Programming Project 4: Power-Flow

EE 581

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1 Introduction

This project will be to develop your own power-flow (also known as load-flow) solver and power system simulator to study power systems in sinusoidal steady-state. The program will be based upon Newton's method and tested on two power systems (6-bus and 9-bus) to verify operation and compare results to those achieved in PowerWorld.

2 I/O Specifications

The desired format of your input and power system description is three sections (or files) of data:

1. bus data (names, numbers, location of generators and loads, knowns and initial values for unknowns for the power-flow variables);
2. line data (name, from bus, to bus, series impedance, shunt admittance, thermal limit, practical stability limit);
3. transformer data (name, from bus, to bus, series equivalent impedance, shunt exciter admittance, rating for limit).

The desired format of your output is a bus table of the same form as the input except with unknown values filled in with answers from the Newton-Raphson algorithm. A second table will provide line and transformer powers, and what percent they are from their practical, loadability limits. See table 2 below for example output.

3 Test Systems

3.1 6-bus

Test your power-flow program on the 6-bus example presented in class. Line and transformer data files should have been created previously, so add a file with the data in table 1 to provide "knowns" and initial conditions for the "unknowns." Since no line data is available from which to compute line loadability for the test cases, use $S_{thermal} = 60$ MVA and $P_{max} = 40$ MW for all lines. Use the transformer ratings to compute percent loading for a transformer.

An example power-flow solution to which to compare your results is given in table 2. Note loadability information is not included in these results.

Name	No.	V (p.u.)	δ (°)	P_G (p.u.)	Q_G (p.u.)	P_L (p.u.)	Q_L (p.u.)
FourCornerLo	1	1.05	0	0.25	0.08	0	0
EleButteLo	2	1.10	0	0.15	0.05	0	0
FourCornerHi	3	1	0	0	0	0	0
EleButteHi	4	1	0	0	0	0	0
SocorroHi	5	1	0	0	0	0	0
SocorroLo	6	1	0	0	0	-0.34	-0.29

Table 1: Bus data for 6 bus power system.

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** Load Flow Solution **
    Bus             Voltage   Angle       Gen Power          Load Power
 No.   Name          (pu)     (rad)      (MW)     (MVAR)     (MW)     (MVAR)
----  ------         ------   ------    ------    ------    ------    ------
  1   FourCornerLo  +1.050    0.000    +0.193    -0.622    +0.000    +0.000
  2   EleButteLo    +1.100    0.013    +0.150    -0.191    +0.000    +0.000
  3   FourCornerHi  +1.149   -0.027    +0.000    +0.000    +0.000    +0.000
  4   EleButteHi    +1.171   -0.033    +0.000    +0.000    +0.000    +0.000
  5   SocorroHi     +1.144   -0.047    +0.000    +0.000    +0.000    +0.000
  6   SocorroLo     +1.024   -0.162    +0.000    +0.000    -0.340    -0.290

** Line powers **
lineN bus1 bus2    P1       Q1       P2       Q2     |P1+i*Q1|
   1    3    4   +0.008   -0.292   -0.008   -0.137    +0.292
   2    3    5   +0.177   -0.102   -0.176   -0.099    +0.204
   3    4    5   +0.166   +0.063   -0.164   -0.266    +0.177
   4    3    4   +0.008   -0.292   -0.008   -0.137    +0.292
   1    1    3   +0.193   -0.622   -0.193   +0.687    +0.652
   2    2    4   +0.150   -0.191   -0.150   +0.210    +0.243
   3    5    6   +0.340   +0.365   -0.340   -0.290    +0.499
```

Table 2: Example power-flow solution for 6-bus system.

3.2 9-bus

Test your power-flow program on the 9-bus example handed out. Create a bus data file similar to that in table 7.1 of the handout, but use reasonable initial conditions for the "unknowns" versus the solution provided. Line and transformer data files also need to be made. After your program has run, results should match those in the table. Since no line data is available from which to compute loadability for the test cases, use $S_{thermal} = 80$ MVA and $P_{max} = 80$ MW for transmission lines and a rating of 150 MVA for transformers.

4 PowerWorld

Enter the data for the 6-bus and 9-bus systems into PowerWorld and use it to compute a load-flow solution as well. Note if it matches that found with your program and what was needed to be done to get the solutions to match.

5 Results

Write a report that summarizes power-flow, your approach/program, test systems, PowerWorld implementation, results and work. Show results for the two test cases and note any problems with the power systems' performance, i.e., lines over limits and/or voltages more than 6% away from their nominal/rated values. Include input data files and power-flow program in appendix.