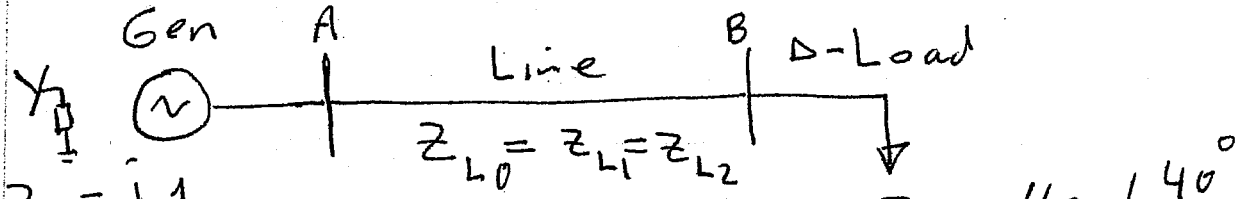
Example 2 [examples 8-5, 6 / Glover]

Consider the system shown by the single-line-diag as:



$Z_{G0} = j\,1$

$Z_{G1} = j\,15$

$Z_{G2} = j\,3$

$Z_n = j\,10$

$E_G = 480 \angle 0^\circ$; LL ; internal voltage

a) Draw the sequence networks and find the sequence currents and phase currents.

b) Assume the generator is operating in unbalance condition with E_{G0}, E_{G1}, E_{G2}. The terminal voltage is given by:

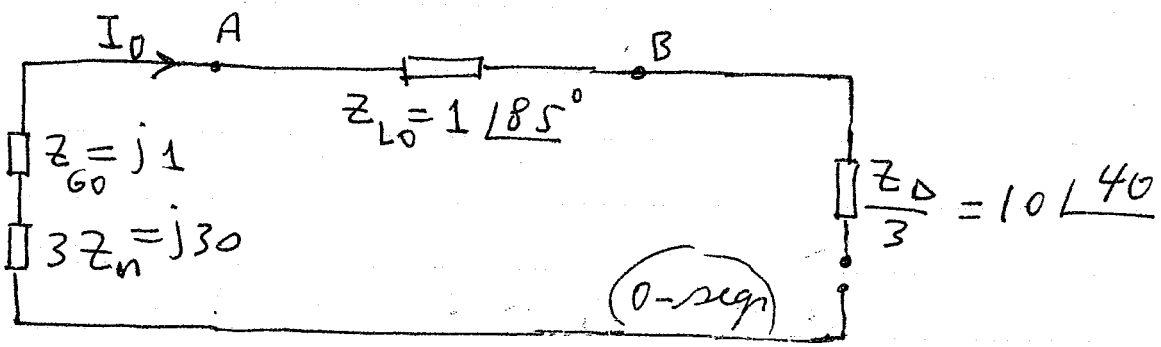
$$\begin{bmatrix} V_{aA} \\ V_{bA} \\ V_{cA} \end{bmatrix} = \begin{bmatrix} 277 \angle 0^\circ \\ 260 \angle -120^\circ \\ 295 \angle 115^\circ \end{bmatrix}$$; unbalance voltage

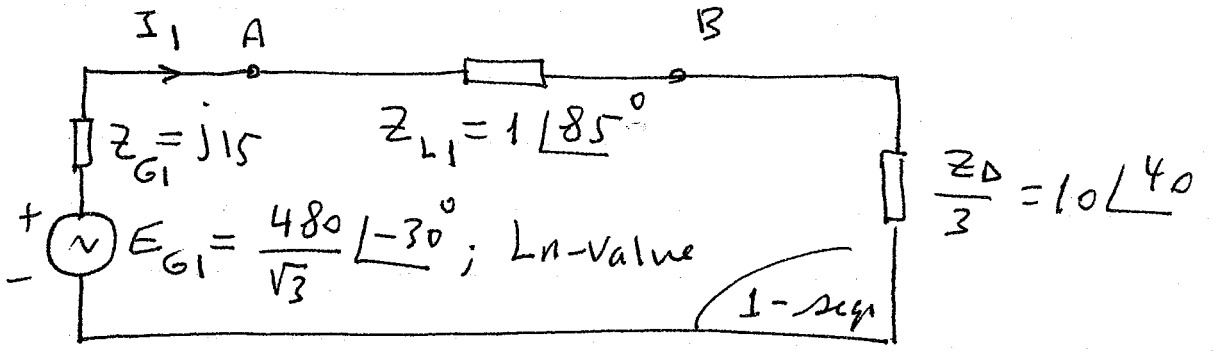
now, find the sequence currents through the sequence networks and the phase currents I_a, I_b, I_c.

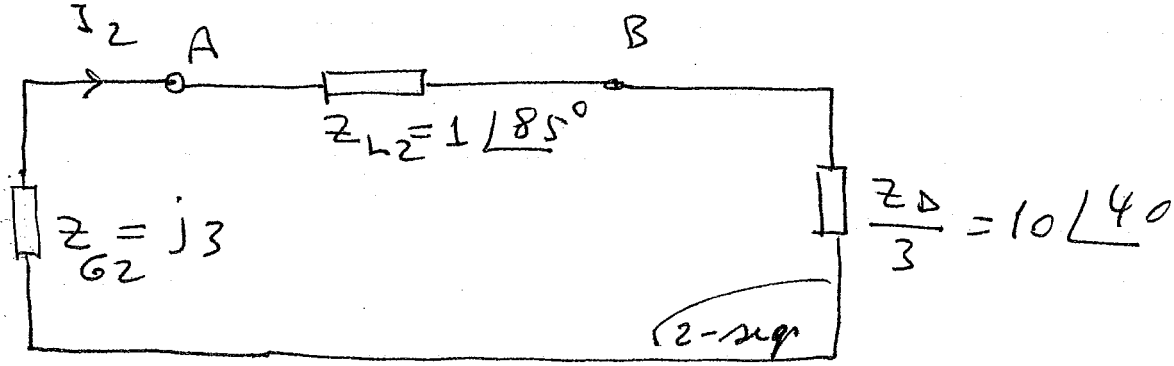
c) Find E_{G0}, E_{G1}, and E_{G2}.

Solution [Example 2]

a) The sequence networks are obtained by connecting seq ckt's of all components together:







$\Rightarrow$

$I_0 = 0$; since there is no source in that ckt and/or the ckt is open.

$I_1 = E_{G1} / [Z_{G1} + Z_{L1} + Z_\Delta/3] = \cdots = 25.83\angle -73.78^\circ$

$I_2 = 0$; since there is no source in this ckt

(over)

Now,

$$\begin{bmatrix} I_a \\ I_b \\ I_c \end{bmatrix} = \begin{bmatrix} 1 & 1 & 1 \\ 1 & a^2 & a \\ 1 & a & a^2 \end{bmatrix} \begin{bmatrix} I_0 \\ I_1 \\ I_2 \end{bmatrix}$$

$$= \cdots = \begin{bmatrix} I_1 \\ a^2 I_1 \\ a I_1 \end{bmatrix} = \begin{bmatrix} 25.83 \angle -73.78 \\ 25.83 \angle -73.78 - 120 \\ 25.83 \angle -73.78 + 120 \end{bmatrix}$$

which gives a 3-phase balanced current (as expected)

b) In this case we are assuming for some reason the voltage at generator terminal is not balanced; the phase-values are given.

- Let's find the seq-values of the 3-ϕ voltage at terminal A:

$$\begin{bmatrix} V_{0A} \\ V_{1A} \\ V_{2A} \end{bmatrix} = \frac{1}{3} \begin{bmatrix} 1 & 1 & 1 \\ 1 & a & a^2 \\ 1 & a^2 & a \end{bmatrix} \begin{bmatrix} V_{aA} \\ V_{bA} \\ V_{cA} \end{bmatrix}$$

$\Rightarrow$

$$V_{0A} = \frac{1}{3}(V_{aA} + V_{bA} + V_{cA}) = \cdots = 15.91 \angle 62.11^\circ$$

$$V_{1A} = \frac{1}{3}(V_{aA} + a V_{bA} + a^2 V_{cA}) = \cdots = 277.1 \angle -1.7$$

$$V_{2A} = \frac{1}{3}(V_{aA} + a^2 V_{bA} + a V_{cA}) = \cdots = 9.22 \angle 216.59^\circ$$

(b) - [continued]

Now, use these values in the seq-networks:

>> $I_0 = 0$; since the ckt is open

>> $I_1 = \dfrac{V_{1A}}{Z_{L_1} + \frac{Z_\Delta}{3}} = \cdots = 25.82 \angle -45.55^\circ$

>> $I_2 = \dfrac{V_{2A}}{Z_{L_2} + \frac{Z_\Delta}{3}} = \cdots = 0.86 \angle 172.81^\circ$

using the above sequence currents, we find the phase currents:

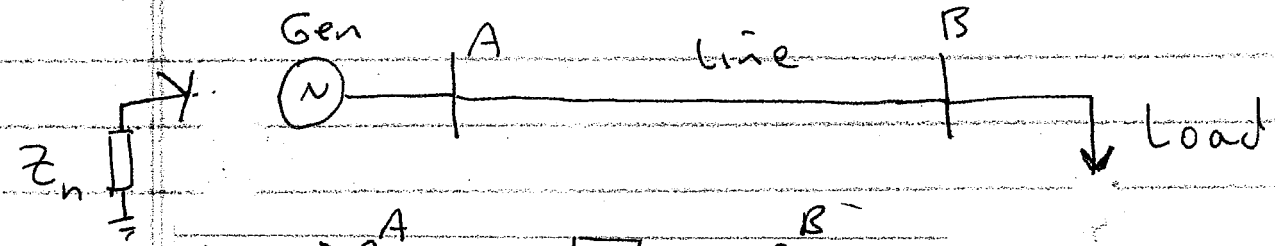
$$\begin{bmatrix} I_a \\ I_b \\ I_c \end{bmatrix} = \begin{bmatrix} 1 & 1 & 1 \\ 1 & a^2 & a \\ 1 & a & a^2 \end{bmatrix} \begin{bmatrix} I_0 \\ I_1 \\ I_2 \end{bmatrix}$$; I_0, I_1, I_2 found above

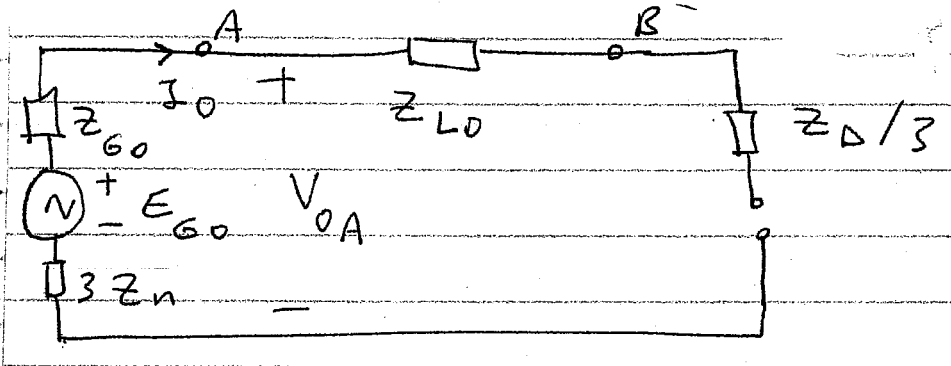
$$\vdots = \begin{bmatrix} 25.15 \angle -46.76^\circ \\ 25.71 \angle 196.34^\circ \\ 26.62 \angle 73.77^\circ \end{bmatrix}$$

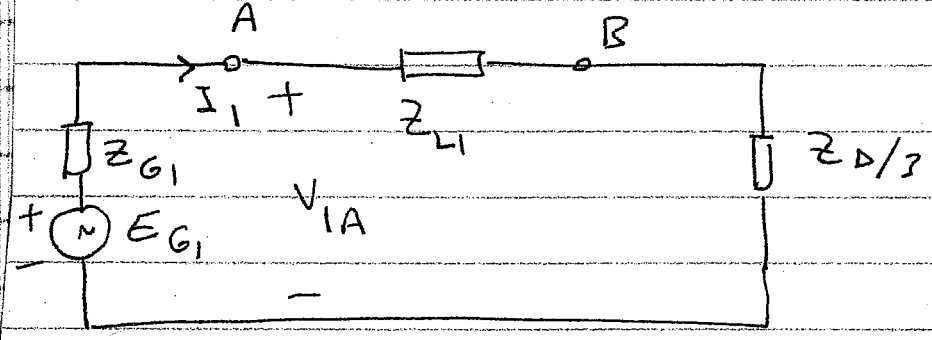
c) The sequence network with unbalanced operation of the generator is as follows:

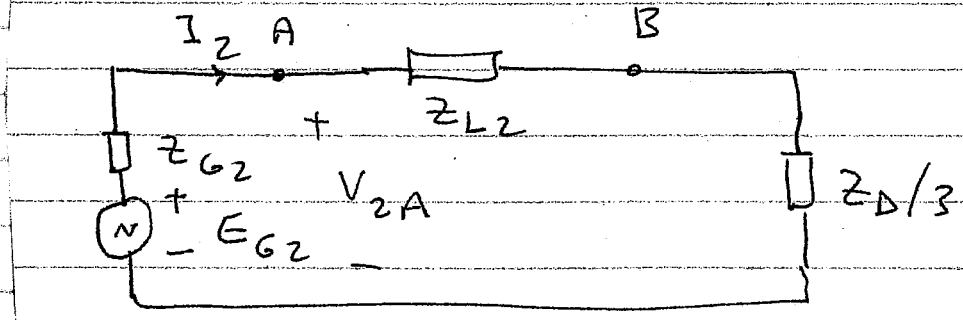
(over)

c) [continued]









$$E_{G0} = Z_{G0} \cdot I_0 + V_{0A} = 0 + V_{A0} = 15.91 \angle 62.11$$

$$E_{G1} = Z_{G1} I_1 + V_{1A} = \cdots$$

just plug in numbers

$$E_{G2} = Z_{G2} I_2 + V_{2A} = \cdots$$