Georgia Institute of Technology
School of Electrical and Computer Engineering

EE4321 **Power System Engineering** **Spring 2009**

Homework Assignment #3
Due February 5, 2009

Problem P1: Consider the electric power system of the Figure P1. The system consists of a generator, a delta-wye connected transformer and a three phase line. Assume a single phase-to-ground fault occurring at point A of the line, located 25.6 miles from the transformer. The fault analysis for this condition is provided below using symmetrical components.

(a) Compute the voltage magnitude of phases B and C at point A during the fault condition, and
(b) Compute the electric current supplied by the generator (all three phases).
(c) Compute the voltages at the three phases of the generator.

Use symmetrical component theory in the computations. System data are as follows:

Generator (350 MVA, 15kV): $z_1 = j0.175\ pu,\ z_2 = j0.21\ pu, and\ z_0 = j0.08\ pu$ (@ 350 MVA)
Transformer (280 MVA, 15kV/115kV): $z_1 = z_2 = z_0 = j0.08\ pu$ (@ 280 MVA)
Transmission line: $z_1 = z_2 = 0.3 + j0.72\ Ohms/mile,\ \ z_0 = 0.45 + j1.75\ Ohms/mile$

Neglect the transformer shunt impedance and the transmission line capacitive shunt impedance.

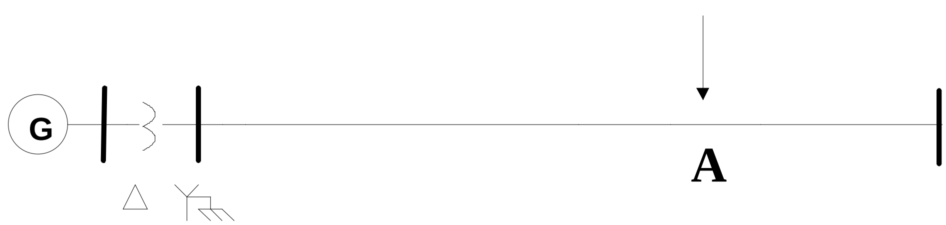


Figure P1. Simplified Power System

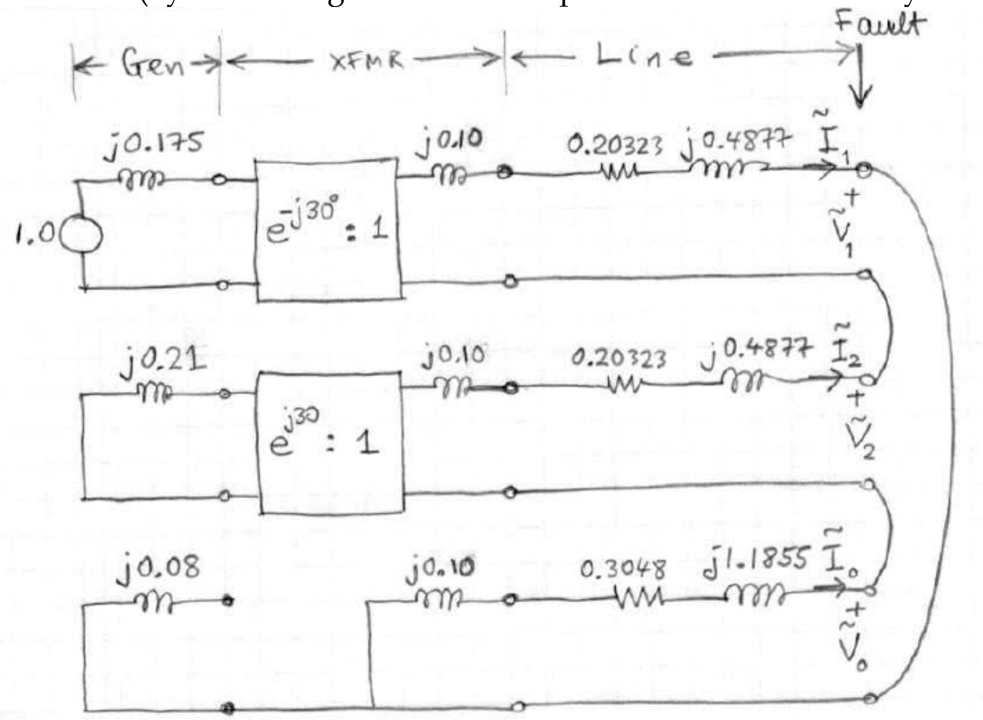
<u>Fault Analysis:</u> The transmission line parameters in the per unit system are:

$$Z_b = \frac{115^2}{350} = 37.79\ \text{Ohms}$$

$$z_1 = z_2 = (0.3 + j0.72) \times 25.6 \frac{1}{37.79} = 0.20323 + j0.4877 \text{ pu}$$

$$z_0 = (0.45 + j1.75) \times 25.6 \frac{1}{37.79} = 0.3048 + j1.1855 \text{ pu}$$

The model is (by converting all values into per unit on a 350 MVA system):



$$\tilde{I}_1 = \tilde{I}_2 = \tilde{I}_0 = \frac{e^{j30^\circ}}{0.71126 + j2.8459} = 0.3409 e^{-j45.97^\circ} = 0.2369 - j0.2451$$

$$\begin{bmatrix} \tilde{I}_a \\ \tilde{I}_b \\ \tilde{I}_c \end{bmatrix} = \begin{bmatrix} 1 & 1 & 1 \\ a^2 & a & 1 \\ a & a^2 & 1 \end{bmatrix} \begin{bmatrix} \tilde{I}_1 \\ \tilde{I}_2 \\ \tilde{I}_0 \end{bmatrix} = \begin{bmatrix} 1.0227 e^{-j45.97^\circ} \\ 0.0 \\ 0.0 \end{bmatrix} \quad pu$$

, or

$$\begin{bmatrix} \tilde{I}_a \\ \tilde{I}_b \\ \tilde{I}_c \end{bmatrix} = \begin{bmatrix} 1 & 1 & 1 \\ a^2 & a & 1 \\ a & a^2 & 1 \end{bmatrix} \begin{bmatrix} \tilde{I}_1 \\ \tilde{I}_2 \\ \tilde{I}_0 \end{bmatrix} = \begin{bmatrix} 1.855 e^{-j45.97^\circ} \\ 0.0 \\ 0.0 \end{bmatrix} \quad \text{kAmperes}$$

Problem P2: (Computer Based Homework – collaboration is permitted and encouraged – homework reports must be individual) Consider the electric power system of Figure P2. The parameters of the various system components are given in the Figure. Consider a single line to ground fault at the load location (near the middle of one of the lines).

The two transmission lines parallel each other for the entire length of 62.7 miles. Each line is suspended on single poles (name: AGC-P-230), uses phase conductors ACSR, BITTERN, shield wires ALUMOWE, 3#7AW, soil resistivity 175 ohm.meters, the poles are spaced 0.1 miles apart, the ground impedance at each pole is 25 ohms and the distance between the two lines is 40 feet (pole to pole).

(a) Compute the positive/negative and zero sequence models of each of the lines and the mutual impedance model between the two lines. For this computation neglect the electric load near the middle of one of the lines.
(b) Compute the single line to ground fault at the load location by modeling the two transmission lines as two mutually coupled lines. During this fault compute the negative sequence current in the generator.
(c) Compute the single line to ground fault at the load location by modeling the two transmission lines as two independent (not mutually coupled) lines. During this fault compute the negative sequence current in the generator.
(d) Compare the results in cases (b) and (c) above.

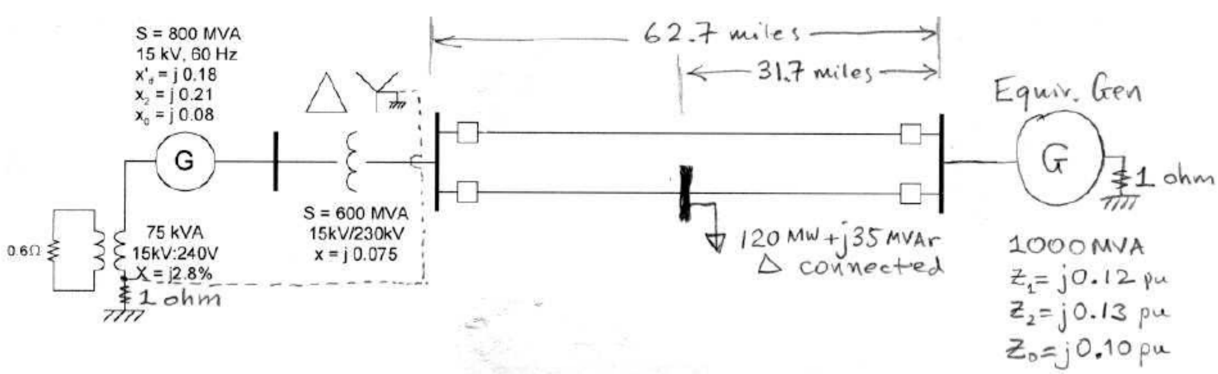


Figure P2