ELG4125: Electric Power Transmission, Distribution, and Utilization

Lab Exercise 2

Instructions:

1. The report is due before **11:59 PM on Sunday, November 13th, 2011**.
2. This report is to be solved INDIVIDUALLY.
3. Save your report in **xxxxxx**.doc, where **xxxxxx** is your student number, and submit it by email.

1. Open the case related to Example 3.12 in the book (4E):
   a. The voltage at the load bus of 341.1 kV at 1.00 tap position and a load of 500+j100 MVA. Confirm this in PowerWorld
   b. What are the load bus voltage values for tap positions 0.9 and 1.1 respectively?
   c. Set the reactive load to zero: How does this affect the load bus voltage?
   d. Assume a per-phase load impedance on the 345 kV side of 238 Ω corresponding to 500 MW at nominal voltage. Calculate the voltage across this load with the 10% tap setting.
   e. Use a tap position of 1.1 together with the 500+j0 MVA load. From PowerWorld, what is the resulting voltage? Is this about the same as you get in "d"?

2. Open your PowerWorld model of the system in Figure 1. Add a shunt capacitor of 50Mvar to bus 3.

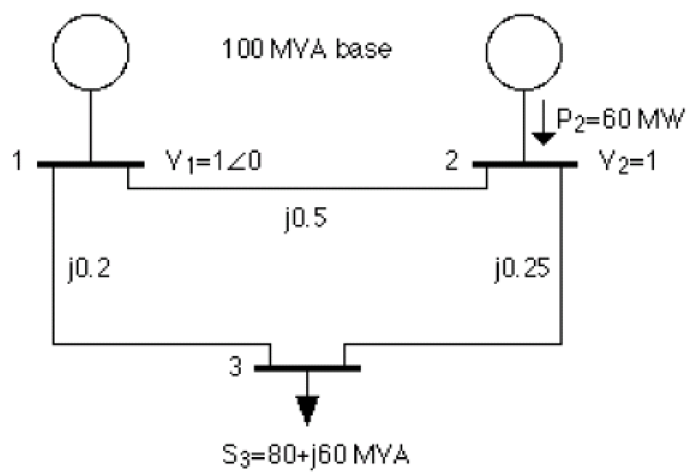

Figure 1 Three-bus power system used for load flow calculations. Voltages and line impedances are in per unit. System base is 100 MVA

a. What is the voltage at the load bus with the capacitor disconnected?
b. The voltage sensitivity to reactive power ($\partial V/\partial Q$) gives an estimate of how much the voltage will change when the reactive power load is changed. This sensitivity can be approximated:
$\partial V \partial Q = (\partial Q \partial V)^{-1} \approx -1/S_{SC}$(p.u.)
Estimate the voltage at bus 3 with the 50 Mvar capacitor added using this expression.
c. From PowerWorld, what is the voltage at the load bus with the capacitor connected? Compare this to the estimated voltage from "b".

3. Run Example 6.14 in the textbook (4E):
   a. Determine the voltage sensitivity to reactive power $\partial V/\partial Q$ by using two values of shunt capacitor reactive power Q at bus Two and read the corresponding bus voltages. Calculate the sensitivity in p.u. voltage/p.u. power.
   b. Compute an approximate value of $\partial V/\partial Q$ at bus Two:
      - Make PowerWorld display the bus admittance matrix Ybus. Right-click on the matrix and save it as a Matlab m-file. Load the matrix into Matlab.
      - The voltage of the controlled buses (1-slack and 3-PV) is fixed. They behave like reference buses and can be eliminated from Ybus: Remove the corresponding rows and columns (1 and 3).
      - Invert the remaining 3x3 matrix. Diagonal element (1,1) corresponding to bus Two is an approximation to $-\partial V/\partial Q$. Compare the obtained value to the result in "a".

4. Continue using the model of the system in Figure 1:
   a. Connect a resistance R to bus 3 (and the Thévenin equivalent). Determine the load power and the bus voltage for the following values of R: Infinity, 0.4, 0.2, 0.1 and 0 p.u.
   b. At the PowerWorld, open the breakers of the line between buses 2 and 3. Set the load at bus 3 to zero. Increase the real power load at bus 3 in steps of 1 MW starting at zero. What power gives the bus voltage 1, 0.89 and 0.71 p.u.? Compare to "a".

5. Use Example 5.10 in the textbook (4E) to study the effect of reactive series compensation of a line:
   a. Set the load to 3000 MW. What is the load voltage and the line angle difference with bypassed (no) reactive series compensation?
   b. Remove the bypasses. What are the load voltage and the line angle difference now?
   c. What is the maximum real power that can be transmitted with and without reactive series compensation? (Increase load until the system has a blackout.)