ECEN 615 Problem Set #4 Fall 2018

Due 11/1/18

1. Code the Tinney Scheme 1 algorithm, and test your algorithm using the Aggieland37 bus network from the course website (in the Lecture 7 zip file). Note, you to not have to actually code adding the fills for this problem. Turn in a listing of your program and the Tinney Scheme 1 numbering for this case. Break ties numerically (i.e., bus 1 before bus 2). Note, to solve this problem you just need the connection topology, not the actual matrix values. There are several ways to get the data needed for this case from PowerWorld. One is to select Case Information, Solution Details, Ybus. Then right-click on any data cell and select Save Ybus in Matlab format. That will give you a text file description of the Ybus.

Solution:

Original elimination order:

Elimination order	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
PW Bus Index	1	3	5	10	12	13	14	15	16	17	18	19	20	21	24	27	28	29

19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
30	31	32	33	34	35	37	38	39	40	41	44	47	48	50	53	54	55	56

Tinney 1 algorithm results in:

Elimination order	14	25	1	2	3	6	7	9	10	12	15	16	17	19	22	23	26	33
PW Bus Index	21	37	1	3	5	13	14	16	17	19	24	27	28	30	33	34	38	50

34	36	37	4	8	11	13	21	24	31	5	18	20	28	29	30	32	35	27
53	55	56	10	15	18	20	32	35	47	12	29	31	40	41	44	48	54	39

For problems 2 to 6 make use of the B7Flat_DC case, which is available on the course website. This case is a modified version of the B7Flat case in which 1) the lines are modeled just using reactances, 2) the case is solved using the dc power flow, and 3) some of the line limits have been increased. Assume the initial injections for this case to be the base case values. Bus 7 is the system slack. For consistency please use the line numbering and from/to bus orientations given for the case. For convenience the line ordering is given at the end of this problem set in Table 1. That is, the line from bus 1 to bus 2 is #1, the line from bus 1 to bus 3 is #2, etc.

Table 1: B7Flat_DC Transmission Line Values

Line Number	From Number	To Number	Circuit	X	Lim A MVA
1	1	2	1	0.06	200
2	1	3	1	0.24	200
3	2	3	1	0.18	80
4	2	4	1	0.18	100
5	2	5	1	0.12	150
6	2	6	1	0.06	200
7	3	4	1	0.03	100
8	4	5	1	0.24	60
9	7	5	1	0.06	200
10	6	7	1	0.24	200
11	6	7	2	0.24	200

2. Using PowerWorld, determine the UTC between bus 2 and the system slack (bus 7). Consider all single line contingencies. For convenience the eleven single element contingencies have already been defined for you.

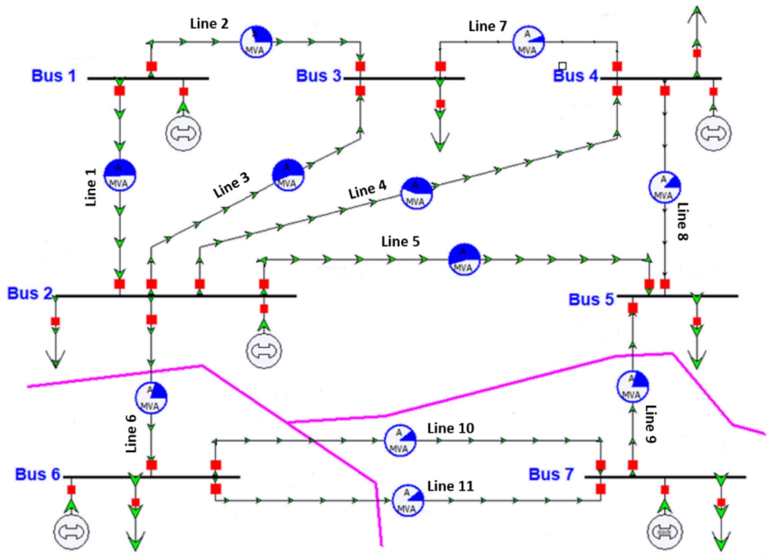
Solution: Switch OFF all AGCs before continegency analysis. Approximate results are shown:

Initial generation at bus 2 = 150 MW

Case/ Contingency	**Line violation (@100%)**		**Bus 2 generation**	**Transaction change (UTC)**
	From bus	**To bus**	**MW**	**MW**
Base case	2	5	320	170
Line 1 out	2	5	352	202
Line 2 out	2	3	277	127
Line 3 out	2	5	299	149
Line 4 out	2	5	292	142
Line 5 out	4	5	203	53
Line 6 out	2	5	203	53
Line 7 out	2	5	315	165
Line 8 out	2	5	275	125
Line 9 out	2	6	349	199
Line 10 out	2	5	273	123
Line 11 out	2	5	273	123

The UTC between bus 2 and system slack bus 7 is the minimum UTC. This equals **53 MW** which occurs for single line contingencies for line 5 and line 6 outages.

3. Using a matrix package such as Matlab, calculate the injection shift factor (ISF) matix.



Solution:

a) Obtain A and $\tilde{\mathbf{B}}$ matrices from the one-line diagram

$\mathbf{A}$ =

	Bus 1	Bus 2	Bus 3	Bus 4	Bus 5	Bus 6
Line 1	1	-1	0	0	0	0
Line 2	1	0	-1	0	0	0
Line 3	0	1	-1	0	0	0
Line 4	0	1	0	-1	0	0
Line 5	0	1	0	0	-1	0
Line 6	0	1	0	0	0	-1
Line 7	0	0	1	-1	0	0
Line 8	0	0	0	1	-1	0
Line 9	0	0	0	0	-1	0
Line 10	0	0	0	0	0	1
Line 11	0	0	0	0	0	1

$\tilde{\mathbf{B}}$ = diag{-16.667, -4.1667, -5.556, -5.556, -8.333, -16.667, -33.333, -4.167, -16.667, -4.167, -4.167}

b) Compute $\mathbf{B}' = \mathbf{A}'\,\tilde{\mathbf{B}}\,\mathbf{A}$

$\mathbf{B}'$ =

-20.8333	16.66667	4.166667	0	0	0
16.66667	-52.7778	5.555556	5.555556	8.333333	16.66667
4.166667	5.555556	-43.0556	33.33333	0	0
0	5.555556	33.33333	-43.0556	4.166667	0
0	8.333333	0	4.166667	-29.1667	0
0	16.66667	0	0	0	-25

c) Finally, compute injection shift factor matrix, $\boldsymbol{\Psi} = \tilde{\mathbf{B}}\,\mathbf{A}[\mathbf{B}']^{-1}$

$\boldsymbol{\Psi} =$

	Bus 1	Bus 2	Bus 3	Bus 4	Bus 5	Bus 6
Line 1	0.811	-0.031	0.180	0.136	0.010	-0.021
Line 2	0.189	0.031	-0.180	-0.136	-0.010	0.021
Line 3	-0.018	0.052	-0.300	-0.227	-0.017	0.035
Line 4	0.010	0.066	-0.213	-0.288	-0.022	0.044
Line 5	0.379	0.400	0.295	0.267	-0.133	0.267
Line 6	0.439	0.450	0.398	0.384	0.183	-0.367
Line 7	0.171	0.084	0.520	-0.363	-0.028	0.056
Line 8	0.182	0.150	0.307	0.349	-0.050	0.100
Line 9	-0.561	-0.550	-0.602	-0.616	-0.817	-0.367
Line 10	0.220	0.225	0.199	0.192	0.092	0.317
Line 11	0.220	0.225	0.199	0.192	0.092	0.317

4. Using your results from question 2, calculate the PTDFs on all the lines for a transaction between bus 2 and bus 7.

Solution: For any line(l), the PTDF due to a transaction between bus 2 and bus 7 (slack) is calculated by taking the difference between ISF values of bus 2 and bus 7 for that line.

$$\varphi_{\ell}^{w(2-7)} = \psi_l^2 - \psi_l^7$$

ψ_l^7 is a zero column (under bus 7), hence,

Hence, $\varphi_{\ell}^{w(2-7)} = \psi_l^2 =$

$\varphi_{line\,1}^{w(2-7)} \rightarrow$	-0.031
$\varphi_{line\,2}^{w(2-7)} \rightarrow$	0.031
	0.052
•	0.066
•	0.400
•	0.450
•	0.084
•	0.150
•	-0.550
	0.225
$\varphi_{line\,11}^{w(2-7)} \rightarrow$	0.225

5. Calculate the LODFs on all lines for the outage of the line between buses 2 and 5.

Solution: Line 5 connects buses 2 and 5. Thus, for any line, l,

$$d_{\ell}^{5} = \frac{\varphi_{\ell}^{(w_5)}}{1 - \varphi_{5}^{(w_5)}}$$

Line, *l*	LODF
1	-0.0898
2	0.0898
3	0.1496
4	0.1895
5	-1.0000
6	0.5711
7	0.2394
8	0.4289
9	0.5711
10	0.2855
11	0.2855

6. Calculate the LODFs on all the lines for the double outage of the line between buses 2 and 5 and the line between buses 2 and 4

Solution:

k1 = Line 4 (connects buses 2 and 4)
k2 = Line 5 (connects buses 2 and 5)

$$[LODF_{l,(2-4)} \;\; LODF_{l,(2-5)}] = \begin{bmatrix} d_\ell^4 & d_\ell^5 \end{bmatrix} \begin{bmatrix} 1 & -d_4^5 \\ -d_5^4 & 1 \end{bmatrix}^{-1}$$

Line	LODF(2-4)	LODF(2-5)
1	-0.2891	-0.1446
2	0.2891	0.1446
3	0.4820	0.2411
4	-1.0000	0.0000
5	0.0000	-1.0000
6	0.2288	0.6143
7	0.7710	0.3855
8	-0.2288	0.3857
9	0.2288	0.6143
10	0.1145	0.3073
11	0.1145	0.3073

7. Extra Credit Problem: Code the Tinney Scheme 2 algorithm, which requires that you actually add the fills. Then test your algorithm using the 37 bus network from problem 4. Turn in a listing of your program and the Tinney Scheme 2 numbering for this case. Break ties numerically (i.e., bus 1 before bus 2).

Tinney 2 algorithm results in:

Elimination order	14	25	1	2	3	6	7	9	10	11	12	15	16	17	19	22	23	26
PW Bus Index	21	37	1	3	5	13	14	16	17	18	19	24	27	28	30	33	34	38

33	34	36	37	4	8	13	24	20	31	5	18	29	21	27	28	30	32	35
50	53	55	56	10	15	20	35	31	47	12	29	41	32	39	40	44	48	54