EE 5240 - Assignment #6 Due: Tues Mar 7th, 9am
Spring Semester 2023 - Mork

Objectives: Continued development of MatLab programming skills. Numerical implementation of Newton-Raphson iterative solution, insights on paralleling of transformers.

1) Continue your work with MatLab with the IEEE standard 14-bus load flow case. It is assumed at this point that your program can successfully read in the data file and form [Ybus]. Continuing on from there,

   a) How many rows and columns will the Jacobian have? Give the matrix equation that will have to be solved for each iteration. (i.e. using proper subscripts, tell which partial derivatives must be evaluated, which voltage and angle quantities are the variables, and which ΔPs and ΔQs must be evaluated). Use partitioning symbols to separate the J1, J2, J3 and J4 areas. Feel free to make use of ... symbols if it makes it easier. **Don't forget that: a) rows and columns related to P & Q of slack bus are omitted; b) rows and columns related to Q of generator buses are omitted!**

   b) Using the bus voltage values given in the Univ of Washington version of the ieee14.cdf file: i) write the algebraic expressions for the J1, J2, J3, and J4 terms of the Jacobian that are related to bus 3 (a PV bus) and bus 5 (a load bus). Manually evaluate these expressions so that you can rely on this for debugging your code. ii) Next, write the expressions for the mismatches ΔP_3, ΔP_5, and ΔQ_5 and manually evaluate them, also keeping the results for debugging purposes. Since the bus voltage and angle values provided in ieee14.cdf are actually the converged solution, what should these mismatches be?

   c) Add the code to your program that constructs the Jacobian matrix and the mismatch vector, and fills these storage arrays with the numeric values needed for the first iteration (you do not need to complete the programing of the iteration itself for this assignment).

   Hand in your hand calculations, a printout of your code, a printout of the Jacobian matrix (in sparse matrix form), and a printout of the mismatch vector. Use the spy function to print the structure of the Jacobian, draw in partition lines, and label the 4 quadrants. Is the Jacobian similar in structure/topology to the admittance matrix? Explain.

2) Do if time allows. This is extremely valuable in order to truly understand the pi-equivalent admittance formulation of off-nominal-tap transformers, and interaction of paralleled transformers. Referring to the lecture notes, Lecture 13, page PS-1 (p.16 of .pdf file), use matlab to evaluate the equations and solve for $\mathbf{I}_a$, $\mathbf{I}_b$, $\mathbf{I}_2$, S_a, and S_b, using the following parameters: jX_{T1} = j.05 pu, jX_{T2} = j.05 pu, off-nominal tap ratio "a" equals $1.05\underline{/-3}°$. Repeat using the admittance matrix method depicted on pp.4-5 of the notes. Show that you can get the same results both ways. Now you have a valuable tool to use to predict the behavior of paralleled transformers, included cases with mismatched impedances or tap settings.

Coming up next: We can make use of the methods for building [Ybus], LU factorization for solution of a linear system of equations for many power systems calcs: power flow, SC, stability, etc. Next exercise will delve into time domain circuit solution and implementation for a network.