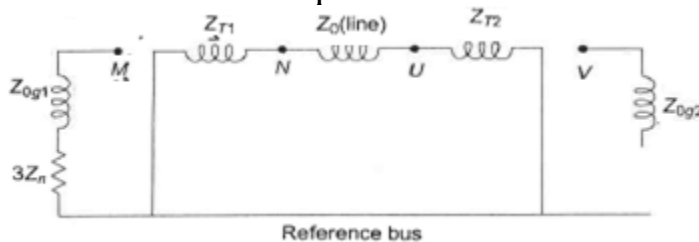




EX1. For the power system whose one-line diagram is shown in Fig. sketch the zero sequence network

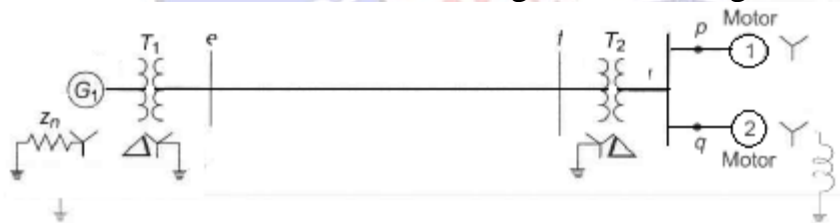


Solution The zero sequence network is drawn in Fig.



Ex2. A 25 MVA, 11 kV, three-phase generator has a sub transient reactance of 20%. The generator supply two motors over transmission line with transformers at both ends as shown in the one-line diagram of Fig. The motors have rated inputs of 15 and 7.5 MVA, both 10 kV with 25% sub transient reactance. The three-phase transformers are both rated 30 MVA, 10.8/121 kV, connection Δ -Y with leakage reactance of 10% of each. The series reactance of the line is 100 ohms. Draw the positive and negative sequence networks of the system with reactance marked in per unit.

Assume that the negative sequence reactance of each machine is equal to its sub transient reactance. Omit resistances. Select generator rating as base in the generator circuit.



Sol.:

$$\text{Transmission line voltage base} = 11 \times \frac{121}{10.8} = 11 \text{ kV}$$

$$\text{Motor voltage base} = 123.2 \times \frac{10.8}{121} = 11 \text{ kV}$$

The reactances of transformers line and motors are converted to pu values on appropriate bases as follows

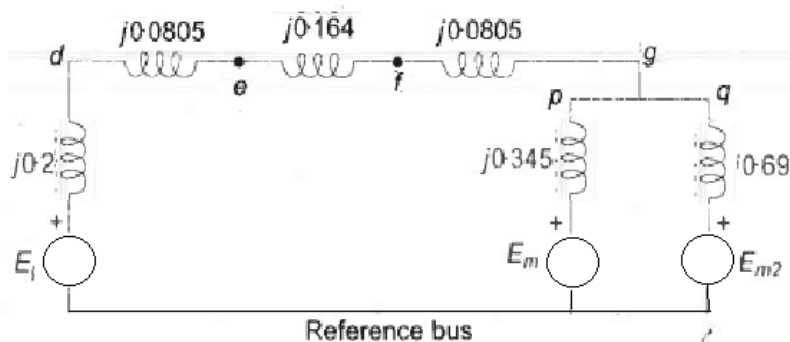
$$\text{Transformer reactance} = 0.1 \times \frac{25}{30} \times \left(\frac{10.8}{11}\right)^2 = 0.0805 \text{ pu}$$

$$\text{Line reactance} = \frac{100 \times 25}{(123.2)^2}$$

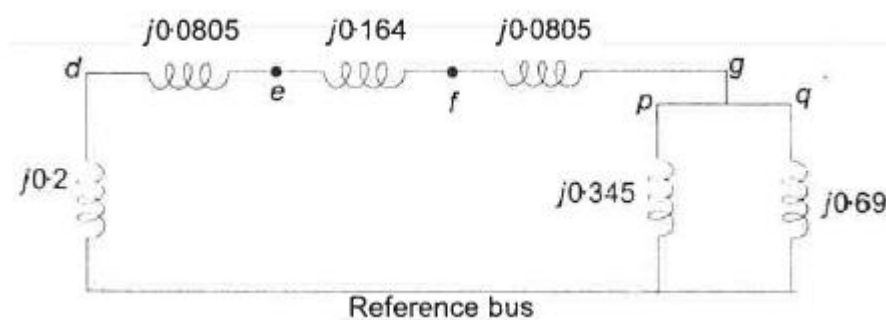
$$\text{Reactance of motor 1} = 0.25 \times \frac{25}{15} \times \left(\frac{10}{11}\right)^2 = 0.345 \text{ pu}$$

$$\text{Reactance of motor 2} = 0.25 \times \frac{25}{7.5} \times \left(\frac{10}{11}\right)^2 = 0.69 \text{ pu}$$

Positive sequence network is



Negative sequence network is



Ex3. Draw the zero-sequence network for the system described in Example 2. Assume zero sequence reactance for the generator and motors of 0.06 per unit. Current limiting reactors of 2.5 ohms each are connected in the neutral of the generator and motor No. 2. The zero-sequence reactance of the transmission line is 300 ohms.

Sol.:

Solution The zero sequence reactance of the transformer is equal to its positive sequence reactance. Hence

Transformer zero sequence reactance: 0.0805 pu

Generator zero sequence reactance : 0.06 pu

$$\text{Zero sequence reactance of motor 1} = 0.06 \times \frac{25}{15} \times \left(\frac{10}{11}\right)^2 = 0.082 \text{ pu}$$

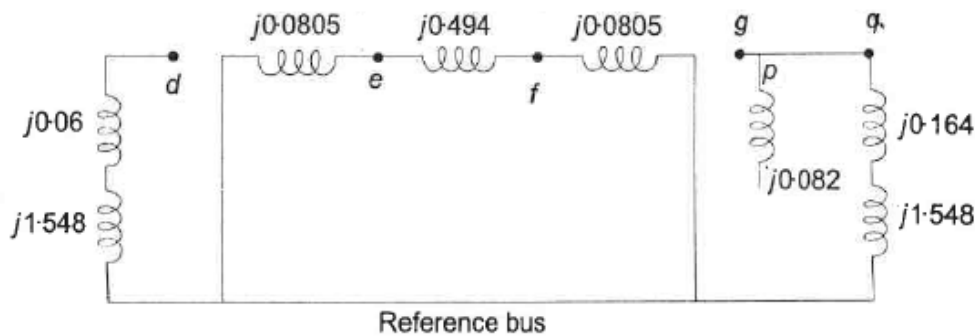
$$\text{Zero sequence reactance of motor 2} = 0.06 \times \frac{25}{7.5} \times \left(\frac{10}{11}\right)^2 = 0.164 \text{ pu}$$

$$\text{Reactance of current limiting reactors} = \frac{2.5 \times 25}{11^2} = 0.516$$

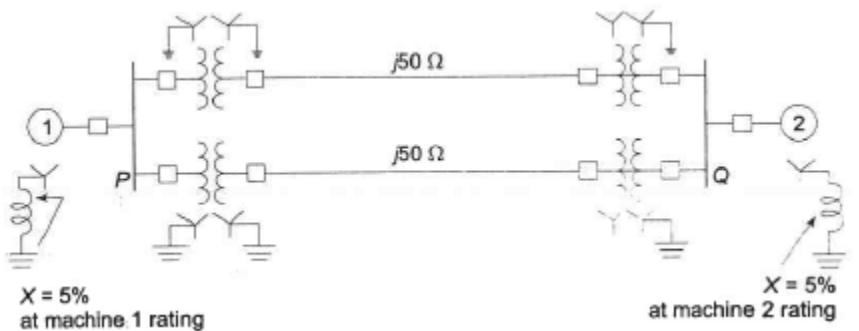
Reactance of current limiting reactor included in zero sequence network' = 3 x 0.516 = 1.548 pu

$$\text{Zero sequence reactance of transmission line} = \frac{300 \times 25}{123.2^2} = 0.494 \text{ pu}$$

The zero sequence network is shown in Fig.



Q1/ Draw the positive, negative and zero sequence impedance networks for the power system of Fig. Choose a base of 50 MVA, 220 kV in the 50Ω transmission lines, and mark all reactance in pu. The ratings of the generators and transformers are:
 G1: 25 MVA, 11 kV, $X'' = 20\%$
 G2: 25 MVA, 11 kV, $X'' = 20\%$
 Three-phase transformer (each): 20 MVA, 11Y /220Y kV, $X = 15\%$
 The negative sequence reactance of each synchronous machine is equal to its sub transient reactance. The zero-sequence reactance of each machine is 8%. Assume that the zero-sequence reactance of lines are 250% of their positive sequence reactance.



Q2/ For the power system of Fig. draw the positive, negative and zero sequence networks. The generators and transformers are rated as follows:
 Generator1 : 25 MVA, 11 kV, $X'' = 0.2$, $X_2 = 0.15$, $X_0 = 0.03$ pu
 Generator2 : 15 MVA, 11 kV, $X'' = 0.2$, $X_2 = 0.15$, $X_0 = 0.05$ pu
 Synchronous Motor 3: 25 MVA, 11 kV, $X'' = 0.2$, $X_2 = 0.02$, $X_0 = 0.1$ pu
 Transformer 1: 25 MVA, 11Δ/120 Y kV, $X = 10\%$
 Transformer 2: 12.5 MVA, 11Δ/120 Y kV, $X = 10\%$
 Transformer 3: 10 MVA, 120Y/11 Y kV, $X = 10\%$
 Choose a base of 50 MVA, 11 kV in the circuit of generator 1.

