```
% ECSE 563 assigmenet 1
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% https://github.com/Bakalala/MGCILL-ECSE-563
```

```
% Question 1

% Load parameters for IEEE9_A1
run('ieee9_A1.m');

Y = admittance(nfrom, nto, r, x, b)
```

```
Y = 9×9 complex
   0.0000 -17.3611i   0.0000 + 0.0000i   0.0000 + 0.0000i   0.0000 +17.3611i ⋯
   0.0000 + 0.0000i   0.0000 -16.0000i   0.0000 + 0.0000i   0.0000 + 0.0000i
   0.0000 + 0.0000i   0.0000 + 0.0000i   0.0000 -17.0648i   0.0000 + 0.0000i
   0.0000 +17.3611i   0.0000 + 0.0000i   0.0000 + 0.0000i   3.3074 -39.3089i
   0.0000 + 0.0000i   0.0000 + 0.0000i   0.0000 + 0.0000i  -1.9422 +10.5107i
   0.0000 + 0.0000i   0.0000 + 0.0000i   0.0000 +17.0648i   0.0000 + 0.0000i
   0.0000 + 0.0000i   0.0000 + 0.0000i   0.0000 + 0.0000i   0.0000 + 0.0000i
   0.0000 + 0.0000i   0.0000 +16.0000i   0.0000 + 0.0000i   0.0000 + 0.0000i
   0.0000 + 0.0000i   0.0000 + 0.0000i   0.0000 + 0.0000i  -1.3652 +11.6041i
```

```
% Calculate V and convert to polar
V = Y \ Iint;
Vpolar_original = [abs(V), rad2deg(angle(V))]
```

```
Vpolar_original = 9×2
    1.0001   -0.0060
    1.0001    9.6638
    1.0001    4.7653
    0.9871   -2.4100
    0.9756   -4.0208
    1.0035    1.9178
    0.9858    0.6152
    0.9963    3.7918
    0.9578   -4.3537
```

```
% Question 2
% Load parameters for IEEE9_A1
run('ieee9_A1.m');

% Impedance matrix
Z = impedance(nfrom, nto, r, x, b)
```

```
Z = 9×9 complex
   0.0103 - 0.6225i  -0.0046 - 0.7614i  -0.0061 - 0.7644i   0.0103 - 0.6801i ⋯
  -0.0046 - 0.7614i   0.0089 - 0.6194i   0.0001 - 0.7484i  -0.0046 - 0.7614i
  -0.0061 - 0.7644i   0.0001 - 0.7484i   0.0096 - 0.6249i  -0.0061 - 0.7644i
   0.0103 - 0.6801i  -0.0046 - 0.7614i  -0.0061 - 0.7644i   0.0103 - 0.6801i
   0.0032 - 0.7208i  -0.0056 - 0.7686i  -0.0037 - 0.7475i   0.0032 - 0.7208i
  -0.0061 - 0.7644i   0.0001 - 0.7484i   0.0096 - 0.6835i  -0.0061 - 0.7644i
  -0.0060 - 0.7684i   0.0047 - 0.7150i   0.0035 - 0.7268i  -0.0060 - 0.7684i
  -0.0046 - 0.7614i   0.0089 - 0.6819i   0.0001 - 0.7484i  -0.0046 - 0.7614i
   0.0053 - 0.7178i  -0.0029 - 0.7439i  -0.0058 - 0.7691i   0.0053 - 0.7178i
```

```
% Question 3
% Load parameters for IEEE9_A1

run('ieee9_A1.m');

Zf = 0;
for idfault = 1:size(Y,1)
    idfault
    [If, Vf] = fault(Y, Iint, idfault, Zf);
    Ifpolar = [abs(If), rad2deg(angle(If))]
    Vpolar = [abs(Vf), rad2deg(angle(Vf))]
    Vpolar_diff = Vpolar_original - Vpolar
    RMSE = rmse(Vpolar_original, Vpolar_diff, 1)

end
```

```
idfault = 
1
Ifpolar = 1×2
    1.6064   89.0450
Vpolar = 9×2
    0.0000  -90.0000
    0.3072  140.4306
    0.2573  153.8770
    0.1136 -159.4655
    0.1924 -163.6047
    0.2336  164.1530
    0.2516  170.6862
    0.2471  157.7116
    0.2076 -162.6161
Vpolar_diff = 9×2
    1.0001   89.9940
    0.6929 -130.7668
    0.7428 -149.1117
    0.8735  157.0555
    0.7832  159.5839
    0.7699 -162.2352
    0.7342 -170.0710
    0.7492 -153.9198
    0.7502  158.2624
RMSE = 1×2
    0.2192  153.1490
idfault = 
2
Ifpolar = 1×2
    1.6146   98.8370
Vpolar = 9×2
    0.2819 -139.9119
    0.0000  -14.0362
    0.2225 -152.4966
    0.3200 -135.8400
    0.3568 -135.4784
    0.2443 -141.4490
    0.2324 -131.4385
    0.1489 -127.9122
    0.3433 -132.6227
Vpolar_diff = 9×2
    0.7182  139.9059
    1.0001   23.7000
    0.7776  157.2619
    0.6671  133.4300
    0.6188  131.4576
    0.7592  143.3667
    0.7534  132.0537
    0.8474  131.7040
    0.6145  128.2690
RMSE = 1×2
    0.2609  129.5585
idfault = 
3
Ifpolar = 1×2
    1.6003   93.8833
Vpolar = 9×2
    0.2328 -161.6563
    0.2262  157.4961
    0.0000 -172.8750
    0.2614 -153.9779
    0.2632 -146.9710
    0.1036 -147.3795
    0.1893 -157.0800
    0.2014 -175.6068
    0.3105 -151.7848
Vpolar_diff = 9×2
    0.7673  161.6503
    0.7739 -147.8324
    1.0001  177.6403
    0.7257  151.5680
    0.7124  142.9502
    0.8999  149.2973
    0.7965  157.6952
    0.7950  179.3985
    0.6473  147.4311
RMSE = 1×2
    0.2177  158.6066
idfault = 
4
Ifpolar = 1×2
    1.4513   86.7213
Vpolar = 9×2
    0.0437   71.4432
    0.2649  116.1588
    0.1906  125.4079
         0         0
    0.0726 -169.4621
    0.1484  134.5347
    0.1518  146.8558
    0.1739  128.6497
    0.0880 -166.3063
Vpolar_diff = 9×2
    0.9565  -71.4492
    0.7352 -106.4950
    0.8095 -120.6426
    0.9871   -2.4100
    0.9030  165.4413
    0.8551 -132.6169
    0.8340 -146.2406
    0.8224 -124.8579
    0.8698  161.9526
RMSE = 1×2
    0.1478  127.7655
idfault = 
5
Ifpolar = 1×2
```

```
    1.4325   85.0458
Vpolar = 9×2
    0.0893  108.9139
    0.2925  112.1503
    0.1938  111.0682
    0.0607  134.8647
    0.0000  180.0000
    0.1459  115.7534
    0.1552  133.1643
    0.1974  121.1475
    0.1133  169.6861
Vpolar_diff = 9×2
    0.9109 -108.9199
    0.7076 -102.4865
    0.8062 -106.3029
    0.9264 -137.2747
    0.9756 -184.0208
    0.8576 -113.8356
    0.8306 -132.5491
    0.7990 -117.3557
    0.8445 -174.0398
RMSE = 1×2
    0.1605  134.1501
idfault =
6
Ifpolar = 1×2
    1.4681   91.1114
Vpolar = 9×2
    0.1227 -173.9318
    0.1847  127.5631
    0.0499   97.2527
    0.1464 -158.1995
    0.1500 -145.8366
         0         0
    0.0824 -169.3758
    0.1134  156.9618
    0.1942 -153.6850
Vpolar_diff = 9×2
    0.8774  173.9258
    0.8154 -117.8993
    0.9502  -92.4874
    0.8407  155.7895
    0.8257  141.8158
    1.0035    1.9178
    0.9034  169.9910
    0.8829 -153.1700
    0.7636  149.3314
RMSE = 1×2
    0.1304  141.1155
idfault =
7
Ifpolar = 1×2
    1.4431   89.8954
Vpolar = 9×2
    0.1092  174.4762
    0.1694  105.7093
    0.0955  123.1476
    0.1265 -165.8622
    0.1439 -156.0517
    0.0551  146.4226
    0.0000  -90.0000
    0.0717  121.6723
    0.1555 -155.8001
Vpolar_diff = 9×2
```

```
    0.8909 -174.4822
    0.8308  -96.0455
    0.9045 -118.3823
    0.8606  163.4522
    0.8317  152.0309
    0.9483 -144.5049
    0.9858   90.6152
    0.9246 -117.8805
    0.8023  151.4464
RMSE = 1×2
    0.1149  140.3415
idfault =
8
Ifpolar = 1×2
    1.4610   93.0408
Vpolar = 9×2
    0.1227 -154.7548
    0.1023   94.5962
    0.0985  165.3541
    0.1562 -143.1117
    0.1909 -141.1043
    0.0923 -164.5400
    0.0769 -137.8407
    0.0000         0
    0.1815 -135.9673
Vpolar_diff = 9×2
    0.8774  154.7488
    0.8978  -84.9325
    0.9016 -160.5888
    0.8309  140.7017
    0.7847  137.0835
    0.9112  166.4578
    0.9089  138.4559
    0.9963    3.7918
    0.7763  131.6137
RMSE = 1×2
    0.1262  135.4792
idfault =
9
Ifpolar = 1×2
    1.4077   84.8158
Vpolar = 9×2
    0.0840   94.7024
    0.2725  101.9756
    0.2056  113.1638
    0.0472  116.1451
    0.0793  159.9429
    0.1582  118.1234
    0.1389  124.8042
    0.1715  106.3706
         0         0
Vpolar_diff = 9×2
    0.9161  -94.7084
    0.7276  -92.3119
    0.7945 -108.3985
    0.9399 -118.5551
    0.8964 -163.9637
    0.8453 -116.2056
    0.8469 -124.1890
    0.8248 -102.5788
    0.9578   -4.3537
RMSE = 1×2
    0.1512  111.5990
```

```

% We notice that Vf(id fault) is always 0, since this is a node to gnd
% fault
% The magnitudes of Vf are around 20% of the V we found in part 1, i.e much
% lower due to the fault - this is exepcted due to a short.
% We calculate the RMSE between the vectors, and we notice that magnitudes
% drop the most for nodes 1,2,3 - which are the slack node, as well as the
2 nodes with the highest phase angle,
% meaning they generate reactive power.
```

```
% Question 4
% Load parameters for IEEE9_A1

run('ieee9_A1.m');

id = [3 5]'
```

```
id = 2×1
     3
     5
```

```
[Eeq, Zeq] = genthevenin(Y, Iint, id)
```

```
Eeq = 2×1 complex
   0.9966 + 0.0831i
   0.9732 - 0.0684i
Zeq = 2×2 complex
   0.0096 - 0.6249i  -0.0037 - 0.7475i
  -0.0037 - 0.7475i   0.0111 - 0.6810i
```

```


id = [9 4]'
```

```
id = 2×1
     9
     4
```

```
[Eeq, Zeq] = genthevenin(Y, Iint, id)
```

```
Eeq = 2×1 complex
   0.9550 - 0.0727i
   0.9862 - 0.0415i
Zeq = 2×2 complex
   0.0099 - 0.6803i   0.0053 - 0.7178i
   0.0053 - 0.7178i   0.0103 - 0.6801i
```

```


%Thevenin equivalent circuit attached at the end for 9/4 node system.
```

```
% Question 5
% Load parameters for IEEE9_A1
run('ieee9_A1.m');
```

```
%5.a
% Simulate outage at line 8
% remove elements in id 8
id = 8;
nfrom(id) = [];
nto(id)   = [];
r(id)     = [];
x(id)     = [];
b_temp = j*b(id);
b(id)     = [];

%Calculate Y for the IEEE9_A1 system with line 8 removed
Y = admittance(nfrom, nto, r, x, b);
V = Y \ Iint;
Vpolar = [abs(V), rad2deg(angle(V))]
```

```
Vpolar = 9×2
    1.2450   -7.4947
    1.3746   16.8116
    1.3218    6.8189
    1.2374   -9.4798
    1.2465   -6.8905
    1.3231    4.6576
    1.3242    7.6509
    1.3566   12.5839
    1.2038  -14.8331
```

```

%Disconnecting line 8 (connection between node 8 and 9) resulted in larger
%voltages and angles in the system. This makes sense since the network
%would have less impedance.

%5.a using gen fault
%Calculate Y for the IEEE9_A1 system - reset the values
run('ieee9_A1.m');

function YF = negative_yf(r, x, b)
    % Full cancellation for a single line
    y  = 1/(r + 1j*x);    % series admittance
    yb = 1j*(b/2);        % half shunt at each end
    YF = -[ y + yb,  -y;
            -y,       y + yb ];
end

Y = admittance(nfrom, nto, r, x, b);
%Setup the parameters
YN = Y;
% we use the previous id we set up in part 1. it will be 8 here since line
% 8. We create a YF matrix that 'is opposite' to the YN matrix for the line
% we are cancelling, and we don't inject any current from the Fault side.
YF = negative_yf(r(id), x(id), b(id));
IintN = Iint;
IintF = [0,0]';
```

```
idN = [8 9]';
idF = [1 2]';
[IT, VNF] = genfault(YN, YF, IintN, IintF, idN, idF);
% The tie line currents for Node 1 as seen from the healthy network
IT;
ITpolar = [abs(IT), rad2deg(angle(IT))]
```

```
ITpolar = 2×2
    3.7529  179.4113
    3.7741   -6.3768
```

```
% The V for Node 1 and then other nodes as seen from the healthy network
VNF;
VNFpolar = [abs(VNF), rad2deg(angle(VNF))];
%Reorder to original order to compare
VNFpolar = VNFpolar([3:9 1 2], :)
```

```
VNFpolar = 9×2
    1.2450   -7.4947
    1.3746   16.8116
    1.3218    6.8189
    1.2374   -9.4798
    1.2465   -6.8905
    1.3231    4.6576
    1.3242    7.6509
    1.3566   12.5839
    1.2038  -14.8331
```

```
% We notice that using gen fault and 'removing the line' give the same
% result. IT is (almost) equal and opposite, the shunt terms deviate them a
% little.



%5.b
%Calculate Y for the IEEE9_A1 system - reset the values
run('ieee9_A1.m');

Y = admittance(nfrom, nto, r, x, b);
%Setup the parameters
YN = Y;
YF = Y;
IintN = Iint;
IintF = Iint;

%make the connections and calculate IT and VNF
idN = [1]';
idF = [5]';
[IT, VNF] = genfault(YN, YF, IintN, IintF, idN, idF);
% The tie line currents for Node 1 as seen from the healthy network
IT;
ITpolar = [abs(IT), rad2deg(angle(IT))]
```

```
ITpolar = 1×2
```

```
    0.0563  157.5645
```

```
% The V for Node 1 and then other nodes as seen from the healthy network
VNF;
VNFpolar = [abs(VNF), rad2deg(angle(VNF))]
```

```
VNFpolar = 9×2
    0.9878   -1.8985
    0.9778    7.5432
    0.9809    2.5375
    0.9752   -4.5362
    0.9638   -6.3143
    0.9862   -0.3529
    0.9694   -1.7310
    0.9779    1.5446
    0.9463   -6.6865
```

```
%5.c

%make the connections and calculate IT and VNF
idN = [3 5]';
idF = [7 4]';
[IT, VNF] = genfault(YN, YF, IintN, IintF, idN, idF);
% The tie line currents for Nodes 3,5 as seen from the healthy network
IT;
ITpolar = [abs(IT), rad2deg(angle(IT))]
```

```
ITpolar = 2×2
    0.2735   -4.3887
    0.2842  175.9323
```

```
% The V for Nodes 3,5 and then other nodes as seen from the healthy network
VNF;
VNFpolar = [abs(VNF), rad2deg(angle(VNF))]
```

```
VNFpolar = 9×2
    0.9918    2.4182
    0.9810   -3.3848
    1.0042    0.2179
    0.9965    8.9018
    0.9910   -2.1735
    0.9985    0.4780
    0.9830   -0.4697
    0.9941    3.0101
    0.9605   -4.4756
```

```
%5.d

% Load parameters for IEEE24_A1
run('ieee24_A1.m');

%Calculate Y for the IEEE24_A1 system
Y = admittance(nfrom, nto, r, x, b);
```

```
%Setup the parameters
YN = Y;
YF = Y;
IintN = Iint;
IintF = Iint;

%make the connections and calculate IT and VNF
idN = [7 13 23]';
idF = [3 15 17]';
[IT, VNF] = genfault(YN, YF, IintN, IintF, idN, idF);
% The tie line currents for Nodes 7,13,23 as seen from the healthy network
IT;
ITpolar = [abs(IT), rad2deg(angle(IT))]
```

```
ITpolar = 3×2
    0.6285    5.0002
    2.0075 -176.1139
    1.8032    4.8616
```

```
% The V for Nodes 7,13,23 and then other nodes as seen from the healthy
network
VNF;
VNFpolar = [abs(VNF), rad2deg(angle(VNF))]
```

```
VNFpolar = 24×2
    0.9957   -8.7532
    1.0131    6.6780
    1.0409   12.4247
    1.0117   -4.5223
    1.0115   -4.8092
    0.9522   -1.5813
    0.9650   -6.4771
    1.0017   -6.5348
    0.9788  -13.4075
    0.9651  -10.2640
    0.9660   -3.6608
    1.0224   -5.4746
    0.9842    2.1057
    0.9999    2.9917
    0.9672    4.8457
     ⋮
```