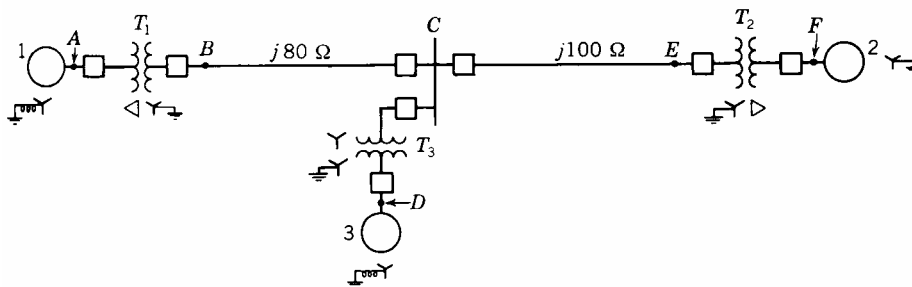


## Problem Set #5 $Y_{BUS}$ and $Z_{BUS}$ models and power flow basics

### 5-1 (Keyhani Lecture)

The one-line diagram of an unloaded power system is shown below. Reactances of the two sections of transmission line are shown on the diagram. The generator and transformer ratings are as follows:

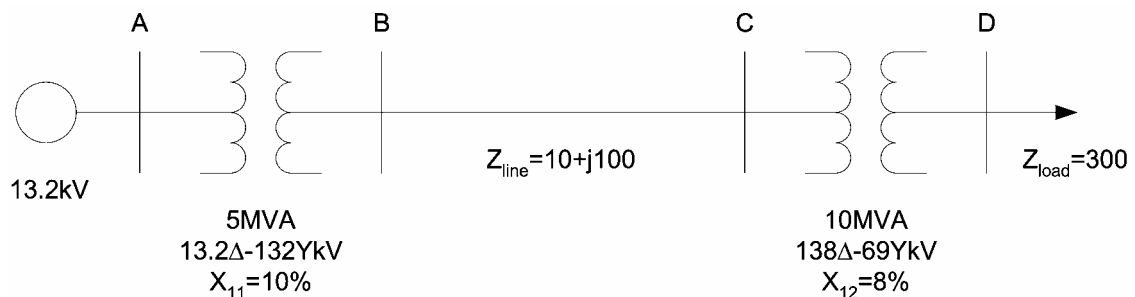
Generator 1:	20 MVA, 13.8 kV, $X''_d = 0.20$ per unit
Generator 2:	30 MVA, 18 kV, $X''_d = 0.20$ per unit
Generator 3:	30 MVA, 20 kV, $X''_d = 0.20$ per unit
Transformer $T_1$ :	25 MVA, 220Y/13.8 $\Delta$ kV, $X = 10\%$
Transformer $T_2$ :	single-phase units, each rated 10 MVA, 127/18 kV, $X = 10\%$
Transformer $T_3$ :	35 MVA, 220Y/22Y kV, $X = 10\%$



- Draw the per unit equivalent circuit with all reactances marked in per unit on your circuit. Choose MVA base of 100.
- Compute the  $Y_{BUS}$  model of the system for short-circuit studies.
- Compute the short circuit current flowing through breaker A for a three-phase fault at point B.
- Compute the  $Y_{BUS}$  model of the system for power flow studies.

### 5-2 (Keyhani Lecture)

Consider a system with the one-line diagram shown below. The three-phase transformer nameplate ratings are listed. The transformer reactances are given in percent:  $10\% = 0.1$  p.u. The transmission line and load impedances are in actual ohms. The generator terminal voltage (magnitude) is 13.2 kV (line-line). Find the generator current, the transmission-line current, the load current, the load voltage, and the power delivered to the load. Assume  $S_b = 10$  MVA.



**5-3 (Keyhani Lecture)**

Consider the same basic system as in Problem 5-2 but with these changes. The generator voltage and load impedance are not specified. Instead, we are given the following information. The voltage (magnitude) at the load is 68 kV and the three-phase load power is 5.0 MW at a PF of 0.9 lagging. Find the load current, the generator voltage, and the generated power.

**5-4 (Keyhani Lecture)**

Consider the same basic system as in Problem 5-2. Assume the generator voltage is set at 10% above its rated value. The load connected to bus is equal to 5MW at a PF of 0.9 lagging. Find the load voltage.

**5-5 (Keyhani Lecture)**

A 15,000-kVA 8.5-kV three-phase generator has a subtransient reactance of 20%. It is connected through a  $\Delta$ -Y transformer to a high-voltage transmission line having a total series reactance of  $70\Omega$ . At the load end of the line is a Y-Y step down transformer. Both transformer banks are composed of single-phase transformers connected for three-phase operation. Each of the three transformers composing each bank is rated 6,667 kVA, 10-100 kV, with a reactance of 10%. The load, represented as impedance, is drawing 10,000 kVA at 12.5 kV and 80% power factor lagging. Draw the one-line diagram and mark base kV in the three parts of the system. Then draw a positive-sequence impedance diagram showing all impedances in per unit. Choose a base of 10,000 kVA, 12.5 kV in the load circuit.

- a) Determine the voltage at the terminals of the generator.
- b) Compute the  $Y_{BUS}$  of the system for short-circuit studies.
- c) Compute the  $Y_{BUS}$  of the system for power-flow studies.

**5-6 (Keyhani Lecture)**

Draw the impedance diagram for the power system shown below. Mark impedance in per unit. Neglect resistance, and use a base of 50 MVA, 138 kV in the 40- $\Omega$  line. The ratings of the generators, motor, and transformers are:

Generator 1	20 MVA, 13.2 kV, $X'' = 15\%$
Generator 2	20 MVA, 13.2 kV, $X'' = 15\%$
Synchronous motor 3	30 MVA, 6.9 kV, $X'' = 20\%$
Three-phase Y-Y transformers	20 MVA, 13.8Y-138Y kV, $X = 10\%$
Three-phase Y- $\Delta$ transformers	15 MVA, 6.9 $\Delta$ -138Y kV, $X = 10\%$

All transformers are connected to step up the voltages of the generators/motor to the transmission-line voltages.

Assume a balanced three-phase fault in the mid section of the 40-Ω line. Compute the short circuit current flowing to the ground.

