6.061 / 6.690 Introduction to Electric Power Systems
Spring 2007

Massachusetts Institute of Technology
Department of Electrical Engineering and Computer Science
6.061/6.690 Introduction to Power Systems

Problem Set 6

Issued: Ses #11
Due: Ses #13

NOTE:

1. This homework set is due *after* Spring Break.
2. We have a **quiz** on Wednesday, March 21. Calculators and crib sheets are encouraged.Crib sheets are a *single* piece of letter-sized paper, handwritten but you can write on both sides.

Problem 1: Figure 1 shows a wye connected load connected to a power source through a delta-wye connected transformer. Assume that the load is two 20 ohm resistors and one 60 ohm resistor connected in wye. The source is balanced, 4160 V, RMS, line-line. The transformer is 4160/600, delta primary, solidly grounded wye secondary. Calculate the positive, negative and zero sequence currents at the load and the phase currents at the 4160 volt source if:

1. The wye connected load is solidly grounded,
2. The wye connected load is ungrounded, and
3. The wye connected load is grounded through a 10 ohm resistor.

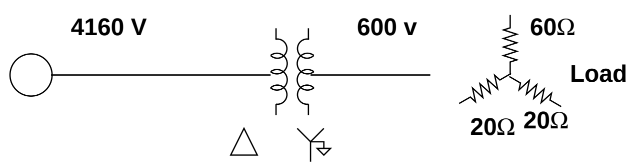

Figure 1: Source and Load

Problem 2: Figure 2 shows a transmission line problem to be used in this problem and the next.

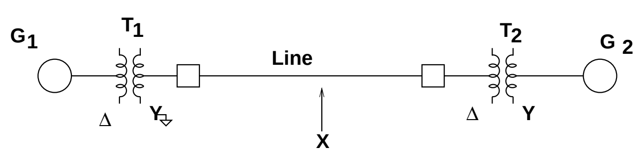

Figure 2: Transmission Line Problem

This system is to be modeled for a fault. Assume the fault occurs at the point on the line marked by the X. Assume that the section of the line to the left of the fault has L=8 mHy, M = 3 mHy and the section to the right of the fault has L=6 mHy, M = 2 mHy. This is a 60 Hz system. The generator G_1 is rated 400 MVA and 26 kV at its terminals. Generator G_2 is rated 200 MVA at 13.8 kV at its terminals. The transformer T_1 has an impedance of

$x_{T1} = j.05$ per-unit on the same base. Transformer T_2 has impedance of $x_{T2} =$ j.05 on a base of 200 MVA. The line voltage is 345 kV, line-line and the transformer turns ratios are consistent with the generator and line voltages.

You may assume that generator G_1 may be represented as a voltage source with positive and negative sequence *reactive* impedances of 18 % on its base. Assume the same thing for generator G_2. At the time of the fault the voltages in the two generators are in phase, so that there is no real nor reactive power transfer between them.

What is the fault current in the line to the 'left' of the fault and in generator G_1 leads (in both per-unit and amperes) if the fault itself is:

1. Symmetric (all three phases)
2. Single line-ground,

Problem 3: for 6.690 In this problem, we are concerned about the impact of line unbalance on the generator. Unlike in Problem 2, the transmission line is unbalanced. Here is some data on the elements of the system: The transmission line may be modeled as having self-inductance of each phase is 14 mHy and mutual inductance between phases A and B and between phases B and C is 8 mHy. Mutual inductance between phases A and C is 4 mHy. The system is operated at 60 Hz. Now: if there is real power transfer between G_1 to G_2 of 200 MW, at unity power factor at the terminals of G_2, with per-unit voltage magnitude of unity, can you estimate the value of negative sequence current flowing in the leads of the generator? A per-unit calculation is OK.

Note: You will have to go beyond what we have done in class to find the cross-admittance between positive sequence voltage and negative sequence current in the transmission line

Problem 4: Figure 3 shows a load flow situation. There are two generators, one generating at unity power factor, the other under voltage control. Each generator is providing one per-unit real power (don't worry about the base). The load is all on a single bus and is 2 per-unit. At the lower right side of the drawing is an infinite or 'swing' bus which maintains a constant angle of zero and voltage magnitude of unity. Line impedances are shown on the drawing.

For this problem, calculate the bus voltages and line currents. In your answer, generate a list of bus voltage magnitudes and angles and a list of line currents.

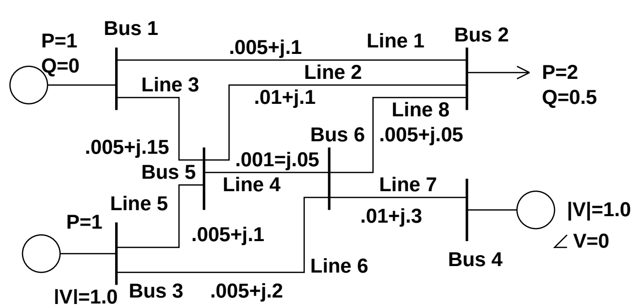

Figure 3: Load Flow Problem