Name: ____

EE 303, Quiz 7, April 9, 2019, Dr. McCalley
20 minutes, closed book, closed notes, closed calculator

A. (40 pts) A transmission line terminated at buses p and q has a series impedance of y=1-j10 pu, and a total line charging susceptance of B_c=2 pu. The voltages at the terminals are $V_p=1.05\angle 45°$ and $V_q=1.01\angle 30°$. Assume the π-equivalent model is an accurate representation of the line. Recall the "exact" power flow equations developed in class are:

$$P_{pq} = V_p^2 G - V_p V_q G\cos(\theta_p - \theta_q) + V_p V_q B\sin(\theta_p - \theta_q)$$

$$Q_{pq} = V_p^2 B - V_p V_q B\cos(\theta_p - \theta_q) - V_p V_q G\sin(\theta_p - \theta_q)$$

(20 pts) Express, numerically (you do not need to evaluate), with no approximation,

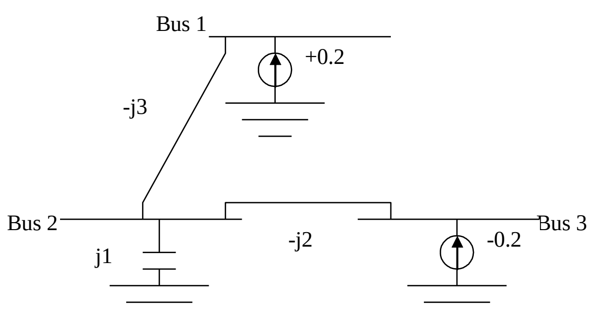
a. the total pu real power flowing *out of the p-bus substation into the line*.
b. the total pu reactive power flowing *out of the p-bus substation into the line*.

a. $P_{bus-to-line} = P_{pq} = (1.05)^2 - (1.05)(1.01)\cos(15°) + (1.05)(1.01)(10)\sin(15°)$

b. $Q_{bus-to-line} = Q_{sp} + Q_{pq} = -(1)(1.05)^2 + (1.05)^2(10) - (1.05)(1.01)(10)\cos(15°) - (1.05)(1.01)\sin(15°)$

Evaluation of the above expressions was not required, but just for comparative purposes I have done it here, resulting in:
$P_{bus-to-line}=P_{pq}$=2.8229 pu.
$Q_{bus-to-line}=Q_{sp}+Q_{pq}$= -1.1025+0.5069= - 0.5956 pu.
(so reactive power is flowing into the substation!)

B. (30 pts) Form the matrix equation relating nodal current injections to nodal voltages for the network below. The imaginary numbers are admittances.



Answer:

$$\begin{bmatrix} -j3 & j3 & 0 \\ j3 & -j4 & j2 \\ 0 & j2 & -j2 \end{bmatrix}\begin{bmatrix} v_1 \\ v_2 \\ v_3 \end{bmatrix} = \begin{bmatrix} 0.2 \\ 0 \\ -0.2 \end{bmatrix}$$

C. (30 pts) In a three-bus power network, bus 1 is a generator bus, bus 2 is a generator bus, and bus 3 is a load bus. Both generator buses are capable of controlling their voltage magnitude. For this power network:

1. Which bus or buses are type PV?
2. Which bus or buses are type PQ?

3. Can we specify the real power injection for all three buses as input data to the power flow problem of this power network? Why or why not?

Answer:

1. Either bus 1 or bus 2 but not both.
2. Bus 3.
3. No,. because we must know losses to specify real power injections for all buses, and we cannot know losses unless we know the line flows, and we cannot know line flows until we solve the problem. This issue is what motivates the need for the swing bus.