ECE 5430 Power Flow Project

Figure 1 shows a single-line diagram of a five-bus power system. Input data are given in Tables 1, 2, and 3. As shown in Table 1, bus 1 is the swing bus, to which a generator is connected. Bus 3 is a voltage-controlled bus, to which a generator and a load are connected. Buses 2, 4, and 5 are load buses.

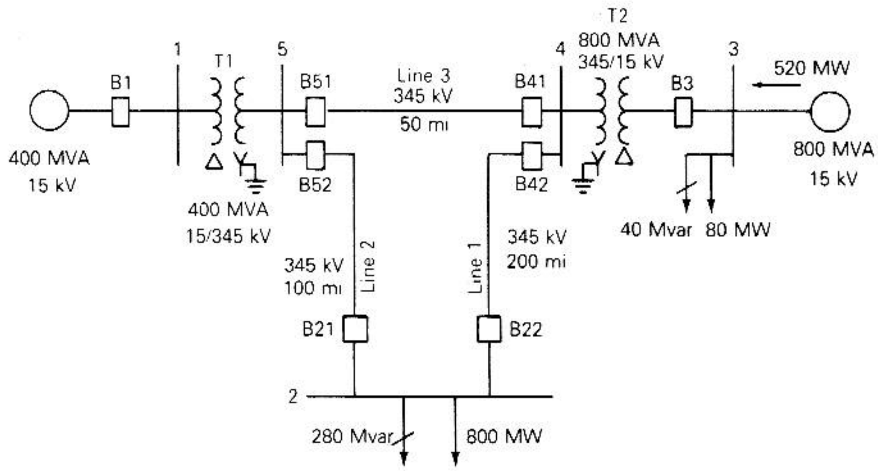

Figure 1. Single-line diagram of a five-bus system.

Table 1

Bus	Type	V per unit	δ degrees	P_G per unit	Q_G per unit	P_L per unit	Q_L per unit	Q_{Gmax} per unit	Q_{Gmin} per unit
1	Swing	1.0	0	—	—	0	0	—	—
2	Load	—	—	0	0	8.0	2.8	—	—
3	Constant voltage	1.05	—	5.2	—	0.8	0.4	4.0	−2.8
4	Load	—	—	0	0	0	0	—	—
5	Load	—	—	0	0	0	0	—	—

* S_{base} = 100 MVA, V_{base} = 15 kV at buses 1, 3, and 345 kV at buses 2, 4, 5

Table 2

Bus-to-Bus	R per unit	X per unit	G_c per unit	B_m per unit	Maximum MVA per unit	Maximum TAP Setting per unit
1–5	0.00150	0.02	0	0	6.0	—
3–4	0.00075	0.01	0	0	10.0	—

Table 3

Bus-to-Bus	R' per unit	X' per unit	G' per unit	B' per unit	Maximum MVA per unit
2–4	0.0090	0.100	0	1.72	12.0
2–5	0.0045	0.050	0	0.88	12.0
4–5	0.00225	0.025	0	0.44	12.0

1. Build this power system in PowerWorld Simulator.

2. Enter the input data for the system components, given in the example. **Initially set transformer taps to 1.0** and run the power flow program for the power system, once using the Gauss-Seidel iteration algorithm and once using the Newton-Raphson (NR) algorithm. Compare the results of the above two cases and see if you can find the number of iterations in each case to find the solution.

3. Develop your own program to implement the NR algorithm using any language you prefer (C/C++, Matlab, Fortran, etc). Use your program to solve the power flow of the system in Figure 1. Compare your result with the one obtained from PowerWorld Simulator.

4. **We will call the case solved with NR, the "base case."** Do you find any bus voltage violations? (The normal range of bus voltage is assumed to be 0.95-1.05 p.u.)

5. For the power system, find the VAR rating of a shunt capacitor bank at bus 2 that increases V2 to 0.95 p.u. Observe the effect of the capacitor bank on the system bus voltages, line loadings, and total I^2R losses. What is the effect and why?

6. Now, take the capacitor bank off to go back to the base case. Suppose both transformers in this system are tap changing transformers whose taps can be varied from 0.85 to 1.15 in increments of 0.05. Determine the tap settings required to increase the voltage at bus 2 to 0.95 p.u., while causing as few high voltage violations as possible at other buses.

7. Install a new transformer between buses 1 and 5, in parallel with the existing transformer between the above two buses. The new transformer is identical to the existing transformer. Tap setting of the transformer is also set to the nominal value, 1.0. Observe and justify the effect of adding the new transformer on the real and reactive power and VA supplied from bus 1 to bus 5.

8. Again return to the base case. Now, add another transmission line between buses 2 and 4. The parameters of the added line are the same as those of the existing line 2-4 (line 1). Observe and justify the effect of the addition of this line on the system bus voltages, line loadings, and total I^2R losses.

9. Return to the base case. Now, suppose the line between buses 2 and 5 is removed for maintenance. Run the power flow program again. Is this operating condition acceptable? i.e., are the bus voltages and line power flows within the acceptable range? Can you improve the existing conditions by adding capacitors at bus 2? Do and justify!

10. Take the capacitor bank off and determine the amount of load you have to shed at bus 2 in order to maintain the voltage at bus 2 above 0.95 p.u. Cut the same percentage of MW and MVAR at bus 2.

In a formal written report give detailed explanation of your observations and justifications, and draw proper conclusions. **The report is to be prepared independently by each student and <u>due in 4 weeks</u>.**