Homework Set 5 - Solutions

ECE 530

November 11, 2015

1

Using PowerWorld, the UTC between buses 2 and 7 is the minimum power transfer capability without overloading any lines considering all single line contingencies. Line 5 or 6 would be the limiting line outage, as only a 53 MW transfer can occur if either line 5 or 6 is disconnected. The UTC is therefore 53 MW.

Contingency	UTC 2-7 (MW)
Base	172
1	203
2	135
3	150
4	143
5	53
6	53
7	165
8	125
9	200
10	125
11	125

PROBLEM 2: CALCULATE THE ISF MATRIX

```
% A Matrix
A = [1  -1 0  0  0  0;
     1  0  -1 0  0  0;
     0  1  -1 0  0  0;
     0  1  0  -1 0  0;
     0  1  0  0  -1 0;
     0  1  0  0  0  -1;
     0  0  1  -1 0  0;
     0  0  0  1  -1 0;
     0  0  0  0  -1 0;
     0  0  0  0  0  1;
     0  0  0  0  0  1 ];
 % B~ = -diag{b1,b2,...,bL}
 xk = [0.06 0.24 0.18 0.18 0.12 0.06 0.03 0.24 0.06 0.24 0.24];
 bk = 1./xk;
 B_tilde = -diag(bk);
 % B' = A^T*B~*A
 B_prime = transpose(A)*B_tilde*A;

% Find the Injection Shift Factor (ISF) Matrix
fprintf('\nProblem 2: ISF Matrix\n')
psi = B_tilde*A*(B_prime)^-1
```

```
Problem 2: ISF Matrix

psi =

    0.8108   -0.0314    0.1799    0.1362    0.0105   -0.0210
    0.1892    0.0314   -0.1799   -0.1362   -0.0105    0.0210
   -0.0180    0.0524   -0.2998   -0.2270   -0.0175    0.0349
    0.0105    0.0664   -0.2130   -0.2875   -0.0221    0.0442
    0.3789    0.3999    0.2951    0.2672   -0.1333    0.2666
    0.4395    0.4499    0.3976    0.3836    0.1834   -0.3667
    0.1711    0.0838    0.5204   -0.3632   -0.0279    0.0559
    0.1816    0.1502    0.3073    0.3492   -0.0501    0.1001
   -0.5605   -0.5501   -0.6024   -0.6164   -0.8166   -0.3667
    0.2197    0.2250    0.1988    0.1918    0.0917    0.3166
    0.2197    0.2250    0.1988    0.1918    0.0917    0.3166
```

PROBLEM 3: CALCULATE THE PTDFS FOR A TRANSACTION BETWEEN 2 AND 7

$$\phi_l^{(w)} = \psi_l^m - \psi_l^n$$

```
psi(:,7) = 0;

for i = 1:11
    PTDF_2to7(i,:) = [i, (psi(i,2)-psi(i,7))];
end

fprintf('\nProblem 3: PTDFs\n')
header = {'LineNumber','PTDFs'};
output = dataset({PTDF_2to7, header{:}});
disp(output)
```

```
Problem 3: PTDFs
    LineNumber    PTDFs
     1            -0.031432
     2             0.031432
     3             0.052386
     4             0.066356
     5              0.39988
     6              0.44994
     7             0.083818
     8              0.15017
     9             -0.55006
    10              0.22497
    11              0.22497
```

PROBLEM 4: CALCULATE THE LODFS FOR AN OUTAGE OF THE LINE BETWEEN 2 AND 5

$$d_l^k = \frac{\phi_l^{(w_k)}}{(1-\phi_k^{(w_k)})}$$

```
for i = 1:11
    LODF_2to5(i,:) = [i,((psi(i,2)-psi(i,5))/(1-(psi(5,2)-psi(5,5))))];
end

LODF_2to5(5,2) = -1.0;

fprintf('\nProblem 4: LODFs\n')
header = {'LineNumber','LODF'};
output = dataset({LODF_2to5, header{:}});
disp(output)
```

```
Problem 4: LODFs
    LineNumber    LODF
     1            -0.089776
     2             0.089776
     3              0.14963
     4              0.18953
     5                   -1
     6              0.57107
     7               0.2394
     8              0.42893
     9              0.57107
    10              0.28554
    11              0.28554
```

PROBLEM 5: CALCULATE LODFS FOR OUTAGES BETWEEN 2 AND 5, AND 2 AND 4

```
for i = 1:11
    LODF_2to4(i,:) = [i,((psi(i,2)-psi(i,4))/(1-(psi(4,2)-psi(4,4))))];
end

LODF_2to4(4,2) = -1.0;

df = [1    -LODF_2to5(4,2);
       -LODF_2to4(5,2)   1];

for i = 1:11
    dkl = [LODF_2to4(i,2) LODF_2to5(i,2)];
    LODFmult(i,:) = [i, dkl*inv(df)];
end

fprintf('\nProblem 5: LODFs\n')
header = {'LineNumber','LODF2and5','LODF2and4'};
output = dataset({LODFmult, header{:}});
disp(output)
```

```
Problem 5: LODFs
    LineNumber    LODF2and5    LODF2and4
     1            -0.28916     -0.14458
     2             0.28916      0.14458
     3             0.48193      0.24096
     4                  -1            0
     5                   0           -1
     6             0.22892      0.61446
     7             0.77108      0.38554
     8            -0.22892      0.38554
     9             0.22892      0.61446
    10             0.11446      0.30723
    11             0.11446      0.30723
```

PROBLEM 6:CALCULATE LODFS FOR OUTAGES BETWEEN 2 AND 6, AND 5 AND 7

```
for i = 1:11
    LODF_2to6(i,:) = [i,((psi(i,2)-psi(i,6))/(1-(psi(6,2)-psi(6,6))))];
    LODF_7to5(i,:) = [i,((psi(i,7)-psi(i,5))/(1-(psi(9,7)-psi(9,5))))];
end

LODF_2to6(6,2) = -1.0;
LODF_7to5(9,2) = -1.0;

fprintf('\nProblem 6: LODFs\n')
header = {'LineNumber','LODF2and6','LODF5and7'};
output = dataset({[LODF_2to6 LODF_7to5(:,2)], header{:}});
disp(output)

df1 = [1, -LODF_2to6(9,2);
    -LODF_7to5(6,2), 1]

% Because the LODFs are the same between the two line outages, df1 is
% singular and the LODFs for the double line outage cannot be calculated.
```

```
Problem 6: LODFs
    LineNumber    LODF2and6    LODF5and7
     1            -0.057143    -0.057143
     2             0.057143     0.057143
     3             0.095238     0.095238
     4              0.12063      0.12063
     5              0.72698      0.72698
     6                   -1           -1
     7              0.15238      0.15238
     8              0.27302      0.27302
     9                   -1           -1
    10                 -0.5         -0.5
    11                 -0.5         -0.5


df1 =

    1.0000    1.0000
    1.0000    1.0000
```

Problem 7: Calculate the OTDF for a transfer from 2 to 7

$$(\phi_l^w)^k = \phi_l^w + d_l^k \times \phi_k^w$$
$$k = 5, l = 2 \rightarrow 7$$

```
for i = 1:11
    dkl = (psi(i,2)-psi(i,5))/(1-(psi(5,2)-psi(5,5)));
    OTDF(i,:) = [i, (PTDF_2to7(i,2) + dkl*PTDF_2to7(5,2))];
end

fprintf('\nProblem 7: OTDFs\n')
header = {'LineNumber','OTDF'};
output = dataset({OTDF, header{:}});
disp(output)
```

```
Problem 7: OTDFs
    LineNumber    OTDF
     1            -0.067332
     2             0.067332
     3              0.11222
     4              0.14214
     5              0.85661
     6               0.6783
     7              0.17955
     8               0.3217
     9              -0.3217
    10              0.33915
    11              0.33915
```