

$X_{dG}'' = j0.15$

$X_{dG}' = j0.15$ (as it is not specified).

Reactance of transformer T:

$X_T = j0.1$

Reactances of motors

$$X_{dM}'' = j0.2 \times \frac{25}{5} \times \frac{(6.9)^2}{(6.9)^2}$$

$$= j1.0 \text{ p.u}$$

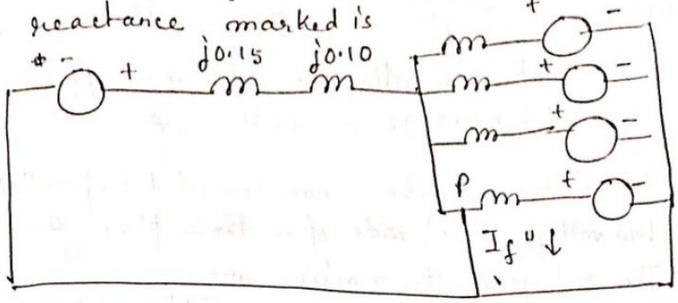
$$X_{dM}' = j0.3 \times \frac{25}{5} \times \frac{(6.9)^2}{(6.9)^2} = j1.5 \text{ p.u}$$

The prefault voltage at the point P is 6.9 kV

$$= \frac{6.9}{6.9} = 1 \text{ p.u}$$ and base current in the 6.9 kV circuit is

$$I_B = \frac{25 \times 10^6}{\sqrt{3} \times 6.9 \times 10^3} = 2091.8 \text{ A}.$$

The reactance diagram with subtransient values of the reactance marked is



a) Subtransient fault current

$$I_f'' = 4 \times \frac{1}{j1.0} + \frac{1}{j0.25} = -j8 \text{ p.u}$$

absolute value of current is $I_f'' = -j8 \times 2091.8$

$$= -j16734.4 \text{ A}.$$

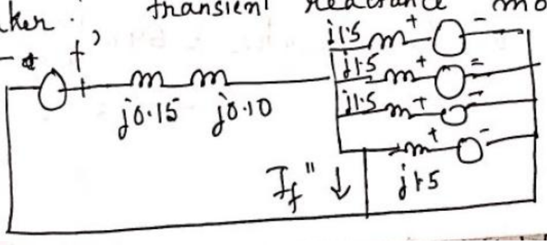
b) sub transient breaker A, $I'' = 3 \times \frac{1}{j1.0} + \frac{1}{j0.25} = -j7 \text{p.}$

Absolute value of current is $I'' = -j7 \times 2091.8$

$$= -j14642.6 \text{ A}.$$

c) Momentary current through breaker A $= 1.6 \times 14642.6$
$= 23428.16$ A.

d) to compute the current to be interrupted by the breaker: transient reactance model is



the current to be interrupted by the breaker A is $= 3 \times \frac{1}{j1.5} + \frac{1}{j0.25} = -j6$ p.u.

To make the allowance for d.c offset current,

HW

$1.1 \times 6 \times 2091 = 13{,}805.88$ A.

2.

Solution: Let us choose a base 100 MVA, for the entire system & a base KV of 33 KV in the overhead line.

Base voltage on the generator side

$= 33 \times \frac{11}{33} = 11$ KV.

Base voltage on the cable $= \frac{6.6}{33} \times 33$

Reactance of generator G_1 :

$$X_{G1,new} = X_{G1,old} \times \frac{(MVA)_{B,new}}{(MVA)_{B,old}} \times \frac{(kV)^2_{B,old}}{(kV)^2_{B,new}}$$

$$= j0.15 \times \frac{100}{10} \times \frac{(11)^2}{(11)^2} = j1.5 \text{ p.u.}$$

Reactance of generator G_2 :

$$X_{G2,new} = X_{G2,old} \times \frac{(MVA)_{B,new}}{(MVA)_{B,old}} \times \frac{(kV)^2_{B,old}}{(kV)^2_{B,new}}$$

$$= j0.125 \times \frac{100}{10} \times \frac{11^2}{11^2} = j1.25 \text{ p.u.}$$

Reactance of Transformer T_1 :

$$X_{T1,new} = X_{T1,old} \times \frac{(MVA)_{B,new}}{(MVA)_{B,old}} \times \frac{(kV)^2_{B,old}}{(kV)^2_{B,new}}$$

$$= j0.1 \times \frac{100}{10} \times \frac{33^2}{33^2} = j1.0 \text{ p.u.}$$

Reactance of transformer T_2

$$X_{T2,new} = X_{T2,old} \times \frac{(MVA)_{B,new}}{(MVA)_{B,old}} \times \frac{(kV)^2_{B,old}}{(kV)^2_{B,new}}$$

$$= j0.08 \times \frac{100}{5} \times \frac{33^2}{33^2} = j1.6 \text{ p.u.}$$

Impedance of the OH Line.

$$Z_{OH} = Z_{TL}(\Omega) \times \frac{(MVA)_{B,new}}{(kV)_B^2}$$

$$= 30 \times (0.27 + j0.36) \times \frac{100}{33^2}$$

$$= 0.744 + j0.99 \text{ p.u}$$

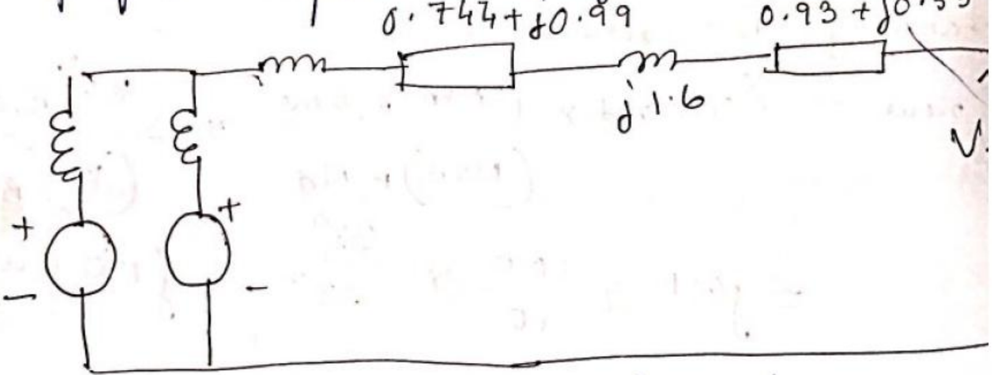
Impedance of cable:

$$Z_C = Z_C(\Omega) \times \frac{(MVA)_{B,new}}{(kV)^2_B}.$$

$$= 3(0.135 + j0.08) \times \frac{100}{6.6^2}$$

$$= 0.93 + j0.55 \text{ p.u.}$$

The prefault impedance diagram:



Since the system is unloaded prior to occurrence of fault, V_{pf} is assumed as 1.0 p.u.

Thevenin's theorem is employed here to find the fault current.

$$V_{Th} = V_{pf} = 1.0 \text{ p.u}$$

To find Z_{TH}

Shorting the generated voltages, equivalent circuit of the system prior to the fault

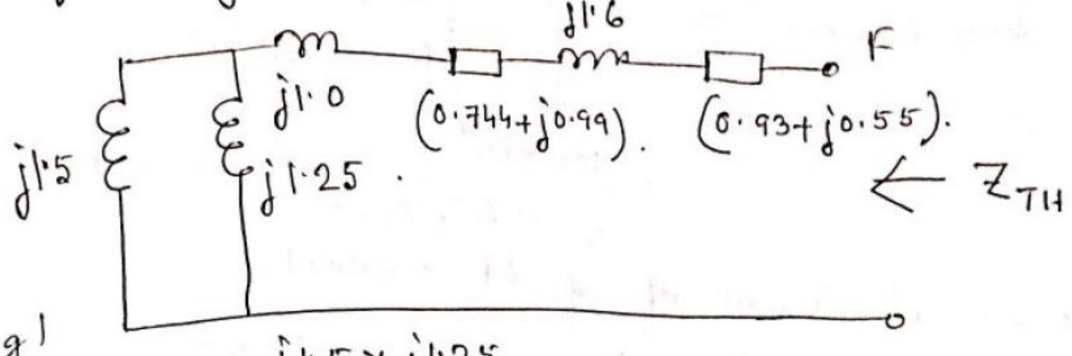
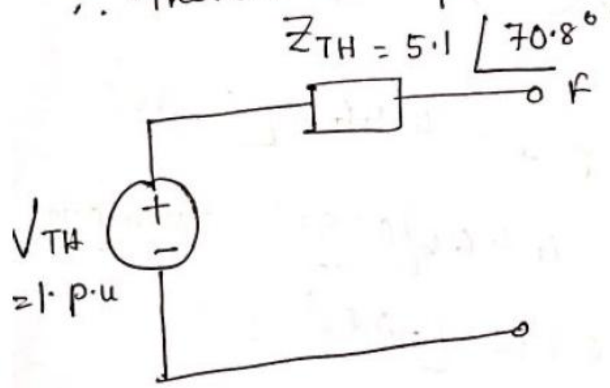


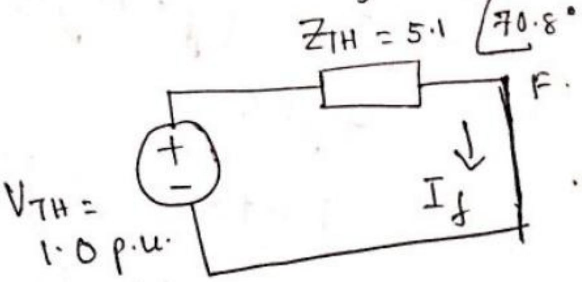
Fig 1

$$Z_{TH} = \frac{j1 \cdot 5 \times j1 \cdot 25}{j1 \cdot 5 + j1 \cdot 25} + \left(j1 \cdot 0 + 0 \cdot 744 + j0 \cdot 99 + j1 \cdot 6 + 0 \cdot 93 + j0 \cdot 55 \right).$$

$$= 1 \cdot 674 + j4 \cdot 82 = 5 \cdot 1 \angle 70 \cdot 8^{\circ} \text{ p.u.}$$

$\therefore$ Thevenin's equivalent circuit w.r.t fault point





Now short circuiting the terminals of the Thevenin's equivalent circuit.

The current flowing through the short circu

The p.u value of the fault current

$$I_f = \frac{V_{TH}}{Z_{TH}} = \frac{1.0 \angle 0^\circ}{5.1 \angle 70.8^\circ} = 0.196 \angle -70.8^\circ$$

The base current $I_B = \frac{\text{Base power}}{\sqrt{3} \times (\text{Base voltage})}$.

$$= \frac{100 \times 10^6}{\sqrt{3} \times 6.6 \times 10^3} = 8747 \text{ A}$$

∴ the absolute value of fault current

$$I_f = 0.196 \angle -70.8^\circ \times 8747 = 1714 \text{ A} \angle -70.8^\circ$$

To find voltage at 11 KV bus during fault

From fig 1 it can be observed that the total impedance between point F and 11 KV bus is

$$= (0.93 + j0.55) + j(1.6) + (0.744 + j0.99) + j1.0$$

$$= 1.674 + j4.14 \text{ p.u} = 4.466 \angle 67.98^\circ$$

Voltage at 11 KV bus $= 4.466 \angle 67.98^\circ \times 0.196 \angle -70.8^\circ$

$$= 0.875 \angle -2.82^\circ \text{ p.u}$$

The absolute value of voltage at 11 KV bus

$$= 0.875 \angle -2.82^\circ \times 11$$

$$= 9.625 \angle -2.82^\circ \text{ KV.}$$

3a

The total complex power flowing into a 3 ϕ. circuit is

$$S = P + jQ = V_a I_a^* + V_b I_b^* + V_c I_c^*.$$

$S =$ total complex power

$P \Rightarrow$ active power,

$Q \Rightarrow$ Reactive power.

$$S = P + jQ = \begin{bmatrix} V_a & V_b & V_c \end{bmatrix} \begin{bmatrix} I_a^* \\ I_b^* \\ I_c^* \end{bmatrix}.$$

$$\begin{bmatrix} V_a & V_b & V_c \end{bmatrix} = \begin{bmatrix} V_a \\ V_b \\ V_c \end{bmatrix}^T = \left\{ \begin{bmatrix} 1 & 1 & 1 \\ 1 & \alpha^2 & \alpha \\ 1 & \alpha & \alpha^2 \end{bmatrix} \begin{bmatrix} V_{a0} \\ V_{a1} \\ V_{a2} \end{bmatrix} \right\}$$

$$= \begin{bmatrix} V_{a0} \\ V_{a1} \\ V_{a2} \end{bmatrix}^T \begin{bmatrix} 1 & 1 & 1 \\ 1 & \alpha^2 & \alpha \\ 1 & \alpha & \alpha^2 \end{bmatrix}.$$

$$\left\{ [A][B] \right\}^T = [B]^T [A]^T.$$

$$\begin{bmatrix} I_a^* \\ I_b^* \\ I_c^* \end{bmatrix} = \begin{bmatrix} I_a \\ I_b \\ I_c \end{bmatrix}^* = \left\{ \begin{bmatrix} 1 & 1 & 1 \\ 1 & \alpha^2 & \alpha \\ 1 & \alpha & \alpha^2 \end{bmatrix} \begin{bmatrix} I_{a0} \\ I_{a1} \\ I_{a2} \end{bmatrix} \right\}$$

$$\left([A][B] \right)^* = [A]^* [B]^*.$$

$$= \begin{bmatrix} 1 & 1 & 1 \\ 1 & \alpha^2 & \alpha \\ 1 & \alpha & \alpha^2 \end{bmatrix}^* \begin{bmatrix} I_{a0} \\ I_{a1} \\ I_{a2} \end{bmatrix}^*.$$

$$\alpha^* = \alpha^2.$$

$$(\alpha^2)^* = \alpha.$$

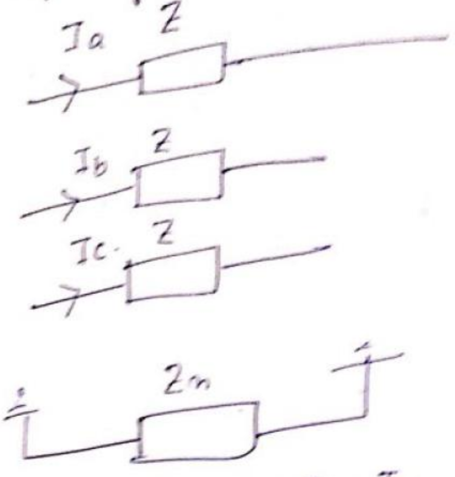
$$\begin{bmatrix} I_a \\ I_b \\ I_c \end{bmatrix} = \begin{bmatrix} 1 & 1 & 1 \\ 1 & \alpha & \alpha^2 \\ 1 & \alpha^2 & \alpha \end{bmatrix} \begin{bmatrix} I_{a0} \\ I_{a1} \\ I_{a2} \end{bmatrix}^*.$$

$$\therefore S = P + jQ = \begin{bmatrix} V_{a0} \\ V_{a1} \\ V_{a2} \end{bmatrix}^T \begin{bmatrix} 1 & 1 & 1 \\ 1 & \alpha^2 & \alpha \\ 1 & \alpha & \alpha^2 \end{bmatrix} \begin{bmatrix} 1 & 1 & 1 \\ 1 & \alpha & \alpha^2 \\ 1 & \alpha^2 & \alpha \end{bmatrix} \begin{bmatrix} I_{a0} \\ I_{a1} \\ I_{a2} \end{bmatrix}$$

$$= \begin{bmatrix} V_{a0} & V_{a1} & V_{a2} \end{bmatrix} \begin{bmatrix} 3 & 0 & 0 \\ 0 & 3 & 0 \\ 0 & 0 & 3 \end{bmatrix} \begin{bmatrix} I_{a0} \\ I_{a1} \\ I_{a2} \end{bmatrix}^*$$

$$S = P + jQ = 3 \left\{ V_{a0} I_{a0}^* + V_{a1} I_{a1}^* + V_{a2} I_{a2}^* \right.$$

Seq. imp of Symmetrical



$I_n = I_a + I_b + I_c$

Voltage drops

$V_a = I_a Z + I_n Z_n$

$= I_a Z + (I_a + I_b + I_c) Z_n$

$= I_a (Z + Z_n) + I_b Z_n + I_c Z_n$

$V_b = I_a Z_n + I_b (Z + Z_n) + I_c Z_n$

$V_c = I_a Z_n + I_b Z_n + I_c (Z + Z_n)$

Matrix form

$$\begin{bmatrix} V_a \\ V_b \\ V_c \end{bmatrix} = \begin{bmatrix} Z+Z_n & Z_n & Z_n \\ Z_n & Z+Z_n & Z_n \\ Z_n & Z_n & Z+Z_n \end{bmatrix} \begin{bmatrix} I_a \\ I_b \\ I_c \end{bmatrix}$$

• Expressing voltages and currents in seq. components

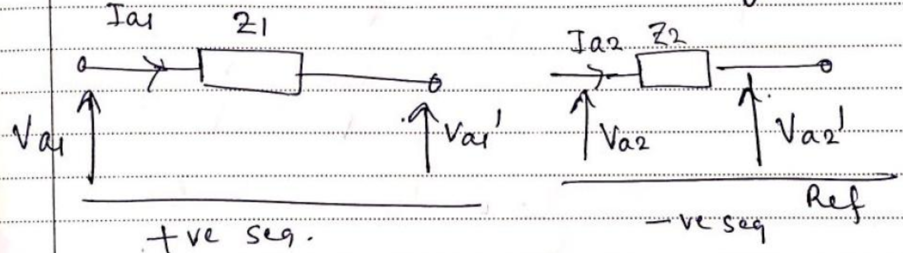
$$\begin{bmatrix} V_{a0} \\ V_{a1} \\ V_{a2} \end{bmatrix} = \frac{1}{3}\begin{bmatrix} 1 & 1 & 1 \\ 1 & \alpha & \alpha^2 \\ 1 & \alpha^2 & \alpha \end{bmatrix}\begin{bmatrix} Z+2_m & Z_m & Z_m \\ Z_m & Z+2_m & Z_m \\ Z_m & Z_m & Z+2_m \end{bmatrix}\begin{bmatrix} 1 & 1 & 1 \\ 1 & \alpha^2 & \alpha \\ 1 & \alpha & \alpha^2 \end{bmatrix}\begin{bmatrix} I_{a0} \\ I_{a1} \\ I_{a2} \end{bmatrix}$$

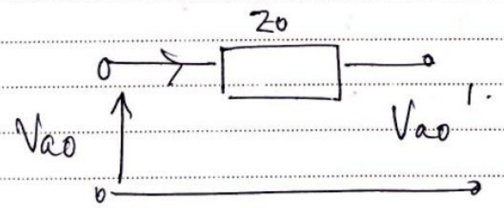
$$= \begin{bmatrix} Z+3_m & 0 & 0 \\ 0 & Z & 0 \\ 0 & 0 & Z \end{bmatrix}\begin{bmatrix} I_{a0} \\ I_{a1} \\ I_{a2} \end{bmatrix}.$$

In symmetrical circuits.

Currents of a given seq. produce voltage drops of the same sequence only!

Seq. Imp are uncoupled in sym circuit





P.u power $S_{pu} = \dfrac{3(V_{a0} I_{a0}^* + V_{a1} I_{a1}^* + V_{a2} I_{a2}^*)}{3 V_B I_B}$

$= V_{a0pu} I_{a0pu}^* + V_{a1pu} I_{a1pu}^* + V_{a2pu} I_{a2pu}^*$

3b

$$S_{pu} = V_{a0} I_{a0}^{*} + V_{a1} I_{a1}^{*} + V_{a2} I_{a2}^{*}$$

$$= (0.1 + j0.05)(0.05 - j0.02)^{*} + (0.9 + j0.2)(0.9 - j0.1$$

$$+ (0.2 + j0.1)(0.2 - j0.1)^{*}.$$

$$= 0.817 + j0.3126 \text{ p.u}$$

Next $S = S_{pu} \times S_B = (0.817 + j0.3126) \times 100$ MV

$$= 81.7 + j31.26 \text{ MVA}$$

active power $P = 81.7$ MW

$Q = 31.26$ MVAR.

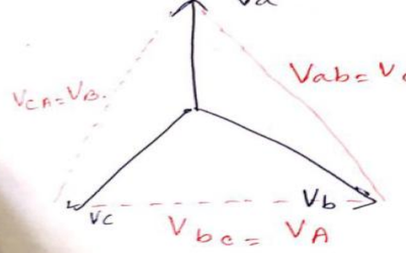
4a

a

Q3/ Relation
line voltages of a star ...

* By sequence voltages it is always meant phase v... of a star or an equivalent star connected system

* star connected system phase voltage differs from line voltage. $V_{LL} = \sqrt{3} V_P$.



Let
phase seq = ~~ABC~~ abc
$V_a, V_b, V_c \Rightarrow$ phase seq
line voltage V_{bc}, V_{ca}, and V_{ab}.

$$V_{bc} = V_c - V_b$$
$$V_{ca} = V_a - V_c$$
$$V_{ab} = V_b - V_a.$$

Let $V_{bc} = V_A$ (opposite to vertex A).
$V_{ca} = V_B$ (" " " B)
$V_{ab} = V_C$ (" " " C).

$\therefore$

$V_A = V_{bc} = V_c - V_b$

$V_B = V_{ca} = V_a - V_c.$

$V_C = V_{ab} = V_b - V_a.$

+ve seq. component of line voltages are.

$$V_{A1} = \frac{1}{3}\left(V_A + \alpha V_B + \alpha^2 V_C\right).$$

$$= \frac{1}{3}\left(V_c - V_b + \alpha\left(V_a - V_c\right) + \alpha^2\left(V_b - V_a\right)\right)$$

$$= \frac{1}{3}\left[\alpha\left[V_a + \alpha V_b + \alpha^2 V_c\right] - \alpha^2\left[V_a + \alpha V_b + \alpha^2 V_c\right]\right].$$

$$= \frac{1}{3}\left(\alpha - \alpha^2\right)\left(V_a + \alpha V_b + \alpha^2 V_c\right)$$

$$= \frac{1}{3}\left(\alpha - \alpha^2\right) \times 3 V_{a1}.$$

$\alpha - \alpha^2 = j\sqrt{3}.$

$$\therefore V_{A1} = \frac{1}{3}\left(j\sqrt{3}\right)\left(3 V_{a1}\right)$$

$$\therefore V_{A1} = j\sqrt{3} V_{a1}.$$

Hence +ve seq. component of line voltage is $\sqrt{3}$ times the +ve seq. component of phase voltage. and leads the corresponding phase voltage by 90°

The -ve seq. of line voltage is.

$$V_{A2} = \frac{1}{3}\left(V_A + \alpha^2 V_B + \alpha V_C\right).$$

$$= \frac{1}{3}\left[(V_c - V_b) + \alpha^2 (V_a - V_c) + \alpha (V_b - V_c)\right]$$

$$= \frac{1}{3}\left[\alpha^2 (V_a + \alpha^2 V_b + \alpha V_c) - \alpha (V_a + \alpha^2 V_b +\right.$$

$$= \frac{1}{3}(\alpha^2 - \alpha)(V_a + \alpha^2 V_b + \alpha V_c).$$

$$= \frac{1}{3}(-j\sqrt{3})(3 V_{a2}).$$

$$V_{A2} = -j\sqrt{3}\, V_{a2}.$$

-ve seq. component of line voltage is $\sqrt{3}$ ti the negative seq. comp. of phase voltage a lags the corresponding phase voltage by 90°.

$$V_{A2} = \frac{1}{3}\left[V_A + \alpha^2 V_B + \alpha V_C\right].$$

$$= \frac{1}{3}\left[(V_c - V_b) + \alpha^2 (V_a - V_c) + \alpha (V_b - V_c)\right]$$

$$= \frac{1}{3}\left[\alpha^2 (V_a + \alpha^2 V_b + \alpha V_c) - \alpha (V_a + \alpha^2 V_b + \alpha V_c)\right]$$

$$= \frac{1}{3}(\alpha^2 - \alpha)\left[V_a + \alpha^2 V_b + \alpha V_c\right].$$

$$= \frac{1}{3}(-j\sqrt{3})(3 V_{a2}) =$$

$$V_{A2} = -j\sqrt{3}\, V_{a2}.$$

Finally the zero seq. component of line voltage.

$$V_{A0} = \frac{1}{3}(V_A + V_B + V_C).$$

$$= \frac{1}{3}\left[(V_c - V_b) + (V_a - V_c) + (V_b - V_a)\right]$$

$$= 0$$

$V_{A0} = 0.$ ⇒ zero seq. compoment of line voltage is zero.

4b

Solution The positive sequence line voltage

$$V_{A1} = j\sqrt{3}\, V_{a1} = \sqrt{3} \times 230 \times \angle(30^\circ + 90^\circ)$$

$$V_{A1} = 398.37 \angle 120^\circ \text{ V.}$$

The negative sequence line voltage is

$$V_{A2} = -j\sqrt{3}\, V_{a2} = \sqrt{3} \times 60 \angle (60^\circ - 90^\circ)$$

$$= 103.92 \angle -30^\circ \text{ V} = (90 - j51.96) \text{ V}$$

Zero sequence component of line voltage is 0.

$$\therefore V_A = V_{A0} + V_{A1} + V_{A2}$$

$$= 312.72 \angle 110^\circ \text{ V}$$

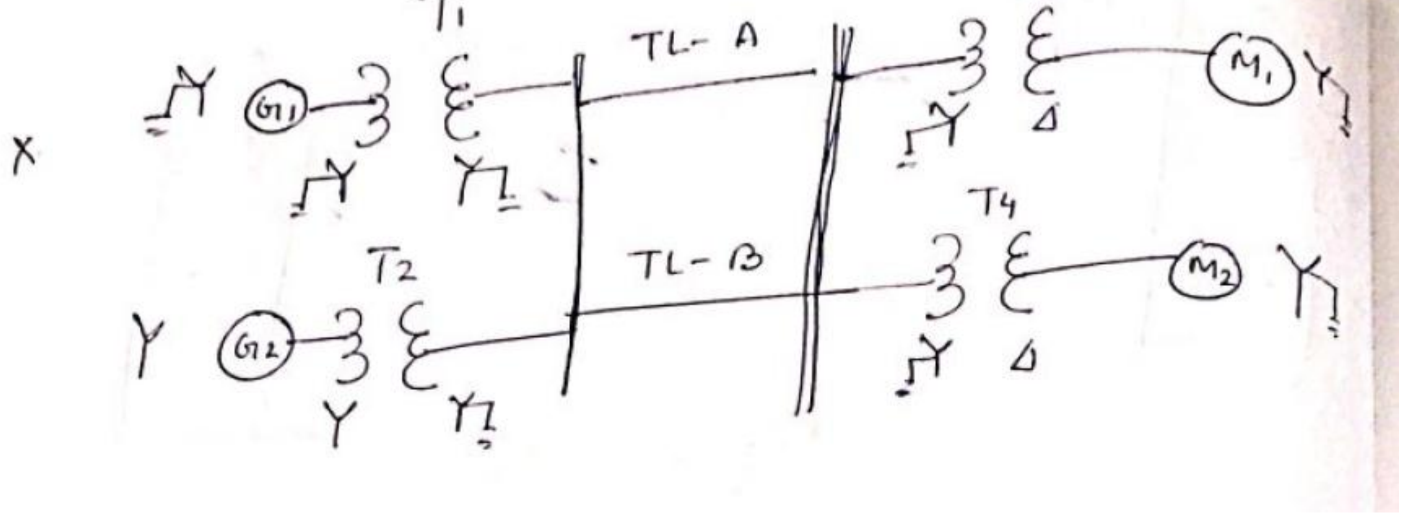
$$V_B = V_{A0} + a^2 V_{A1} + a V_{A2}$$

$$= 411.7 \angle 14.62^\circ \text{ V.}$$

$$V_C = V_{A0} + a V_{A1} + a^2 V_{A2}$$

$$= 451.13 \angle -126^\circ \text{ V.}$$

5.



Base values.

Base power for the entire system is 200 MVA

Base voltage on the transmission lines = 220 kV.

" " " " G_1 & G_2 = $220 \times \frac{11}{220} = 11$ kV.

" " " " M_1 and M_2 = $220 \times \frac{6.9}{220} = 6.6$ kV.

Reactance of G_1 and G_2

$$X_1 = X_2 = j0.2 \times \frac{(MVA)_{B,new}}{(MVA)_{B,old}} \times \frac{KV^2_{B,old}}{KV^2_{B,new}}$$

$$= j0.2 \times \frac{200}{104} \times \frac{11.8^2}{11^2} = j0.44 \text{ p.u.}$$

$X_0 = j0.1 \times \frac{200}{104} \times \frac{11.8^2}{11^2} = j0.22$ p.u.

Reactances of transformers T_1 and T_2

$X_1 = X_2 = X_0 = j0.1 \times \frac{200}{125} \times \frac{11^2}{11^2} = j0.16$ p.u.

Reactance of T.L.

$X_1 = X_2 = X(\Omega) \times \frac{(MVA)_{B,new}}{KV^2_B}$

$= j30 \times \frac{200}{220^2} = j0.124$ p.u.

$X_0 = j60 \times \frac{200}{220^2} = j0.248$ p.u.

Reactances of transformers T_3 and T_4:

$X_1 = X_2 = X_0 = j0.12 \times \frac{200}{120} \times \frac{230^2}{220^2} = j0.22$ p.

Reactances of Motor M_1:

$X_1 = X_2 = j0.3 \times \frac{200}{175} \times \frac{6.6^2}{6.6^2} = j0.342$

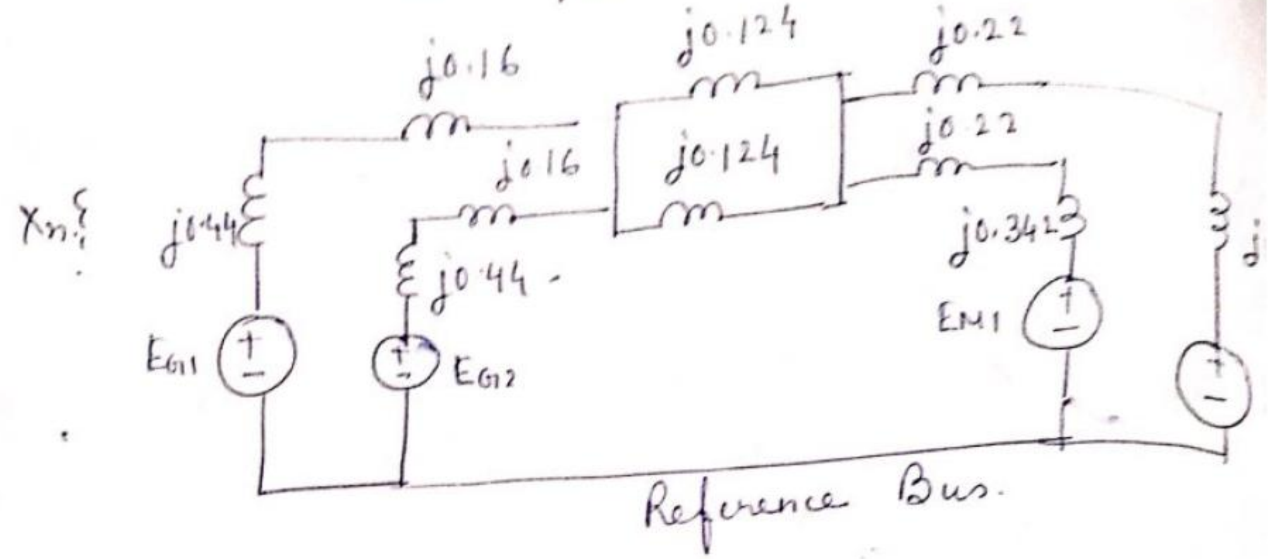
$X_0 = j0.15 \times \frac{200}{175} \times \frac{6.6^2}{6.6^2} = j0.171$ p.u.

actances of motor M_2:

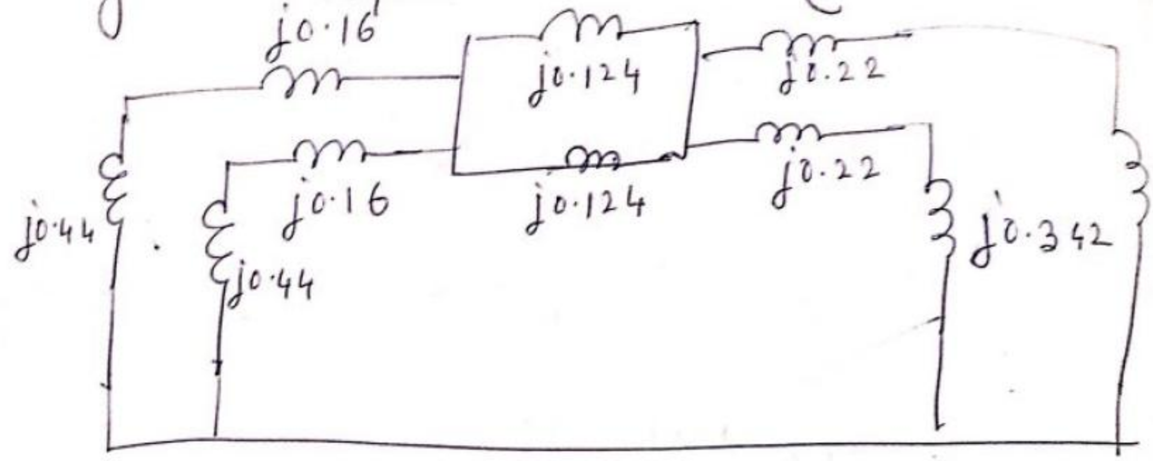
$= X_2 = j0.3 \times \frac{200}{50} \times \frac{6.9^2}{6.6^2} = j1.31$ p.u.

$X_0 = j0.1 \times \frac{200}{50} \times \frac{6.9^2}{6.6^2} = j0.4372$ p.u.

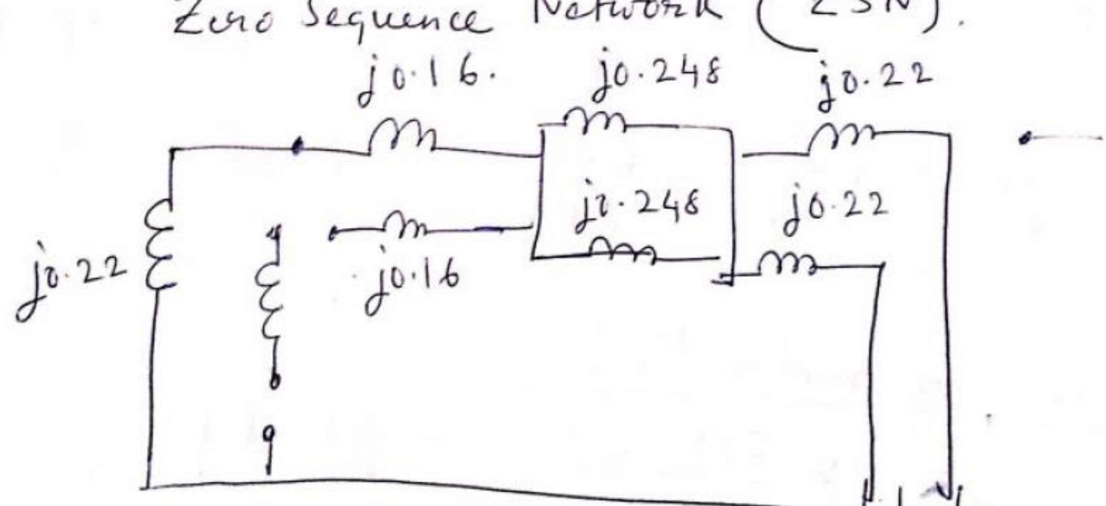
Positive Sequence Network (PSN).



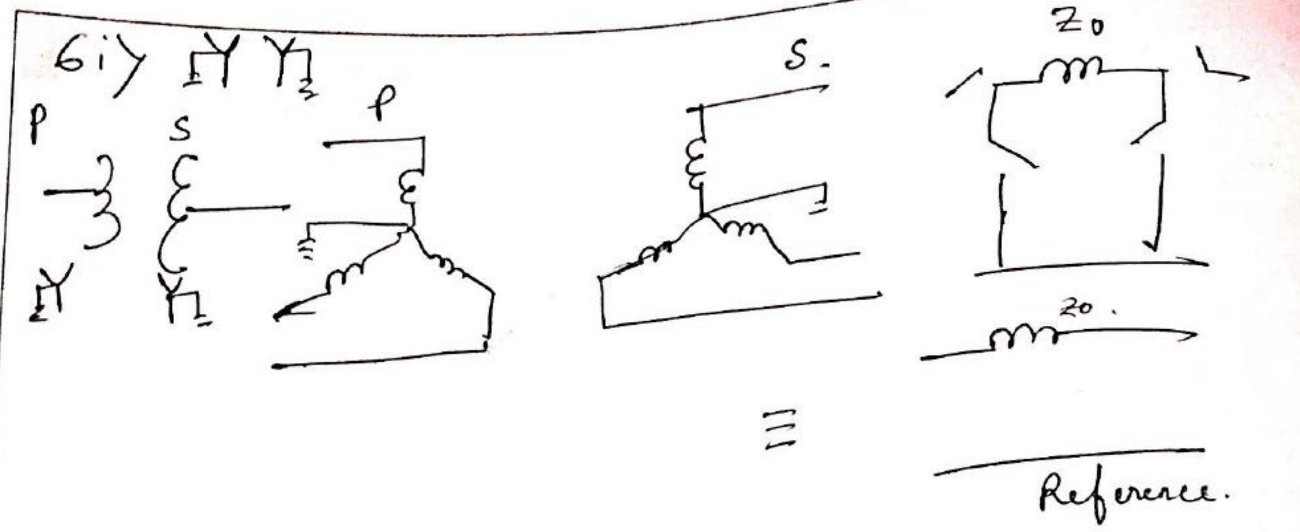
Negative Sequence Network (NSN).



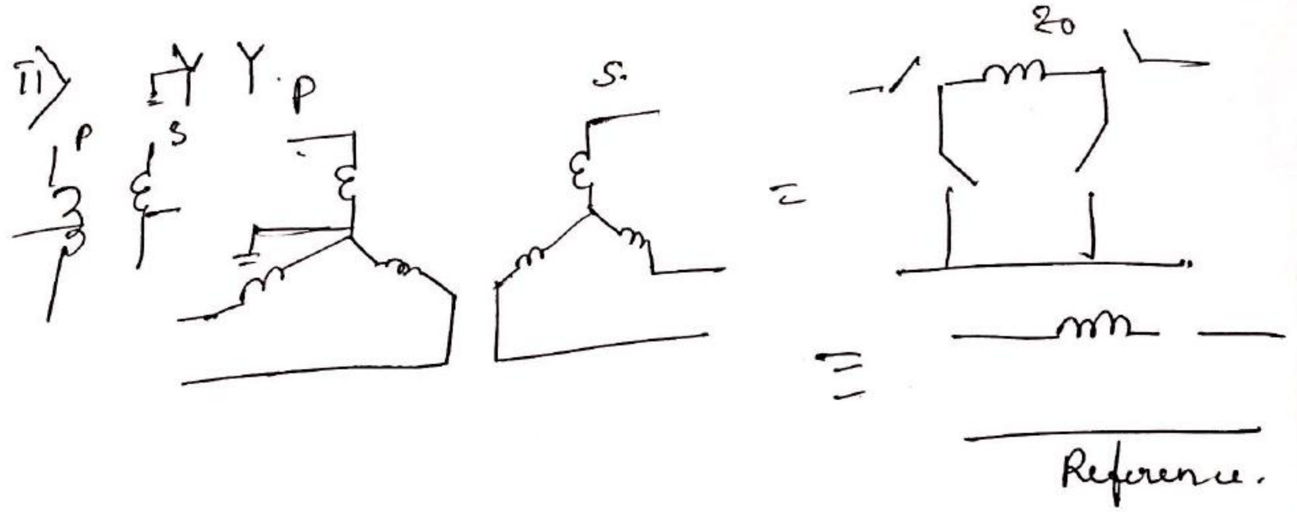
Zero Sequence Network (ZSN).



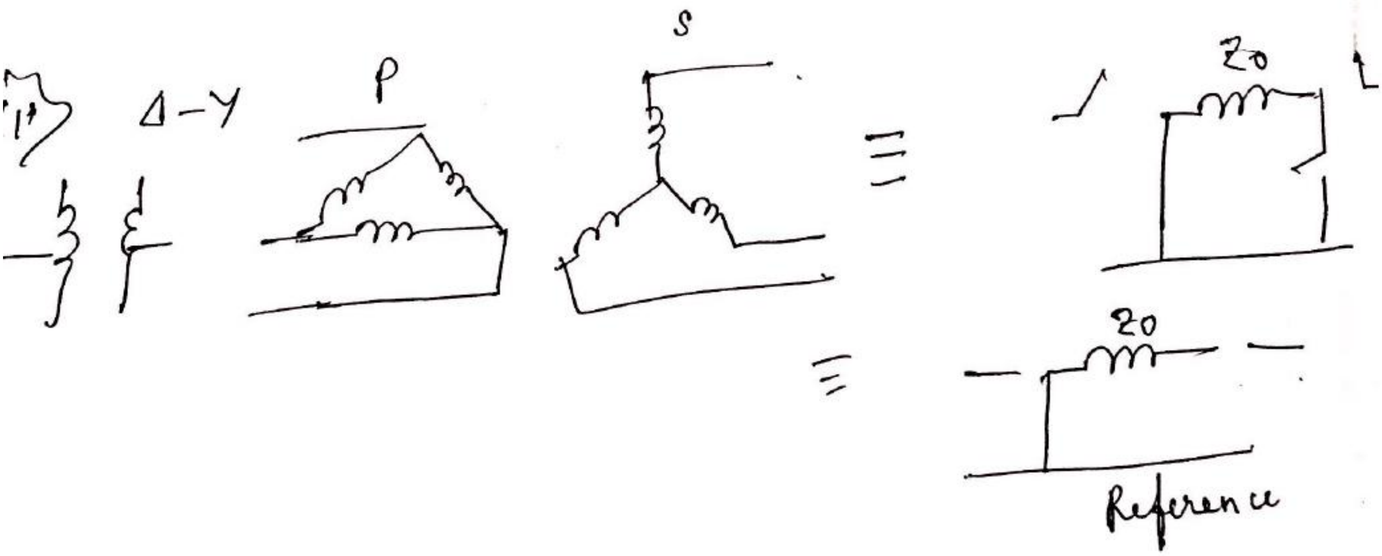
6i) Y Y



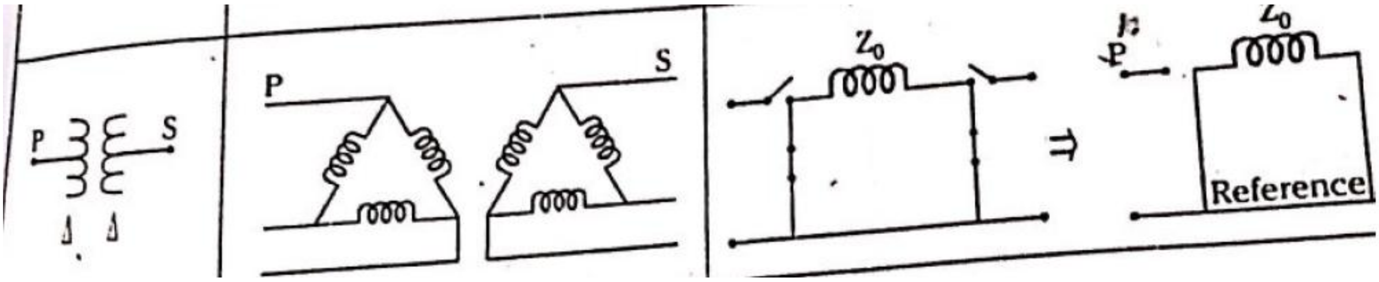
ii) Y Y



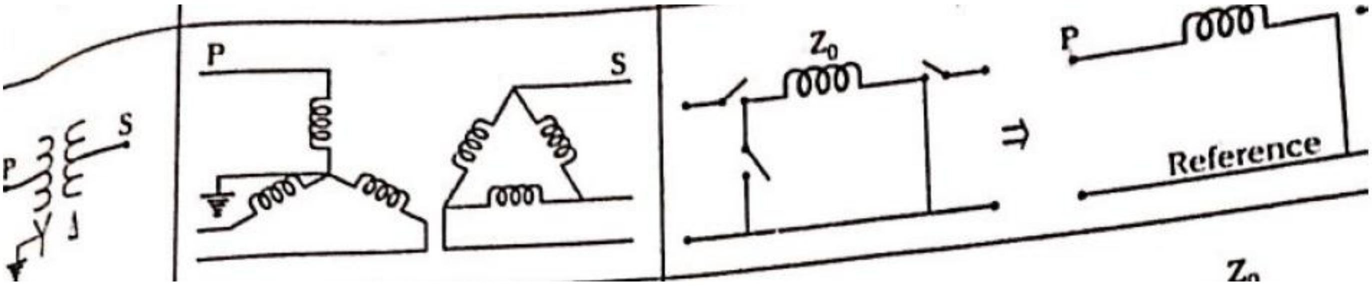
iii) Δ-Y



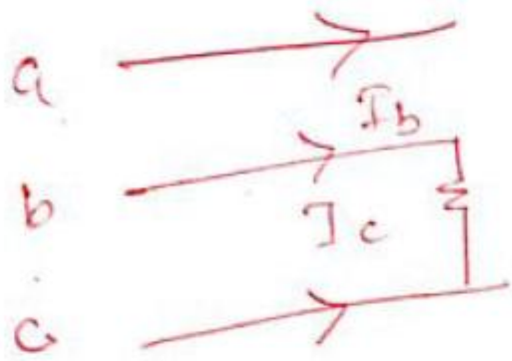
iv



v.



6b



Solution $I_a = 0$.

$$I_b = -I_c = \frac{100\ \text{KVA}}{3} = 33.33\ A.$$

$$I_a = 0 \angle 0^\circ\ A$$

$$I_b = 33.33 \angle 0^\circ A$$

$$I_c = -33.33 \angle 0^\circ A = 33.33 \angle 180^\circ\ A$$

Symmetrical components of line currents:

$$I_{a0} = \frac{1}{3}\left(I_a + I_b + I_c\right).$$

$$= \frac{1}{3}\left(0 + 33.33 - 33.33\right) = 0A$$

$$I_{a1} = \frac{1}{3}\left(I_a + aI_b + a^2 I_c\right).$$

$$= 19.24 \angle 90^\circ A$$

$$I_{a2} = \frac{1}{3}\left(I_a + a^2 I_b + aI_c\right).$$

$$= \frac{1}{3}\left(0 + 33.33 \angle 240^\circ + 33.33 \angle 300^\circ\right).$$

$$= 19.24 \angle -90^\circ A$$

7.

Solution: Base power = 25 MVA,
Base voltage = 11 KV. (Generator)

Base voltage of T.L = $\cancel{11 \times \frac{10.8}{121}}$ $11 \times \frac{121}{10.8} = 123.24$ V.

" " of motors = $123.24 \times \frac{10.8}{121} = 11$ KV.

Generator

+ve seq reactance = -ve seq reactance = $j0.2 \times \frac{25}{25} \times \frac{11^2}{11^2} = j0.2$ p.u.

Transformer

+ve seq = - seq reactance = zero seq reactance

$= j0.1 \times \frac{25}{30} \times \frac{10.8^2}{11^2} = j0.08$ p.u.

T.L

+ve seq. reactance = -ve seq. reactance = $j100 \times \frac{25}{123.24^2}$

$= j0.16$ p.u

Zero seq. reactance = $j300 \times \frac{25}{123.24^2} = j0.49$ p.u

M1

+ve seq. reactance = -ve seq. reactance

$= j0.25 \times \frac{25}{15} \times \frac{10^2}{11^2} = j0.344$ p.u

M2

+ve seq. reactance = -ve seq. reactance

$= j0.25 \times \frac{25}{7.5} \times \frac{10^2}{11^2} = j0.69$ p.u ~~j0.091~~ p.u

Zero seq. reactance of gen ~~and motor2~~:

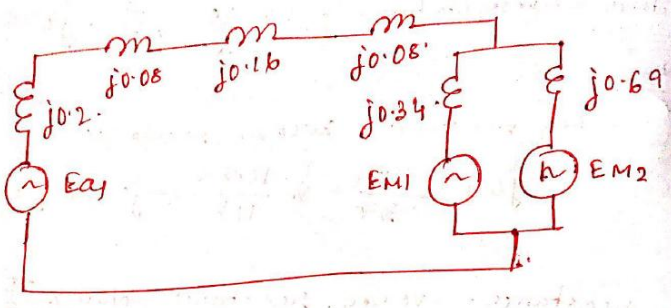
is $0.06 + 3 \times 2.5 \times \frac{25}{11^2} = j1.55$ p.u.

$+ j0.06$ p.u

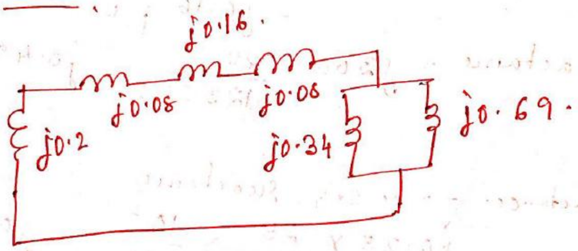
zero seq. ...

(7) $j0.06 + 3 \times 2.5 \times \frac{25}{11^2} = j0.06 + j1.55$

positive seq. network (PSN).



NSN



ZSN.