

**Massachusetts Institute of Technology**  
**Department of Electrical Engineering and Computer Science**  
 6.691 Seminar in Advanced Electric Power Systems

Problem Set 7

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 Due May 17, 2006

**Unbalanced line** A generator is connected to an 'infinite bus' as shown in Figure 1. Note this is a 60 Hz system and the generator has *synchronous reactance*  $x_d = 2.0$  per-unit and *negative sequence reactance*  $x_d'' = 0.2$  per-unit. Assume that the transformer has a leakage reactance of  $x_t = 0.1$  per-unit on the same base as the generator.

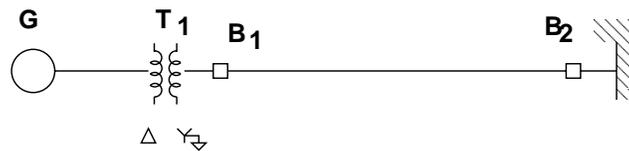


Figure 1: One Machine, Infinite Bus

This transmission line has a layout similar to what is shown in Figure 2. The line is *not* transposed so that the mutual inductances are unbalanced. We have estimated that the self- and mutual inductances of the line are:

$$\begin{aligned} L_a = L_b = L_c &= 2.40 \mu\text{Hy}/\text{m} \\ L_{ab} = L_{bc} &= 2.06 \mu\text{Hy}/\text{m} \\ L_{ac} &= 1.03 \mu\text{Hy}/\text{m} \end{aligned}$$

The line is 100 km long. Assume the generator is delivering rated power at unity power factor to the infinite bus. In this problem you will calculate the negative sequence current, in per-unit, on the generator.

Working in per-unit on the generator base,

- Find the per-unit coupling matrix:

$$\begin{bmatrix} v_0 \\ v_1 \\ v_2 \end{bmatrix} = \underline{\underline{x}} \begin{bmatrix} i_0 \\ i_1 \\ i_2 \end{bmatrix}$$

- Find the operating point:
  - Torque angle,
  - Internal voltage  $e_a$

In finding the torque angle, assume that all you need to know is the positive sequence quantities.

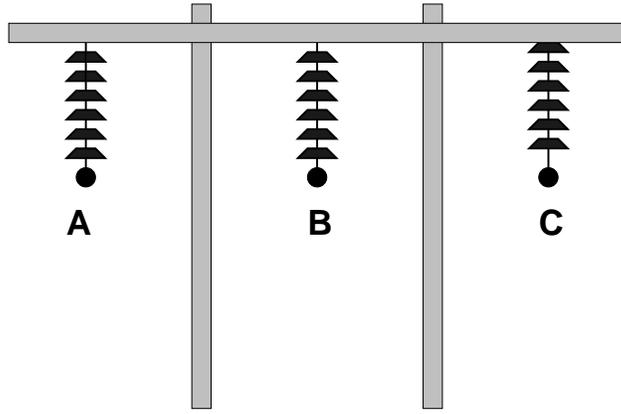


Figure 2: Transmission Line Configuration

- Calculate the vector difference between internal and infinite bus voltages.
- Now you should be able to calculate negative sequence current in the machine.
- Is there zero sequence current anywhere? Where and what is it (in per-unit)?