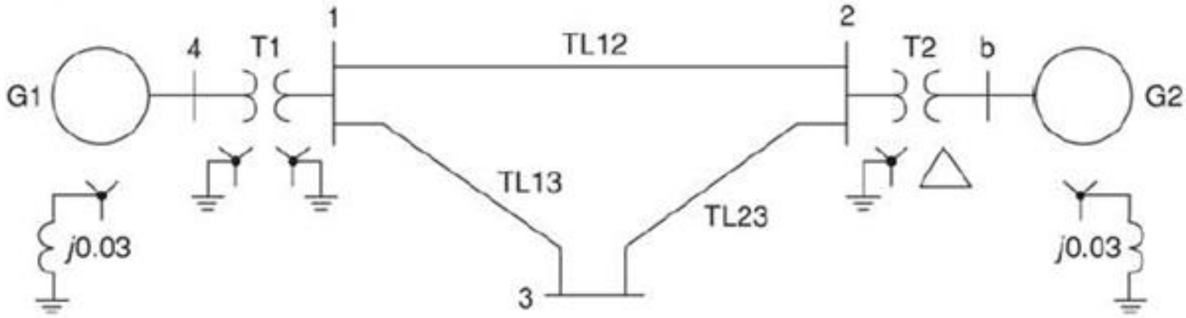
Çankaya University
Electrical & Electronics Engineering Department
EE 465 Power Systems Homework # 4

1-

Equipment ratings and per-unit reactances for the system shown in Figure are given as follows:



Synchronous generators:

G1	100 MVA	25 kV	$X_1 = X_2 = 0.2$	$X_0 = 0.05$
G2	100 MVA	13.8 kV	$X_1 = X_2 = 0.2$	$X_0 = 0.05$

Transformers:

T1	100 MVA	25/230 kV	$X_1 = X_2 = X_0 = 0.05$
T2	100 MVA	13.8/230 kV	$X_1 = X_2 = X_0 = 0.05$

Transmission lines:

TL12	100 MVA	230 kV	$X_1 = X_2 = 0.1$	$X_0 = 0.3$
TL13	100 MVA	230 kV	$X_1 = X_2 = 0.1$	$X_0 = 0.3$
TL23	100 MVA	230 kV	$X_1 = X_2 = 0.1$	$X_0 = 0.3$

Using a 100-MVA, 230-kV base for the transmission lines, draw the per-unit sequence networks and reduce them to their Thévenin equivalents, "looking in" at bus 3. Neglect Δ–Y phase shifts. Compute the fault currents for a bolted three-phase fault at bus 3.

2-

A 500-MVA, 13.8-kV synchronous generator with $X_d'' = X_2 = 0.20$ and $X_0 = 0.05$ per unit is connected to a 500-MVA, 13.8-kV Δ/500-kV Y transformer with 0.10 per-unit leakage reactance. The generator and transformer neutrals are solidly grounded. The generator is operated at no-load and rated voltage, and the high-voltage side of the transformer is disconnected from the power system. Compare the subtransient fault currents for the following bolted faults at the transformer high-voltage terminals: three-phase fault, single line-to-ground fault, line-to-line fault, and double line-to-ground fault.

Prof. Dr. İres İSKENDER

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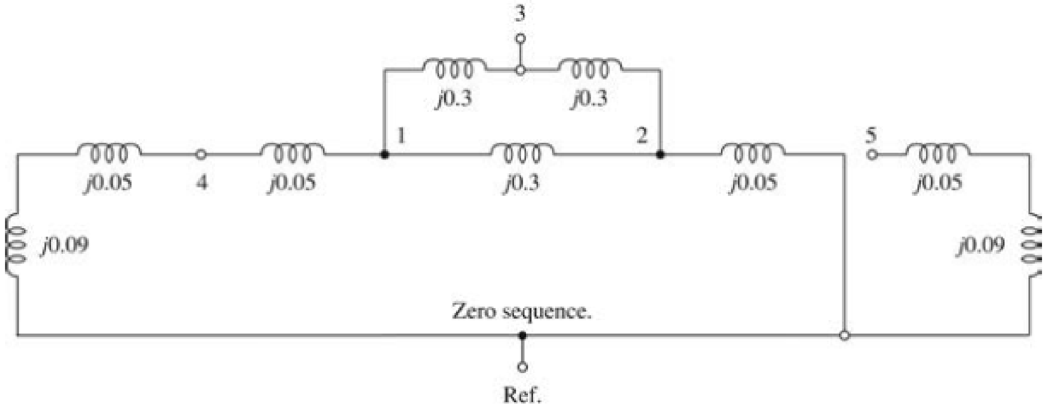
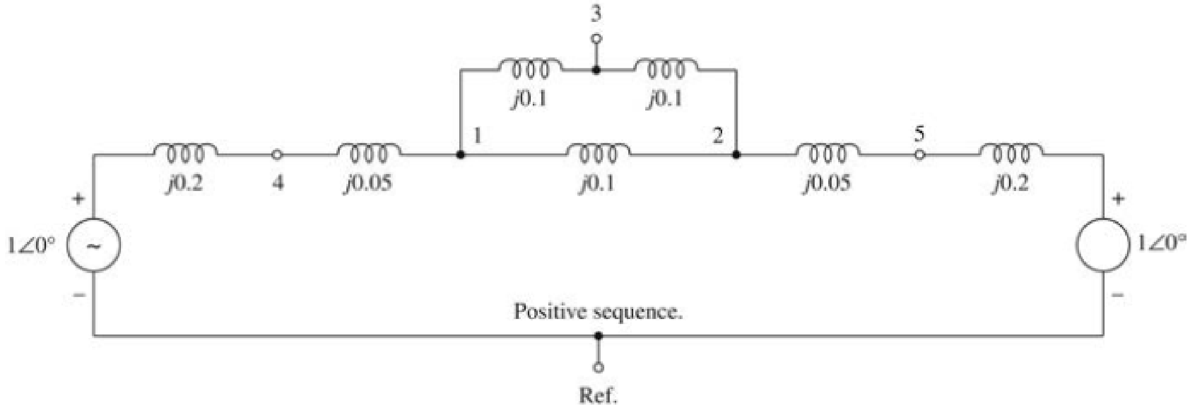
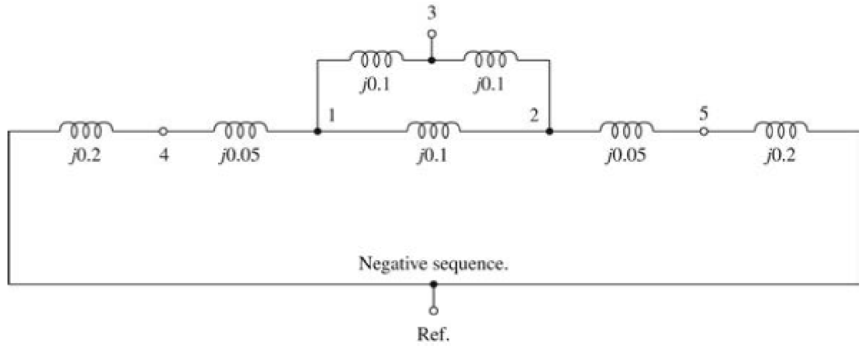
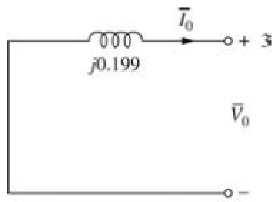
The zero-,positive-, and negative sequence networks are shown below:

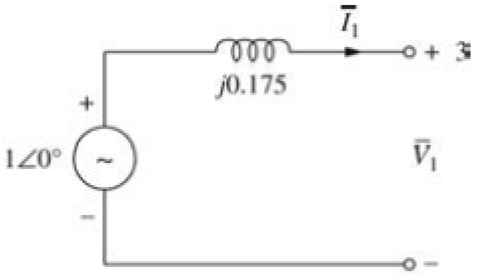


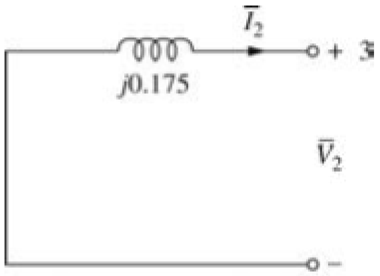




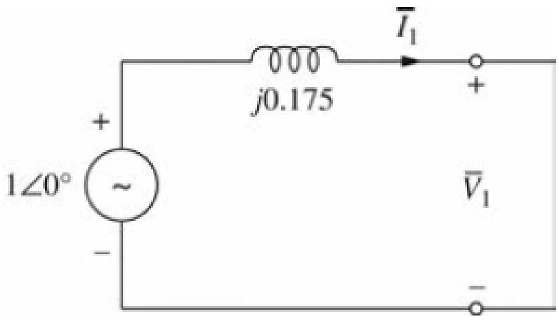
Using delta-wye transformation and series-parallel combinations, thévenin equivalents looking into bus 3 are shown below:







For a bolted 3-phase fault at bus 3,



$\bar{V}_1 = 0$; Also $\bar{V}_2 = \bar{V}_0 = 0$

$\bar{I}_0 = 0; \bar{I}_2 = 0$

$$\bar{I}_1 = \frac{1\angle 0^\circ}{j0.175} = -j5.71$$

The fault current is 5.71 pu.

$$\begin{bmatrix} \bar{I}_a \\ \bar{I}_b \\ \bar{I}_c \end{bmatrix} = \begin{bmatrix} 1 & 1 & 1 \\ 1 & a^2 & a \\ 1 & a & a^2 \end{bmatrix} \begin{bmatrix} 0 \\ -j5.71 \\ 0 \end{bmatrix} = \begin{bmatrix} 5.71\angle -90^\circ \\ 5.71\angle 150^\circ \\ 5.71\angle 30^\circ \end{bmatrix}$$

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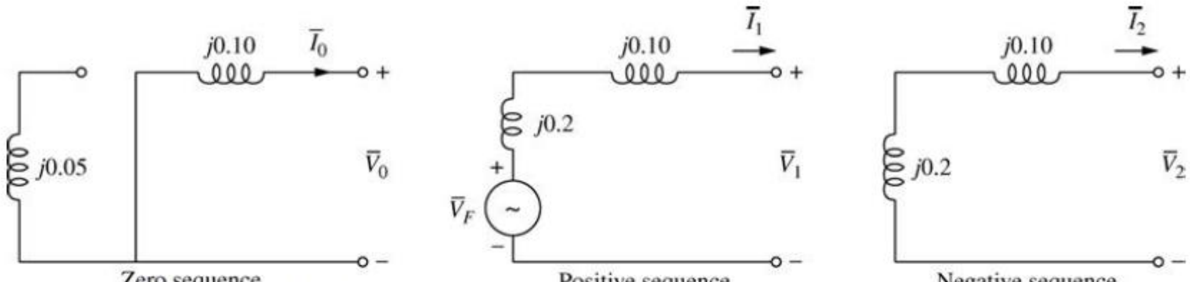

------ $\sqrt{3}\,V_{baseH}$ $\sqrt{3}\,(500)$

Three- phase fault:

$$\bar{I}_0 = \bar{I}_2 = 0 \quad \bar{I}_1 = \frac{\bar{V}_F}{\bar{Z}_1} = \frac{1.0\angle 0^\circ}{j0.30} = -j3.333\,\text{per unit}$$

$$\bar{I}_a'' = \bar{I}_1 = -j3.333\,\text{per unit} = \underline{\underline{-j1.925}}\,\text{kA}$$

Single line-to-ground fault:

$$\bar{I}_0 = \bar{I}_1 = \bar{I}_2 = \frac{\bar{V}_F}{\bar{Z}_0 + \bar{Z}_1 + \bar{Z}_2} = \frac{1.0\angle 0^\circ}{j(0.1+0.3+0.3)} = -j1.429\,\text{per unit}$$

$$\bar{I}_a'' = 3\bar{I}_0'' = -j4.286\,\text{per unit} = \underline{\underline{-j2.474}}\,\text{kA}$$

Line-to-line fault:

$$\bar{I}_0 = 0 \quad \bar{I}_1 = -\bar{I}_2 = \frac{\bar{V}_F}{\bar{Z}_1 + \bar{Z}_2} = \frac{1.0\angle 0^\circ}{j(0.3+0.3)} = -j1.667\,\text{per unit}$$

$$\bar{I}_b'' = (a^2 - a)\bar{I}_1 = (a^2 - a)(-j1.667) = 2.887\angle 180^\circ\,\text{per unit}$$

$$\bar{I}_b'' = \underline{\underline{1.667\angle 180^\circ}}\,\text{kA}$$

Double line-to-ground fault:

$$\bar{I}_1 = \frac{\bar{V}_F}{\bar{Z}_1 + \bar{Z}_2 \| \bar{Z}_0} = \frac{1.0\angle 0^\circ}{j(0.3 + 0.3\|0.1)} = \frac{1.0}{j0.375} = -j2.667 \text{ per unit}$$

$$\bar{I}_2 = -\bar{I}_1\left(\frac{Z_0}{Z_0 + Z_2}\right) = (j2.667)\left(\frac{.1}{.4}\right) = j0.667 \text{ per unit}$$

$$\bar{I}_0 = -\bar{I}_1\left(\frac{Z_2}{Z_0 + Z_2}\right) = (j2.667)\left(\frac{.3}{.4}\right) = j2.0 \text{ per unit}$$

$$\bar{I}''_B = \bar{I}_c + a^2\bar{I}_1 + a\bar{I}_2 = 2.0\angle 90^\circ + 2.667\angle 150^\circ + .667\angle 210^\circ = 4.163\angle 134^\circ \text{ per unit}$$

$$= \underline{\underline{2.404}}\angle 134^\circ \text{ kA}$$