EE 521 Power System Analysis and EE 523 Power System Stability and Control Algorithms

Preamble and Control Inputs

```
tic;
addpath functions\
systemName = "ieee11"
powerFlowMethod =  "NRPF"
useSparseDSA = false;
includeOPFScenarios = false;
showOPFFormulae = false;
showOPFValues = false;
numIterations = 50; %I don't wait for the system to converge,
printPowerFlowConvergenceMessages = false;
% neither do I care if the system converges earlier.
toleranceLimit = 1e-3; %mean of absolute values of
% corrections should be less than this for convergence to be achieved.
displayRawData = true;
displayYBus = true;
displayTables = true; %show busData, branchData, ybus,
% basically data structures which are not the final output.
printJacobians = true  ; %Print Jacobians during NRPF iterations? Does not work if displayTable
printMismatches = false; %Print Mismatches during NRPF iterations? Does not work if displayTabl
printCorrections = false;
disableTaps = false; %Disable Tap-changers when commputing YBus?
showPlots = true;
displayResults = true;
reducedBranchColumnsCDFReading = true;
showImages = true; %might add iteration specific images later.
verboseCDFReading = false; %Will give a verbose output when reading CDF files.
MVAb = 100; %Currently the same for all systems in database.
```

```
folder_rawData = "rawData/"; %location of CDF .txt file for the system
file_rawData = strcat(folder_rawData, systemName, "cdf.txt"); %Exact location of CDF .txt file
folder_processedData = "processedData/";
% Should configure it to be read from the CDF file later.
latex_interpreter %for LaTeX typesetting in plots
```

Read CDF file and store the data in neat MATLAB `tables`: `busData` and `branchData`.

```
[busData, branchData, N, numBranch] = ...
    readCDF(file_rawData, reducedBranchColumnsCDFReading, verboseCDFReading);
if displayTables && displayRawData
    displayRawDataAsTables(busData, branchData, N, numBranch);
end
```

Extract Y_{Bus}, Adjacency List E from the `branchData table.`

```
if useSparseDSA
    [nnzYBus, NYBus] = makeSparseYBus(busData, branchData, displayTables, displayYBus); %#ok
else
    [ybus, BMatrix, ~, ~, ~, E] = ybusGenerator(busData, branchData);
    ybusTable = array2table(ybus, VariableNames=[string(1:N)], RowNames=[string(1:N)]);

end

if ~useSparseDSA && displayTables && displayYBus
    display(ybusTable);
end
```

Run Newton Raphson Power Flow and obtain a steady state snapshot of the system variables P_i, Q_i, V_i, δ_i $\forall$ buses $i \in [1, N], i \in \mathbb{N}$

```
[PSpecified, QSpecified, V, delta, ...
    listOfPQBuses, listOfPVBuses, nPQ, nPV, ...
    listOfNonSlackBuses] = initializeVectors(busData, N, MVAb);

if useSparseDSA
    doTheSparseThing(PSpecified, QSpecified, V, delta, nnzYBus, NYBus, busData); %#ok
else
    if contains(systemName, 'caseThree')
        resultsFromCaseTwo = load("processedData\ieee11-caseTwoResults");
        resultsFromCaseTwo = resultsFromCaseTwo.resultTable;
        wiggle = 0.35; %minimum 0.35 value for good result
        V = V*(1-wiggle) + wiggle*resultsFromCaseTwo.V;
        delta = delta*(1-wiggle) + wiggle*resultsFromCaseTwo.delta;
    end
    [P, Q, V, delta] = solveForPowerFlow(PSpecified, QSpecified, V, delta, ybus, BMatrix, E, N

    resultTable = displayPowerFlowResults(N, P, Q, V, delta, displayResults);
    if contains(systemName, 'caseTwo')
        save("processedData\ieee11-caseTwoResults", "resultTable");
    end
end
```

Compare obtained snapshot values of V_i and δ_i against the ones given in the CDF file.

```
plotPowerFlowResults(showPlots, useSparseDSA, V, busData, systemName, powerFlowMethod, delta);
```

Economic Dispatch and Optimal Power Flow Calculations:

```
if includeOPFScenarios && strcmp(systemName, 'ieee14') && ~useSparseDSA
    runOPFScenarios(busData, P, Q, V, delta, N, ybus, BMatrix, E, nPQ, nPV, listOfPQBuses, lis
end
```

```
toc;
```

Have a nice day!

In case you encounter a Java Heap Memory error, delete the above gif, or go to `Preferences->General->Java Heap Memory` and increase the allocated size.

EE 521 Power System Analysis and EE 523 Power System Stability and Control Algorithms

Preamble and Control Inputs

```
systemName =
"ieee11"

powerFlowMethod =
"NRPF"
```

Read CDF file and store the data in neat MATLAB `tables`: `busData` and `branchData`.

```
busData = 11×18 table
```

...

	bus	busName	loadFlowArea	lossZone	busType	vFinal
1	1	"Bus 1 HV"	1	1	3	1.0300
2	2	"Bus 2 HV"	1	1	2	1.0100
3	3	"Bus 3 HV"	2	1	2	1.0300
4	4	"Bus 4 HV"	2	1	2	1.0100
5	5	"Bus 5 HV"	1	1	0	1.0060
6	6	"Bus 6 LV"	1	1	0	0.9780
7	7	"Bus 7 ZV"	1	1	0	0.9610
8	8	"Bus 8 TV"	3	1	0	0.9490
9	9	"Bus 9 LV"	2	1	0	0.9710
10	10	"Bus 10 LV"	2	1	0	0.9840
11	11	"Bus 11 LV"	2	1	0	1.0080

```
branchData = 10×15 table
```

...

	i	j	loadFlowArea	lossZone	ckt	type	R
1	1	5	1	1	1	0	0
2	2	6	1	1	1	0	0
3	3	11	2	1	1	0	0
4	4	10	2	1	1	0	0
5	5	6	1	1	1	0	0.0025
6	6	7	1	1	1	0	0.0010
7	7	8	1	1	1	0	0.0055
8	8	9	2	1	1	0	0.0055
9	9	10	2	1	1	0	0.0010
10	10	11	2	1	1	0	0.0025

```
N = 11
numBranch = 10
```

Extract Y_{Bus}, Adjacency List E from the `branchData table.`

```
ybusTable = 11×11 table
```

...

	1	2	3	4	5
1 1	0.0000 -59.9880i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 +59.9880i
2 2	0.0000 + 0.0000i	0.0000 -59.9880i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i
3 3	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 -59.9880i	0.0000 + 0.0000i	0.0000 + 0.0000i
4 4	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 -59.9880i	0.0000 + 0.0000i
5 5	0.0000 +59.9880i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	3.9604 -99.5701i
6 6	0.0000 + 0.0000i	0.0000 +59.9880i	0.0000 + 0.0000i	0.0000 + 0.0000i	-3.9604 +39.6040i
7 7	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i
8 8	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i
9 9	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i
10 10	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 +59.9880i	0.0000 + 0.0000i
11 11	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 +59.9880i	0.0000 + 0.0000i	0.0000 + 0.0000i

Run Newton Raphson Power Flow and obtain a steady state snapshot of the system variables $P_i, Q_i, V_i, \delta_i\ \forall$ buses $i \in [1, N], i \in \mathbb{N}$

```
Iteration Number 1 Jacobian:
JTable = 17×17 table
```

...

	$delta_2$	$delta_3$	$delta_4$	$delta_5$	$delta_6$	$delta_7$
1 P_2	60.5879	0	0	0	-60.5879	0
2 P_3	0	61.7876	0	0	0	0
3 P_4	0	0	60.5879	0	0	0
4 P_5	0	0	0	101.3916	-39.6040	0
5 P_6	-60.5879	0	0	-39.6040	199.2017	-99.0099
6 P_7	0	0	0	0	-99.0099	117.0117
7 P_8	0	0	0	0	0	-18.0018
8 P_9	0	0	0	0	0	0
9 P_10	0	0	-60.5879	0	0	0
10 P_11	0	-61.7876	0	0	0	0
11 Q_5	0	0	0	-3.9604	3.9604	0
12 Q_6	-0	0	0	3.9604	-13.8614	9.9010
13 Q_7	0	0	0	0	9.9010	-11.7012

	$delta_2$	$delta_3$	$delta_4$	$delta_5$	$delta_6$	$delta_7$
14 Q_8	0	0	0	0	0	1.8002
15 Q_9	0	0	0	0	0	0
16 Q_10	0	0	-0	0	0	0
17 Q_11	0	-0	0	0	0	0

```
Iteration Number 2 Jacobian:
JTable = 17×17 table
```

...

	$delta_2$	$delta_3$	$delta_4$	$delta_5$	$delta_6$	$delta_7$
1 P_2	62.4416	0	0	0	-62.4416	0
2 P_3	0	64.1116	0	0	0	0
3 P_4	0	0	62.9589	0	0	0
4 P_5	0	0	0	106.8334	-42.8853	0
5 P_6	-62.4416	0	0	-41.5654	211.8705	-107.8634
6 P_7	0	0	0	0	-105.0023	125.0538
7 P_8	0	0	0	0	0	-19.2736
8 P_9	0	0	0	0	0	0
9 P_10	0	0	-62.9589	0	0	0
10 P_11	0	-64.1116	0	0	0	0
11 Q_5	0	0	0	-4.0096	-2.3765	0
12 Q_6	7.2464	0	0	10.8216	-14.4060	-3.6620
13 Q_7	0	0	0	0	24.9486	-23.0256
14 Q_8	0	0	0	0	0	5.8554
15 Q_9	0	0	0	0	0	0
16 Q_10	0	0	7.3065	0	0	0
17 Q_11	0	7.4943	0	0	0	0

```
Iteration Number 3 Jacobian:
JTable = 17×17 table
```

...

	$delta_2$	$delta_3$	$delta_4$	$delta_5$	$delta_6$	$delta_7$
1 P_2	59.1939	0	0	0	-59.1939	0
2 P_3	0	62.0471	0	0	0	0
3 P_4	0	0	59.5177	0	0	0
4 P_5	0	0	0	101.3844	-39.4132	0
5 P_6	-59.1939	0	0	-38.0634	192.0894	-94.8321
6 P_7	0	0	0	0	-92.1279	108.8595
7 P_8	0	0	0	0	0	-15.9653

	$delta_2$	$delta_3$	$delta_4$	$delta_5$	$delta_6$	$delta_7$
8 P_9	0	0	0	0	0	0
9 P_10	0	0	-59.5177	0	0	0
10 P_11	0	-62.0471	0	0	0	0
11 Q_5	0	0	0	-4.0635	-2.8751	0
12 Q_6	6.9933	0	0	10.6227	-13.4428	-4.1732
13 Q_7	0	0	0	0	22.8692	-20.6724
14 Q_8	0	0	0	0	0	5.4665
15 Q_9	0	0	0	0	0	0
16 Q_10	0	0	6.9950	0	0	0
17 Q_11	0	7.1920	0	0	0	0

```
Iteration Number 4 Jacobian:
JTable = 17×17 table
```

...

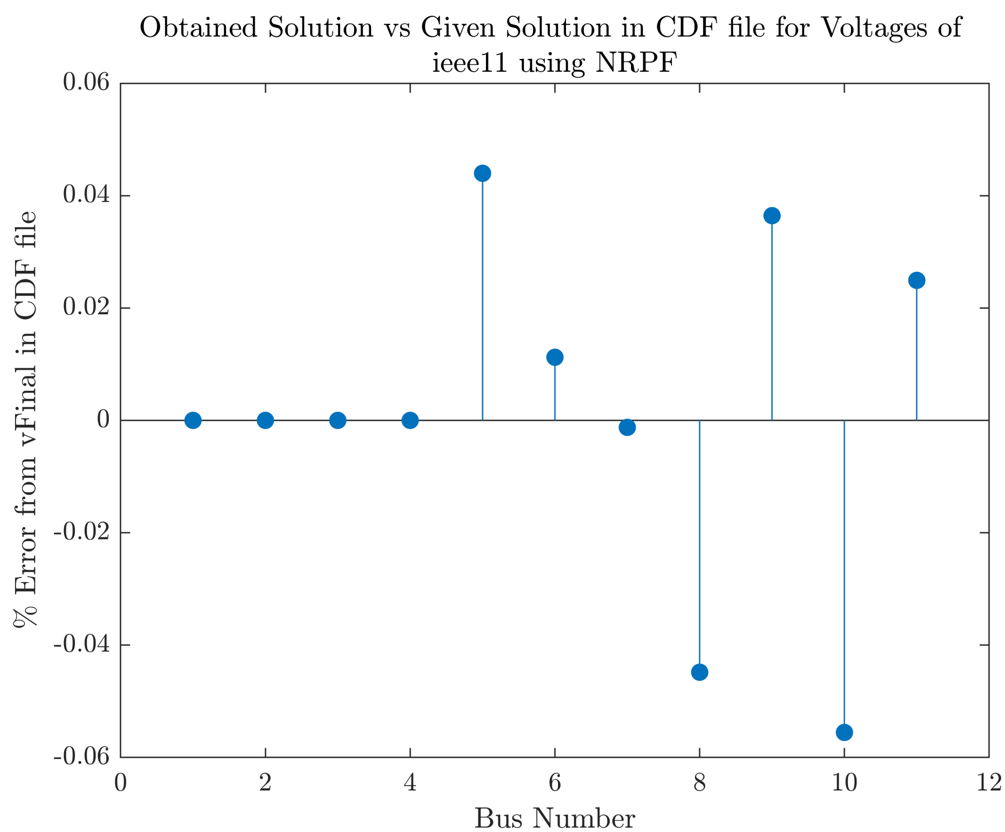
	$delta_2$	$delta_3$	$delta_4$	$delta_5$	$delta_6$	$delta_7$
1 P_2	58.8549	0	0	0	-58.8549	0
2 P_3	0	61.8842	0	0	0	0
3 P_4	0	0	59.1799	0	0	0
4 P_5	0	0	0	100.8691	-39.0748	0
5 P_6	-58.8549	0	0	-37.7096	190.0235	-93.4590
6 P_7	0	0	0	0	-90.7375	107.0731
7 P_8	0	0	0	0	0	-15.5496
8 P_9	0	0	0	0	0	0
9 P_10	0	0	-59.1799	0	0	0
10 P_11	0	-61.8842	0	0	0	0
11 Q_5	0	0	0	-4.0129	-2.9865	0
12 Q_6	6.9997	0	0	10.6650	-13.2670	-4.3977
13 Q_7	0	0	0	0	22.8173	-20.4812
14 Q_8	0	0	0	0	0	5.5247
15 Q_9	0	0	0	0	0	0
16 Q_10	0	0	6.9998	0	0	0
17 Q_11	0	7.1900	0	0	0	0

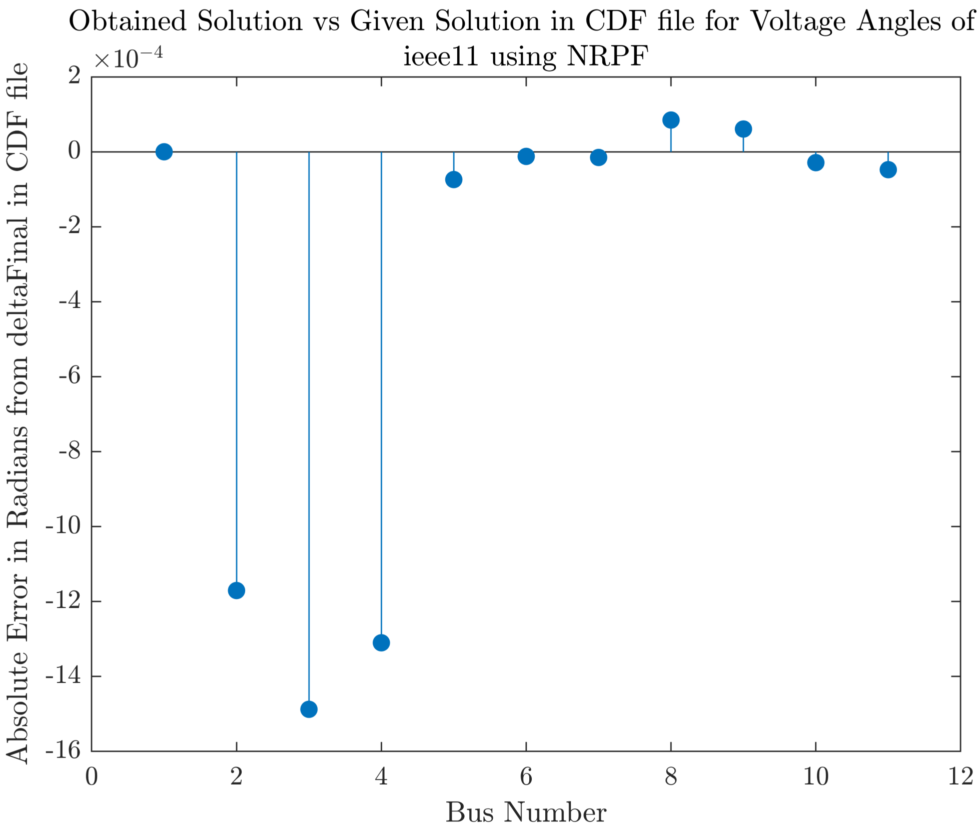
```
Convergence using NRPF achieved in 4 iterations.
resultTable = 11×4 table
```

	P	Q	V	delta
1 Bus_1	6.9995	1.8469	1.0300	0
2 Bus_2	6.9997	2.3389	1.0100	-0.1705

	P	Q	V	delta
3 Bus_3	7.1900	1.7571	1.0300	-0.4727
4 Bus_4	6.9998	2.0139	1.0100	-0.6506
5 Bus_5	-0.0009	0.0003	1.0064	-0.1128
6 Bus_6	-0.0023	0.0010	0.9781	-0.2889
7 Bus_7	-9.6703	-0.9983	0.9610	-0.4356
8 Bus_8	0.0003	0.0022	0.9486	-0.6778
9 Bus_9	-17.6648	-0.9988	0.9714	-0.9152
10 Bus_10	-0.0009	0.0007	0.9835	-0.7683
11 Bus_11	-0.0001	0.0001	1.0083	-0.5884

Compare obtained snapshot values of V_i and δ_i against the ones given in the CDF file.





Economic Dispatch and Optimal Power Flow Calculations:

```
Elapsed time is 1.376304 seconds.
```

Have a nice day!

In case you encounter a Java Heap Memory error, delete the above gif, or go to `Preferences->General->Java Heap Memory` and increase the allocated size.

EE 521 Power System Analysis and EE 523 Power System Stability and Control Algorithms

Preamble and Control Inputs

```
systemName =
"ieee11"

powerFlowMethod =
"Fast Decoupled NRPF"
```

Read CDF file and store the data in neat MATLAB `tables`: `busData` and `branchData`.

`busData = 11×18 table`

...

	bus	busName	loadFlowArea	lossZone	busType	vFinal
1	1	"Bus 1 HV"	1	1	3	1.0300
2	2	"Bus 2 HV"	1	1	2	1.0100
3	3	"Bus 3 HV"	2	1	2	1.0300
4	4	"Bus 4 HV"	2	1	2	1.0100
5	5	"Bus 5 HV"	1	1	0	1.0060
6	6	"Bus 6 LV"	1	1	0	0.9780
7	7	"Bus 7 ZV"	1	1	0	0.9610
8	8	"Bus 8 TV"	3	1	0	0.9490
9	9	"Bus 9 LV"	2	1	0	0.9710
10	10	"Bus 10 LV"	2	1	0	0.9840
11	11	"Bus 11 LV"	2	1	0	1.0080

`branchData = 10×15 table`

...

	i	j	loadFlowArea	lossZone	ckt	type	R
1	1	5	1	1	1	0	0
2	2	6	1	1	1	0	0
3	3	11	2	1	1	0	0
4	4	10	2	1	1	0	0
5	5	6	1	1	1	0	0.0025
6	6	7	1	1	1	0	0.0010
7	7	8	1	1	1	0	0.0055
8	8	9	2	1	1	0	0.0055
9	9	10	2	1	1	0	0.0010
10	10	11	2	1	1	0	0.0025

```
N = 11
numBranch = 10
```

Extract Y_{Bus}, Adjacency List E from the `branchData table.`

```
ybusTable = 11×11 table
```

...

	1	2	3	4	5
1 1	0.0000 -59.9880i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 +59.9880i
2 2	0.0000 + 0.0000i	0.0000 -59.9880i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i
3 3	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 -59.9880i	0.0000 + 0.0000i	0.0000 + 0.0000i
4 4	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 -59.9880i	0.0000 + 0.0000i
5 5	0.0000 +59.9880i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	3.9604 -99.5701i
6 6	0.0000 + 0.0000i	0.0000 +59.9880i	0.0000 + 0.0000i	0.0000 + 0.0000i	-3.9604 +39.6040i
7 7	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i
8 8	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i
9 9	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i
10 10	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 +59.9880i	0.0000 + 0.0000i
11 11	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 +59.9880i	0.0000 + 0.0000i	0.0000 + 0.0000i

Run Newton Raphson Power Flow and obtain a steady state snapshot of the system variables $P_i, Q_i, V_i, \delta_i \ \forall$ buses $i \in [1, N], i \in \mathbb{N}$

```
Iteration Number 1 Jacobian J11:
J11Table = 10×10 table
```

...

	$delta_2$	$delta_3$	$delta_4$	$delta_5$	$delta_6$	$delta_7$
1 P_2	60.5879	0	0	0	-60.5879	0
2 P_3	0	61.7876	0	0	0	0
3 P_4	0	0	60.5879	0	0	0
4 P_5	0	0	0	101.8314	-40	0
5 P_6	-60.5879	0	0	-40	200.6491	-100
6 P_7	0	0	0	0	-100	122.5843
7 P_8	0	0	0	0	0	-18.1818
8 P_9	0	0	0	0	0	0
9 P_10	0	0	-60.5879	0	0	0
10 P_11	0	-61.7876	0	0	0	0

```
Iteration Number 1 Jacobians:
J22Table = 7×7 table
```

...

	$DeltaVByV_5$	$DeltaVByV_6$	$DeltaVByV_7$	$DeltaVByV_8$
1 Q_5	98.0700	2.6691	0	0
2 Q_6	-2.6691	199.6509	9.6758	0
3 Q_7	0	-9.6758	119.5336	0.9156
4 Q_8	0	0	-0.9156	36.4006
5 Q_9	0	0	0	-1.1135
6 Q_10	0	0	0	0
7 Q_11	0	0	0	0

```
Iteration Number 2 Jacobian J11:
J11Table = 10×10 table
```

...

	$delta_2$	$delta_3$	$delta_4$	$delta_5$	$delta_6$	$delta_7$
1 P_2	60.3141	0	0	0	-60.7189	0
2 P_3	0	62.3014	0	0	0	0
3 P_4	0	0	59.9979	0	0	0
4 P_5	0	0	0	104.0569	-40.8771	0
5 P_6	-60.7189	0	0	-40.8771	201.4831	-100.1002
6 P_7	0	0	0	0	-100.1002	121.4679
7 P_8	0	0	0	0	0	-18.3333
8 P_9	0	0	0	0	0	0
9 P_10	0	0	-60.4006	0	0	0
10 P_11	0	-62.7256	0	0	0	0

```
Iteration Number 2 Jacobians:
J22Table = 7×7 table
```

...

	$DeltaVByV_5$	$DeltaVByV_6$	$DeltaVByV_7$	$DeltaVByV_8$
1 Q_5	104.0890	5.2546	0	0
2 Q_6	-5.2546	200.7991	12.2541	0
3 Q_7	0	-12.2541	119.2798	2.8758
4 Q_8	0	0	-2.8758	37.8586
5 Q_9	0	0	0	-3.0141
6 Q_10	0	0	0	0
7 Q_11	0	0	0	0

```
Iteration Number 3 Jacobian J11:
J11Table = 10×10 table
```

...

	$delta_2$	$delta_3$	$delta_4$	$delta_5$	$delta_6$	$delta_7$
1 P_2	60.3472	0	0	0	-60.7475	0

	$delta_2$	$delta_3$	$delta_4$	$delta_5$	$delta_6$	$delta_7$
2 P_3	0	62.2490	0	0	0	0
3 P_4	0	0	60.2359	0	0	0
4 P_5	0	0	0	103.8189	-40.8578	0
5 P_6	-60.7475	0	0	-40.8578	200.9119	-100.0309
6 P_7	0	0	0	0	-100.0309	120.6333
7 P_8	0	0	0	0	0	-18.1160
8 P_9	0	0	0	0	0	0
9 P_10	0	0	-60.6283	0	0	0
10 P_11	0	-62.6447	0	0	0	0

```
Iteration Number 3 Jacobians:
J22Table = 7×7 table
```

...

	$DeltaVByV_5$	$DeltaVByV_6$	$DeltaVByV_7$	$DeltaVByV_8$
1 Q_5	103.9159	6.2959	0	0
2 Q_6	-6.2959	201.5133	13.2413	0
3 Q_7	0	-13.2413	119.2940	3.5434
4 Q_8	0	0	-3.5434	36.9668
5 Q_9	0	0	0	-3.5277
6 Q_10	0	0	0	0
7 Q_11	0	0	0	0

```
Iteration Number 4 Jacobian J11:
J11Table = 10×10 table
```

...

	$delta_2$	$delta_3$	$delta_4$	$delta_5$	$delta_6$	$delta_7$
1 P_2	60.2266	0	0	0	-60.6285	0
2 P_3	0	62.3337	0	0	0	0
3 P_4	0	0	60.1280	0	0	0
4 P_5	0	0	0	103.4944	-40.7363	0
5 P_6	-60.6285	0	0	-40.7363	199.8126	-99.4471
6 P_7	0	0	0	0	-99.4471	119.5230
7 P_8	0	0	0	0	0	-17.8883
8 P_9	0	0	0	0	0	0
9 P_10	0	0	-60.5275	0	0	0
10 P_11	0	-62.7432	0	0	0	0

```
Iteration Number 4 Jacobians:
J22Table = 7×7 table
```

...

	$DeltaVByV_5$	$DeltaVByV_6$	$DeltaVByV_7$	$DeltaVByV_8$
1 Q_5	103.7460	6.6942	0	0
2 Q_6	-6.6942	200.8864	13.6182	0
3 Q_7	0	-13.6182	118.4077	3.8240
4 Q_8	0	0	-3.8240	36.2420
5 Q_9	0	0	0	-3.7792
6 Q_10	0	0	0	0
7 Q_11	0	0	0	0

```
Iteration Number 5 Jacobian J11:
J11Table = 10×10 table
```

...

	$delta_2$	$delta_3$	$delta_4$	$delta_5$	$delta_6$	$delta_7$
1 P_2	60.0596	0	0	0	-60.4631	0
2 P_3	0	62.2855	0	0	0	0
3 P_4	0	0	60.0921	0	0	0
4 P_5	0	0	0	103.1760	-40.5700	0
5 P_6	-60.4631	0	0	-40.5700	198.6490	-98.7362
6 P_7	0	0	0	0	-98.7362	118.4582
7 P_8	0	0	0	0	0	-17.6965
8 P_9	0	0	0	0	0	0
9 P_10	0	0	-60.4955	0	0	0
10 P_11	0	-62.6960	0	0	0	0

```
Iteration Number 5 Jacobians:
J22Table = 7×7 table
```

...

	$DeltaVByV_5$	$DeltaVByV_6$	$DeltaVByV_7$	$DeltaVByV_8$
1 Q_5	103.4619	6.8323	0	0
2 Q_6	-6.8323	199.7971	13.7453	0
3 Q_7	0	-13.7453	117.2997	3.9255
4 Q_8	0	0	-3.9255	35.7639
5 Q_9	0	0	0	-3.8720
6 Q_10	0	0	0	0
7 Q_11	0	0	0	0

```
Iteration Number 6 Jacobian J11:
J11Table = 10×10 table
```

...

	$delta_2$	$delta_3$	$delta_4$	$delta_5$	$delta_6$	$delta_7$
1 P_2	59.8900	0	0	0	-60.2951	0

	$delta_2$	$delta_3$	$delta_4$	$delta_5$	$delta_6$	$delta_7$
2 P_3	0	62.2742	0	0	0	0
3 P_4	0	0	59.9676	0	0	0
4 P_5	0	0	0	102.8990	-40.4034	0
5 P_6	-60.2951	0	0	-40.4034	197.5940	-98.0666
6 P_7	0	0	0	0	-98.0666	117.5266
7 P_8	0	0	0	0	0	-17.5231
8 P_9	0	0	0	0	0	0
9 P_10	0	0	-60.3720	0	0	0
10 P_11	0	-62.6867	0	0	0	0

```
Iteration Number 6 Jacobians:
J22Table = 7×7 table
```

...

	$DeltaVByV_5$	$DeltaVByV_6$	$DeltaVByV_7$	$DeltaVByV_8$
1 Q_5	103.1740	6.8791	0	0
2 Q_6	-6.8791	198.6139	13.7861	0
3 Q_7	0	-13.7861	116.3147	3.9608
4 Q_8	0	0	-3.9608	35.2898
5 Q_9	0	0	0	-3.9109
6 Q_10	0	0	0	0
7 Q_11	0	0	0	0

```
Iteration Number 7 Jacobian J11:
J11Table = 10×10 table
```

...

	$delta_2$	$delta_3$	$delta_4$	$delta_5$	$delta_6$	$delta_7$
1 P_2	59.7425	0	0	0	-60.1491	0
2 P_3	0	62.2192	0	0	0	0
3 P_4	0	0	59.8926	0	0	0
4 P_5	0	0	0	102.6631	-40.2560	0
5 P_6	-60.1491	0	0	-40.2560	196.6758	-97.4659
6 P_7	0	0	0	0	-97.4659	116.7314
7 P_8	0	0	0	0	0	-17.3876
8 P_9	0	0	0	0	0	0
9 P_10	0	0	-60.2988	0	0	0
10 P_11	0	-62.6320	0	0	0	0

```
Iteration Number 7 Jacobians:
J22Table = 7×7 table
```

...

	$DeltaVByV_5$	$DeltaVByV_6$	$DeltaVByV_7$	$DeltaVByV_8$
1 Q_5	102.8985	6.8979	0	0
2 Q_6	-6.8979	197.6053	13.7969	0
3 Q_7	0	-13.7969	115.3650	3.9776
4 Q_8	0	0	-3.9776	34.9996
5 Q_9	0	0	0	-3.9276
6 Q_10	0	0	0	0
7 Q_11	0	0	0	0

```
Iteration Number 8 Jacobian J11:
J11Table = 10×10 table
```

...

	$delta_2$	$delta_3$	$delta_4$	$delta_5$	$delta_6$	$delta_7$
1 P_2	59.6076	0	0	0	-60.0154	0
2 P_3	0	62.1891	0	0	0	0
3 P_4	0	0	59.7921	0	0	0
4 P_5	0	0	0	102.4619	-40.1253	0
5 P_6	-60.0154	0	0	-40.1253	195.8881	-96.9574
6 P_7	0	0	0	0	-96.9574	116.0614
7 P_8	0	0	0	0	0	-17.2681
8 P_9	0	0	0	0	0	0
9 P_10	0	0	-60.1988	0	0	0
10 P_11	0	-62.6027	0	0	0	0

```
Iteration Number 8 Jacobians:
J22Table = 7×7 table
```

...

	$DeltaVByV_5$	$DeltaVByV_6$	$DeltaVByV_7$	$DeltaVByV_8$
1 Q_5	102.6754	6.9052	0	0
2 Q_6	-6.9052	196.6376	13.8012	0
3 Q_7	0	-13.8012	114.6379	3.9845
4 Q_8	0	0	-3.9845	34.6974
5 Q_9	0	0	0	-3.9375
6 Q_10	0	0	0	0
7 Q_11	0	0	0	0

```
Iteration Number 9 Jacobian J11:
J11Table = 10×10 table
```

...

	$delta_2$	$delta_3$	$delta_4$	$delta_5$	$delta_6$	$delta_7$
1 P_2	59.4997	0	0	0	-59.9085	0

	$delta_2$	$delta_3$	$delta_4$	$delta_5$	$delta_6$	$delta_7$
2 P_3	0	62.1453	0	0	0	0
3 P_4	0	0	59.7226	0	0	0
4 P_5	0	0	0	102.2901	-40.0162	0
5 P_6	-59.9085	0	0	-40.0162	195.2256	-96.5210
6 P_7	0	0	0	0	-96.5210	115.4918
7 P_8	0	0	0	0	0	-17.1705
8 P_9	0	0	0	0	0	0
9 P_10	0	0	-60.1303	0	0	0
10 P_11	0	-62.5590	0	0	0	0

```
Iteration Number 9 Jacobians:
J22Table = 7×7 table
```

...

	$DeltaVByV_5$	$DeltaVByV_6$	$DeltaVByV_7$	$DeltaVByV_8$
1 Q_5	102.4608	6.9105	0	0
2 Q_6	-6.9105	195.9012	13.8004	0
3 Q_7	0	-13.8004	113.9477	3.9901
4 Q_8	0	0	-3.9901	34.4887
5 Q_9	0	0	0	-3.9437
6 Q_10	0	0	0	0
7 Q_11	0	0	0	0

```
Iteration Number 10 Jacobian J11:
J11Table = 10×10 table
```

...

	$delta_2$	$delta_3$	$delta_4$	$delta_5$	$delta_6$	$delta_7$
1 P_2	59.4016	0	0	0	-59.8112	0
2 P_3	0	62.1164	0	0	0	0
3 P_4	0	0	59.6469	0	0	0
4 P_5	0	0	0	102.1462	-39.9216	0
5 P_6	-59.8112	0	0	-39.9216	194.6586	-96.1542
6 P_7	0	0	0	0	-96.1542	115.0121
7 P_8	0	0	0	0	0	-17.0853
8 P_9	0	0	0	0	0	0
9 P_10	0	0	-60.0550	0	0	0
10 P_11	0	-62.5306	0	0	0	0

```
Iteration Number 10 Jacobians:
J22Table = 7×7 table
```

...

	$DeltaVByV_5$	$DeltaVByV_6$	$DeltaVByV_7$	$DeltaVByV_8$
1 Q_5	102.3009	6.9131	0	0
2 Q_6	-6.9131	195.1972	13.8011	0
3 Q_7	0	-13.8011	113.4258	3.9933
4 Q_8	0	0	-3.9933	34.2776
5 Q_9	0	0	0	-3.9488
6 Q_10	0	0	0	0
7 Q_11	0	0	0	0

```
Iteration Number 11 Jacobian J11:
J11Table = 10×10 table
```

...

	$delta_2$	$delta_3$	$delta_4$	$delta_5$	$delta_6$	$delta_7$
1 P_2	59.3238	0	0	0	-59.7343	0
2 P_3	0	62.0836	0	0	0	0
3 P_4	0	0	59.5897	0	0	0
4 P_5	0	0	0	102.0226	-39.8431	0
5 P_6	-59.7343	0	0	-39.8431	194.1833	-95.8411
6 P_7	0	0	0	0	-95.8411	114.6027
7 P_8	0	0	0	0	0	-17.0138
8 P_9	0	0	0	0	0	0
9 P_10	0	0	-59.9985	0	0	0
10 P_11	0	-62.4980	0	0	0	0

```
Iteration Number 11 Jacobians:
J22Table = 7×7 table
```

...

	$DeltaVByV_5$	$DeltaVByV_6$	$DeltaVByV_7$	$DeltaVByV_8$
1 Q_5	102.1454	6.9162	0	0
2 Q_6	-6.9162	194.6686	13.7997	0
3 Q_7	0	-13.7997	112.9327	3.9966
4 Q_8	0	0	-3.9966	34.1205
5 Q_9	0	0	0	-3.9527
6 Q_10	0	0	0	0
7 Q_11	0	0	0	0

```
Iteration Number 12 Jacobian J11:
J11Table = 10×10 table
```

...

	$delta_2$	$delta_3$	$delta_4$	$delta_5$	$delta_6$	$delta_7$
1 P_2	59.2532	0	0	0	-59.6643	0

	$delta_2$	$delta_3$	$delta_4$	$delta_5$	$delta_6$	$delta_7$
2 P_3	0	62.0596	0	0	0	0
3 P_4	0	0	59.5330	0	0	0
4 P_5	0	0	0	101.9194	-39.7752	0
5 P_6	-59.6643	0	0	-39.7752	193.7751	-95.5766
6 P_7	0	0	0	0	-95.5766	114.2564
7 P_8	0	0	0	0	0	-16.9519
8 P_9	0	0	0	0	0	0
9 P_10	0	0	-59.9422	0	0	0
10 P_11	0	-62.4742	0	0	0	0

```
Iteration Number 12 Jacobians:
J22Table = 7×7 table
```

...

	$DeltaVByV_5$	$DeltaVByV_6$	$DeltaVByV_7$	$DeltaVByV_8$
1 Q_5	102.0306	6.9180	0	0
2 Q_6	-6.9180	194.1650	13.8000	0
3 Q_7	0	-13.8000	112.5544	3.9988
4 Q_8	0	0	-3.9988	33.9683
5 Q_9	0	0	0	-3.9562
6 Q_10	0	0	0	0
7 Q_11	0	0	0	0

```
Iteration Number 13 Jacobian J11:
J11Table = 10×10 table
```

...

	$delta_2$	$delta_3$	$delta_4$	$delta_5$	$delta_6$	$delta_7$
1 P_2	59.1968	0	0	0	-59.6084	0
2 P_3	0	62.0351	0	0	0	0
3 P_4	0	0	59.4878	0	0	0
4 P_5	0	0	0	101.8303	-39.7184	0
5 P_6	-59.6084	0	0	-39.7184	193.4316	-95.3506
6 P_7	0	0	0	0	-95.3506	113.9599
7 P_8	0	0	0	0	0	-16.8994
8 P_9	0	0	0	0	0	0
9 P_10	0	0	-59.8975	0	0	0
10 P_11	0	-62.4499	0	0	0	0

```
Iteration Number 13 Jacobians:
J22Table = 7×7 table
```

...

	$DeltaVByV_5$	$DeltaVByV_6$	$DeltaVByV_7$	$DeltaVByV_8$
1 Q_5	101.9193	6.9201	0	0
2 Q_6	-6.9201	193.7815	13.7990	0
3 Q_7	0	-13.7990	112.2009	4.0011
4 Q_8	0	0	-4.0011	33.8496
5 Q_9	0	0	0	-3.9591
6 Q_10	0	0	0	0
7 Q_11	0	0	0	0

```
Iteration Number 14 Jacobian J11:
J11Table = 10×10 table
```

...

	$delta_2$	$delta_3$	$delta_4$	$delta_5$	$delta_6$	$delta_7$
1 P_2	59.1458	0	0	0	-59.5579	0
2 P_3	0	62.0160	0	0	0	0
3 P_4	0	0	59.4451	0	0	0
4 P_5	0	0	0	101.7556	-39.6694	0
5 P_6	-59.5579	0	0	-39.6694	193.1358	-95.1586
6 P_7	0	0	0	0	-95.1586	113.7080
7 P_8	0	0	0	0	0	-16.8540
8 P_9	0	0	0	0	0	0
9 P_10	0	0	-59.8552	0	0	0
10 P_11	0	-62.4310	0	0	0	0

```
Iteration Number 14 Jacobians:
J22Table = 7×7 table
```

...

	$DeltaVByV_5$	$DeltaVByV_6$	$DeltaVByV_7$	$DeltaVByV_8$
1 Q_5	101.8359	6.9215	0	0
2 Q_6	-6.9215	193.4205	13.7991	0
3 Q_7	0	-13.7991	111.9240	4.0027
4 Q_8	0	0	-4.0027	33.7385
5 Q_9	0	0	0	-3.9616
6 Q_10	0	0	0	0
7 Q_11	0	0	0	0

```
Iteration Number 15 Jacobian J11:
J11Table = 10×10 table
```

...

	$delta_2$	$delta_3$	$delta_4$	$delta_5$	$delta_6$	$delta_7$
1 P_2	59.1045	0	0	0	-59.5170	0

	$delta_2$	$delta_3$	$delta_4$	$delta_5$	$delta_6$	$delta_7$
2 P_3	0	61.9976	0	0	0	0
3 P_4	0	0	59.4101	0	0	0
4 P_5	0	0	0	101.6910	-39.6281	0
5 P_6	-59.5170	0	0	-39.6281	192.8858	-94.9943
6 P_7	0	0	0	0	-94.9943	113.4918
7 P_8	0	0	0	0	0	-16.8153
8 P_9	0	0	0	0	0	0
9 P_10	0	0	-59.8205	0	0	0
10 P_11	0	-62.4128	0	0	0	0

```
Iteration Number 15 Jacobians:
J22Table = 7×7 table
```

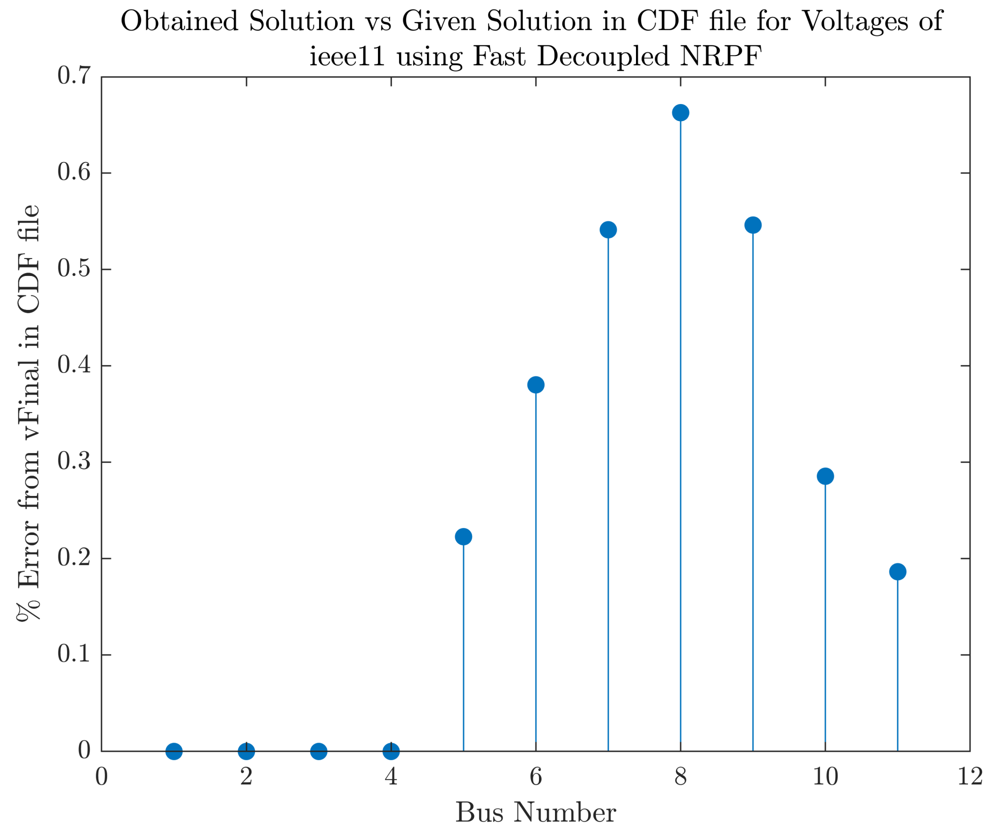
...

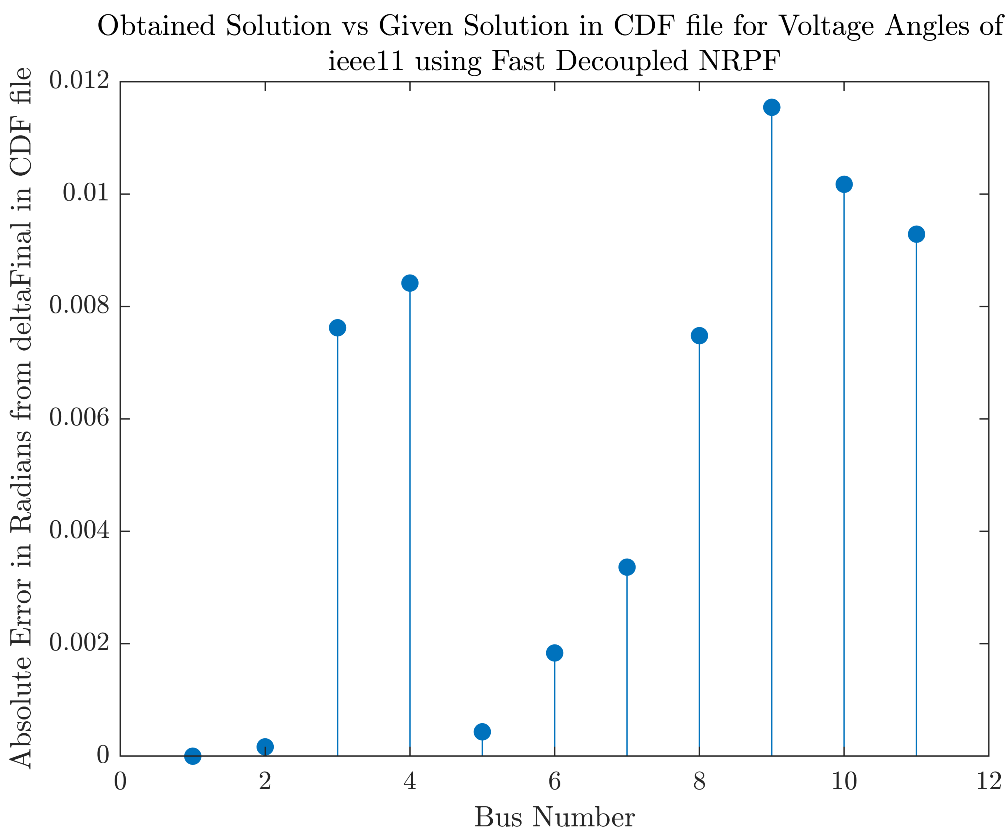
	$DeltaVByV_5$	$DeltaVByV_6$	$DeltaVByV_7$	$DeltaVByV_8$
1 Q_5	101.7561	6.9231	0	0
2 Q_6	-6.9231	193.1396	13.7985	0
3 Q_7	0	-13.7985	111.6690	4.0043
4 Q_8	0	0	-4.0043	33.6491
5 Q_9	0	0	0	-3.9637
6 Q_10	0	0	0	0
7 Q_11	0	0	0	0

```
Convergence using Fast Decoupled NRPF achieved in 15 iterations.
resultTable = 11×4 table
```

	P	Q	V	delta
1 Bus_1	6.9841	1.7193	1.0300	0
2 Bus_2	6.9999	2.0898	1.0100	-0.1691
3 Bus_3	7.1894	1.6439	1.0300	-0.4636
4 Bus_4	6.9993	1.7842	1.0100	-0.6408
5 Bus_5	-0.0001	0.0332	1.0082	-0.1123
6 Bus_6	-0.0001	0.1289	0.9817	-0.2870
7 Bus_7	-9.6684	-0.9079	0.9662	-0.4323
8 Bus_8	0.0002	0.0375	0.9553	-0.6704
9 Bus_9	-17.6618	-0.9235	0.9763	-0.9037
10 Bus_10	-0.0020	0.1126	0.9868	-0.7581
11 Bus_11	-0.0005	0.0279	1.0099	-0.5791

Compare obtained snapshot values of V_i and δ_i against the ones given in the CDF file.





Economic Dispatch and Optimal Power Flow Calculations:

```
Elapsed time is 3.608046 seconds.
```

Have a nice day!

In case you encounter a Java Heap Memory error, delete the above gif, or go to `Preferences->General->Java Heap Memory` and increase the allocated size.

EE 521 Power System Analysis and EE 523 Power System Stability and Control Algorithms

Preamble and Control Inputs

```
systemName =
"ieee11-caseTwo-"

powerFlowMethod =
"NRPF"
```

Read CDF file and store the data in neat MATLAB `tables`: `busData` and `branchData`.

`busData = 11×18 table`

...

	bus	busName	loadFlowArea	lossZone	busType	vFinal
1	1	"Bus 1 HV"	1	1	3	1.0300
2	2	"Bus 2 HV"	1	1	2	1.0100
3	3	"Bus 3 HV"	2	1	2	1.0300
4	4	"Bus 4 HV"	2	1	2	1.0100
5	5	"Bus 5 HV"	1	1	0	1.0200
6	6	"Bus 6 LV"	1	1	0	1.0120
7	7	"Bus 7 ZV"	1	1	0	1.0210
8	8	"Bus 8 TV"	3	1	0	1.0100
9	9	"Bus 9 LV"	2	1	0	1.0020
10	10	"Bus 10 LV"	2	1	0	1.0010
11	11	"Bus 11 LV"	2	1	0	1.0150

`branchData = 10×15 table`

...

	i	j	loadFlowArea	lossZone	ckt	type	R
1	1	5	1	1	1	0	0
2	2	6	1	1	1	0	0
3	3	11	2	1	1	0	0
4	4	10	2	1	1	0	0
5	5	6	1	1	1	0	0.0025
6	6	7	1	1	1	0	0.0010
7	7	8	1	1	1	0	0.0037
8	8	9	2	1	1	0	0.0055
9	9	10	2	1	1	0	0.0010
10	10	11	2	1	1	0	0.0025

```
N = 11
numBranch = 10
```

Extract Y_{Bus}, Adjacency List E from the `branchData table.`

```
ybusTable = 11×11 table
```

...

	1	2	3	4	5
1 1	0.0000 -59.9880i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 +59.9880i
2 2	0.0000 + 0.0000i	0.0000 -59.9880i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i
3 3	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 -59.9880i	0.0000 + 0.0000i	0.0000 + 0.0000i
4 4	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 -59.9880i	0.0000 + 0.0000i
5 5	0.0000 +59.9880i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	3.9604 -99.5701i
6 6	0.0000 + 0.0000i	0.0000 +59.9880i	0.0000 + 0.0000i	0.0000 + 0.0000i	-3.9604 +39.6040i
7 7	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i
8 8	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i
9 9	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i
10 10	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 +59.9880i	0.0000 + 0.0000i
11 11	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 +59.9880i	0.0000 + 0.0000i	0.0000 + 0.0000i

Run Newton Raphson Power Flow and obtain a steady state snapshot of the system variables $P_i, Q_i, V_i, \delta_i\ \forall$ buses $i \in [1, N], i \in \mathbb{N}$

```
Iteration Number 1 Jacobian:
JTable = 17×17 table
```

...

	$delta_2$	$delta_3$	$delta_4$	$delta_5$	$delta_6$	$delta_7$
1 P_2	60.5879	0	0	0	-60.5879	0
2 P_3	0	61.7876	0	0	0	0
3 P_4	0	0	60.5879	0	0	0
4 P_5	0	0	0	101.3916	-39.6040	0
5 P_6	-60.5879	0	0	-39.6040	199.2017	-99.0099
6 P_7	0	0	0	0	-99.0099	126.0097
7 P_8	0	0	0	0	0	-26.9998
8 P_9	0	0	0	0	0	0
9 P_10	0	0	-60.5879	0	0	0
10 P_11	0	-61.7876	0	0	0	0
11 Q_5	0	0	0	-3.9604	3.9604	0
12 Q_6	-0	0	0	3.9604	-13.8614	9.9010
13 Q_7	0	0	0	0	9.9010	-12.6032

	$delta_2$	$delta_3$	$delta_4$	$delta_5$	$delta_6$	$delta_7$
14 Q_8	0	0	0	0	0	2.7022
15 Q_9	0	0	0	0	0	0
16 Q_10	0	0	-0	0	0	0
17 Q_11	0	-0	0	0	0	0

```
Iteration Number 2 Jacobian:
JTable = 17×17 table
```

...

	$delta_2$	$delta_3$	$delta_4$	$delta_5$	$delta_6$	$delta_7$
1 P_2	64.3143	0	0	0	-64.3143	0
2 P_3	0	64.4459	0	0	0	0
3 P_4	0	0	63.7632	0	0	0
4 P_5	0	0	0	109.4332	-44.7054	0
5 P_6	-64.3143	0	0	-43.3132	224.7675	-117.1400
6 P_7	0	0	0	0	-113.9729	147.1125
7 P_8	0	0	0	0	0	-32.2870
8 P_9	0	0	0	0	0	0
9 P_10	0	0	-63.7632	0	0	0
10 P_11	0	-64.4459	0	0	0	0
11 Q_5	0	0	0	-3.9040	-2.5600	0
12 Q_6	7.4638	0	0	11.3619	-14.5457	-4.2799
13 Q_7	0	0	0	0	27.3912	-26.4053
14 Q_8	0	0	0	0	0	7.5339
15 Q_9	0	0	0	0	0	0
16 Q_10	0	0	7.3998	0	0	0
17 Q_11	0	7.5334	0	0	0	0

```
Iteration Number 3 Jacobian:
JTable = 17×17 table
```

...

	$delta_2$	$delta_3$	$delta_4$	$delta_5$	$delta_6$	$delta_7$
1 P_2	61.1546	0	0	0	-61.1546	0
2 P_3	0	62.4514	0	0	0	0
3 P_4	0	0	60.4908	0	0	0
4 P_5	0	0	0	104.0460	-41.2510	0
5 P_6	-61.1546	0	0	-39.8939	204.8646	-103.8161
6 P_7	0	0	0	0	-101.0427	129.3982
7 P_8	0	0	0	0	0	-27.5832

	$delta_2$	$delta_3$	$delta_4$	$delta_5$	$delta_6$	$delta_7$
8 P_9	0	0	0	0	0	0
9 P_10	0	0	-60.4908	0	0	0
10 P_11	0	-62.4514	0	0	0	0
11 Q_5	0	0	0	-4.1447	-2.7286	0
12 Q_6	7.0047	0	0	10.8431	-14.2238	-3.6240
13 Q_7	0	0	0	0	24.1099	-23.0510
14 Q_8	0	0	0	0	0	6.6574
15 Q_9	0	0	0	0	0	0
16 Q_10	0	0	7.0010	0	0	0
17 Q_11	0	7.1934	0	0	0	0

```
Iteration Number 4 Jacobian:
JTable = 17×17 table
```

...

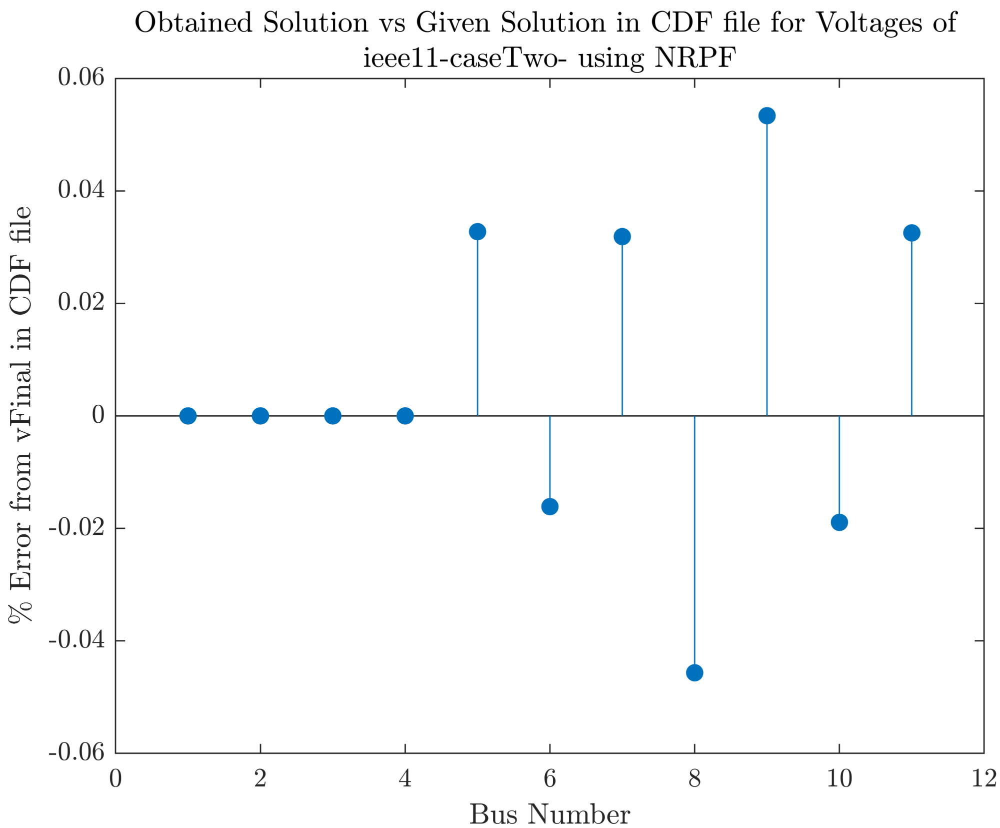
	$delta_2$	$delta_3$	$delta_4$	$delta_5$	$delta_6$	$delta_7$
1 P_2	60.9063	0	0	0	-60.9063	0
2 P_3	0	62.3224	0	0	0	0
3 P_4	0	0	60.2338	0	0	0
4 P_5	0	0	0	103.6639	-40.9989	0
5 P_6	-60.9063	0	0	-39.6348	203.3142	-102.7731
6 P_7	0	0	0	0	-100.0132	127.9725
7 P_8	0	0	0	0	0	-27.1827
8 P_9	0	0	0	0	0	0
9 P_10	0	0	-60.2338	0	0	0
10 P_11	0	-62.3224	0	0	0	0
11 Q_5	0	0	0	-4.1236	-2.7890	0
12 Q_6	6.9999	0	0	10.8523	-14.1924	-3.6598
13 Q_7	0	0	0	0	23.9384	-22.8184
14 Q_8	0	0	0	0	0	6.6388
15 Q_9	0	0	0	0	0	0
16 Q_10	0	0	6.9999	0	0	0
17 Q_11	0	7.1900	0	0	0	0

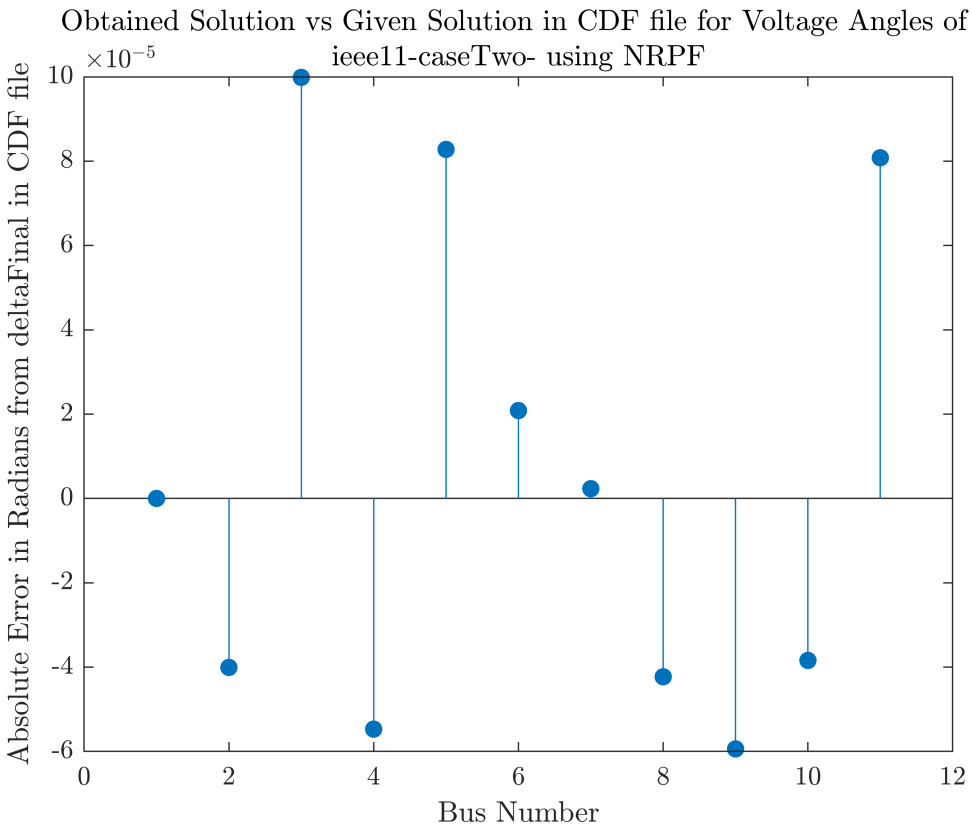
```
Convergence using NRPF achieved in 4 iterations.
resultTable = 11×4 table
```

	P	Q	V	delta
1 Bus_1	6.9125	0.9763	1.0300	0
2 Bus_2	6.9999	0.2874	1.0100	-0.1631

	P	Q	V	delta
3 Bus_3	7.1900	1.3188	1.0300	-0.3319
4 Bus_4	6.9999	0.9600	1.0100	-0.5076
5 Bus_5	-0.0003	0.0001	1.0203	-0.1099
6 Bus_6	0.0001	0.0004	1.0118	-0.2775
7 Bus_7	-9.6704	-0.9992	1.0213	-0.4128
8 Bus_8	-0.0002	0.0006	1.0095	-0.5526
9 Bus_9	-17.6690	-0.9991	1.0025	-0.7645
10 Bus_10	0.0003	0.0005	1.0008	-0.6233
11 Bus_11	0	0.0001	1.0153	-0.4467

Compare obtained snapshot values of V_i and δ_i against the ones given in the CDF file.





Economic Dispatch and Optimal Power Flow Calculations:

```
Elapsed time is 1.369501 seconds.
```

Have a nice day!

In case you encounter a Java Heap Memory error, delete the above gif, or go to `Preferences->General->Java Heap Memory` and increase the allocated size.

EE 521 Power System Analysis and EE 523 Power System Stability and Control Algorithms

Preamble and Control Inputs

```
systemName =
"ieee11-caseTwo-"

powerFlowMethod =
"Fast Decoupled NRPF"
```

Read CDF file and store the data in neat MATLAB `tables: busData` and `branchData`.

```
busData = 11×18 table
```

...

	bus	busName	loadFlowArea	lossZone	busType	vFinal
1	1	"Bus 1 HV"	1	1	3	1.0300
2	2	"Bus 2 HV"	1	1	2	1.0100
3	3	"Bus 3 HV"	2	1	2	1.0300
4	4	"Bus 4 HV"	2	1	2	1.0100
5	5	"Bus 5 HV"	1	1	0	1.0200
6	6	"Bus 6 LV"	1	1	0	1.0120
7	7	"Bus 7 ZV"	1	1	0	1.0210
8	8	"Bus 8 TV"	3	1	0	1.0100
9	9	"Bus 9 LV"	2	1	0	1.0020
10	10	"Bus 10 LV"	2	1	0	1.0010
11	11	"Bus 11 LV"	2	1	0	1.0150

```
branchData = 10×15 table
```

...

	i	j	loadFlowArea	lossZone	ckt	type	R
1	1	5	1	1	1	0	0
2	2	6	1	1	1	0	0
3	3	11	2	1	1	0	0
4	4	10	2	1	1	0	0
5	5	6	1	1	1	0	0.0025
6	6	7	1	1	1	0	0.0010
7	7	8	1	1	1	0	0.0037
8	8	9	2	1	1	0	0.0055
9	9	10	2	1	1	0	0.0010
10	10	11	2	1	1	0	0.0025

```
N = 11
numBranch = 10
```

Extract Y_{Bus}, Adjacency List E from the `branchData table.`

```
ybusTable = 11×11 table
```

...

	1	2	3	4	5
1 1	0.0000 -59.9880i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 +59.9880i
2 2	0.0000 + 0.0000i	0.0000 -59.9880i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i
3 3	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 -59.9880i	0.0000 + 0.0000i	0.0000 + 0.0000i
4 4	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 -59.9880i	0.0000 + 0.0000i
5 5	0.0000 +59.9880i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	3.9604 -99.5701i
6 6	0.0000 + 0.0000i	0.0000 +59.9880i	0.0000 + 0.0000i	0.0000 + 0.0000i	-3.9604 +39.6040i
7 7	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i
8 8	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i
9 9	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i
10 10	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 +59.9880i	0.0000 + 0.0000i
11 11	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 +59.9880i	0.0000 + 0.0000i	0.0000 + 0.0000i

Run Newton Raphson Power Flow and obtain a steady state snapshot of the system variables $P_i, Q_i, V_i, \delta_i\ \forall$ buses $i \in [1, N], i \in \mathbb{N}$

```
Iteration Number 1 Jacobian J11:
J11Table = 10×10 table
```

...

	$delta_2$	$delta_3$	$delta_4$	$delta_5$	$delta_6$	$delta_7$
1 P_2	60.5879	0	0	0	-60.5879	0
2 P_3	0	61.7876	0	0	0	0
3 P_4	0	0	60.5879	0	0	0
4 P_5	0	0	0	101.8314	-40	0
5 P_6	-60.5879	0	0	-40	200.6491	-100
6 P_7	0	0	0	0	-100	135.8652
7 P_8	0	0	0	0	0	-27.2702
8 P_9	0	0	0	0	0	0
9 P_10	0	0	-60.5879	0	0	0
10 P_11	0	-61.7876	0	0	0	0

```
Iteration Number 1 Jacobians:
J22Table = 7×7 table
```

...

	$DeltaVByV_5$	$DeltaVByV_6$	$DeltaVByV_7$	$DeltaVByV_8$
1 Q_5	98.0708	2.0941	0	0
2 Q_6	-2.0941	199.5635	9.0994	0
3 Q_7	0	-9.0994	128.5016	0.9525
4 Q_8	0	0	-0.9525	45.4849
5 Q_9	0	0	0	-1.1567
6 Q_10	0	0	0	0
7 Q_11	0	0	0	0

```
Iteration Number 2 Jacobian J11:
J11Table = 10×10 table
```

...

	$delta_2$	$delta_3$	$delta_4$	$delta_5$	$delta_6$	$delta_7$
1 P_2	60.2894	0	0	0	-60.6941	0
2 P_3	0	62.3028	0	0	0	0
3 P_4	0	0	59.9808	0	0	0
4 P_5	0	0	0	104.0408	-40.8609	0
5 P_6	-60.6941	0	0	-40.8609	203.2130	-101.7909
6 P_7	0	0	0	0	-101.7909	137.4177
7 P_8	0	0	0	0	0	-27.9890
8 P_9	0	0	0	0	0	0
9 P_10	0	0	-60.3834	0	0	0
10 P_11	0	-62.7270	0	0	0	0

```
Iteration Number 2 Jacobians:
J22Table = 7×7 table
```

...

	$DeltaVByV_5$	$DeltaVByV_6$	$DeltaVByV_7$	$DeltaVByV_8$
1 Q_5	104.0396	4.5396	0	0
2 Q_6	-4.5396	198.6628	11.7357	0
3 Q_7	0	-11.7357	134.7113	2.6985
4 Q_8	0	0	-2.6985	46.6301
5 Q_9	0	0	0	-2.8769
6 Q_10	0	0	0	0
7 Q_11	0	0	0	0

```
Iteration Number 3 Jacobian J11:
J11Table = 10×10 table
```

...

	$delta_2$	$delta_3$	$delta_4$	$delta_5$	$delta_6$	$delta_7$
1 P_2	60.9105	0	0	0	-61.3150	0

	$delta_2$	$delta_3$	$delta_4$	$delta_5$	$delta_6$	$delta_7$
2 P_3	0	62.2260	0	0	0	0
3 P_4	0	0	60.3452	0	0	0
4 P_5	0	0	0	104.2781	-41.2433	0
5 P_6	-61.3150	0	0	-41.2433	205.0155	-103.0160
6 P_7	0	0	0	0	-103.0160	138.4018
7 P_8	0	0	0	0	0	-28.1841
8 P_9	0	0	0	0	0	0
9 P_10	0	0	-60.7415	0	0	0
10 P_11	0	-62.6246	0	0	0	0

```
Iteration Number 3 Jacobians:
J22Table = 7×7 table
```

...

	$DeltaVByV_5$	$DeltaVByV_6$	$DeltaVByV_7$	$DeltaVByV_8$
1 Q_5	103.4945	5.8580	0	0
2 Q_6	-5.8580	204.9811	12.8914	0
3 Q_7	0	-12.8914	134.4874	3.4004
4 Q_8	0	0	-3.4004	47.5039
5 Q_9	0	0	0	-3.4165
6 Q_10	0	0	0	0
7 Q_11	0	0	0	0

```
Iteration Number 4 Jacobian J11:
J11Table = 10×10 table
```

...

	$delta_2$	$delta_3$	$delta_4$	$delta_5$	$delta_6$	$delta_7$
1 P_2	60.8587	0	0	0	-61.2568	0
2 P_3	0	62.3773	0	0	0	0
3 P_4	0	0	60.2610	0	0	0
4 P_5	0	0	0	104.4303	-41.3345	0
5 P_6	-61.2568	0	0	-41.3345	205.2871	-103.5625
6 P_7	0	0	0	0	-103.5625	138.9251
7 P_8	0	0	0	0	0	-28.2756
8 P_9	0	0	0	0	0	0
9 P_10	0	0	-60.6601	0	0	0
10 P_11	0	-62.7876	0	0	0	0

```
Iteration Number 4 Jacobians:
J22Table = 7×7 table
```

...

	$DeltaVByV_5$	$DeltaVByV_6$	$DeltaVByV_7$	$DeltaVByV_8$
1 Q_5	104.6030	6.4381	0	0
2 Q_6	-6.4381	203.7895	13.5491	0
3 Q_7	0	-13.5491	137.3028	3.6932
4 Q_8	0	0	-3.6932	46.9533
5 Q_9	0	0	0	-3.6930
6 Q_10	0	0	0	0
7 Q_11	0	0	0	0

```
Iteration Number 5 Jacobian J11:
J11Table = 10×10 table
```

...

	$delta_2$	$delta_3$	$delta_4$	$delta_5$	$delta_6$	$delta_7$
1 P_2	61.0604	0	0	0	-61.4620	0
2 P_3	0	62.3300	0	0	0	0
3 P_4	0	0	60.3712	0	0	0
4 P_5	0	0	0	104.3333	-41.4135	0
5 P_6	-61.4620	0	0	-41.4135	205.5974	-103.7414
6 P_7	0	0	0	0	-103.7414	138.9472
7 P_8	0	0	0	0	0	-28.2975
8 P_9	0	0	0	0	0	0
9 P_10	0	0	-60.7748	0	0	0
10 P_11	0	-62.7403	0	0	0	0

```
Iteration Number 5 Jacobians:
J22Table = 7×7 table
```

...

	$DeltaVByV_5$	$DeltaVByV_6$	$DeltaVByV_7$	$DeltaVByV_8$
1 Q_5	104.0624	6.7265	0	0
2 Q_6	-6.7265	206.1404	13.7638	0
3 Q_7	0	-13.7638	136.2970	3.8402
4 Q_8	0	0	-3.8402	47.4083
5 Q_9	0	0	0	-3.8043
6 Q_10	0	0	0	0
7 Q_11	0	0	0	0

```
Iteration Number 6 Jacobian J11:
J11Table = 10×10 table
```

...

	$delta_2$	$delta_3$	$delta_4$	$delta_5$	$delta_6$	$delta_7$
1 P_2	60.9649	0	0	0	-61.3637	0

	$delta_2$	$delta_3$	$delta_4$	$delta_5$	$delta_6$	$delta_7$
2 P_3	0	62.3848	0	0	0	0
3 P_4	0	0	60.3029	0	0	0
4 P_5	0	0	0	104.3467	-41.3964	0
5 P_6	-61.3637	0	0	-41.3964	205.4568	-103.7942
6 P_7	0	0	0	0	-103.7942	138.9863
7 P_8	0	0	0	0	0	-28.2902
8 P_9	0	0	0	0	0	0
9 P_10	0	0	-60.7058	0	0	0
10 P_11	0	-62.7975	0	0	0	0

```
Iteration Number 6 Jacobians:
J22Table = 7×7 table
```

...

	$DeltaVByV_5$	$DeltaVByV_6$	$DeltaVByV_7$	$DeltaVByV_8$
1 Q_5	104.5170	6.8281	0	0
2 Q_6	-6.8281	204.9243	13.9149	0
3 Q_7	0	-13.9149	137.4081	3.8840
4 Q_8	0	0	-3.8840	47.0193
5 Q_9	0	0	0	-3.8585
6 Q_10	0	0	0	0
7 Q_11	0	0	0	0

```
Iteration Number 7 Jacobian J11:
J11Table = 10×10 table
```

...

	$delta_2$	$delta_3$	$delta_4$	$delta_5$	$delta_6$	$delta_7$
1 P_2	61.0420	0	0	0	-61.4429	0
2 P_3	0	62.3496	0	0	0	0
3 P_4	0	0	60.3425	0	0	0
4 P_5	0	0	0	104.2787	-41.4090	0
5 P_6	-61.4429	0	0	-41.4090	205.4900	-103.7662
6 P_7	0	0	0	0	-103.7662	138.8764
7 P_8	0	0	0	0	0	-28.2745
8 P_9	0	0	0	0	0	0
9 P_10	0	0	-60.7472	0	0	0
10 P_11	0	-62.7618	0	0	0	0

```
Iteration Number 7 Jacobians:
J22Table = 7×7 table
```

...

	$DeltaVByV_5$	$DeltaVByV_6$	$DeltaVByV_7$	$DeltaVByV_8$
1 Q_5	104.1661	6.8876	0	0
2 Q_6	-6.8876	205.9323	13.9354	0
3 Q_7	0	-13.9354	136.6290	3.9159
4 Q_8	0	0	-3.9159	47.2326
5 Q_9	0	0	0	-3.8774
6 Q_10	0	0	0	0
7 Q_11	0	0	0	0

```
Iteration Number 8 Jacobian J11:
J11Table = 10×10 table
```

...

	$delta_2$	$delta_3$	$delta_4$	$delta_5$	$delta_6$	$delta_7$
1 P_2	60.9730	0	0	0	-61.3725	0
2 P_3	0	62.3707	0	0	0	0
3 P_4	0	0	60.2986	0	0	0
4 P_5	0	0	0	104.2812	-41.3851	0
5 P_6	-61.3725	0	0	-41.3851	205.3435	-103.7307
6 P_7	0	0	0	0	-103.7307	138.8339
7 P_8	0	0	0	0	0	-28.2565
8 P_9	0	0	0	0	0	0
9 P_10	0	0	-60.7027	0	0	0
10 P_11	0	-62.7838	0	0	0	0

```
Iteration Number 8 Jacobians:
J22Table = 7×7 table
```

...

	$DeltaVByV_5$	$DeltaVByV_6$	$DeltaVByV_7$	$DeltaVByV_8$
1 Q_5	104.3937	6.9009	0	0
2 Q_6	-6.9009	205.1290	13.9759	0
3 Q_7	0	-13.9759	137.1187	3.9198
4 Q_8	0	0	-3.9198	47.0070
5 Q_9	0	0	0	-3.8890
6 Q_10	0	0	0	0
7 Q_11	0	0	0	0

```
Iteration Number 9 Jacobian J11:
J11Table = 10×10 table
```

...

	$delta_2$	$delta_3$	$delta_4$	$delta_5$	$delta_6$	$delta_7$
1 P_2	61.0059	0	0	0	-61.4066	0

	$delta_2$	$delta_3$	$delta_4$	$delta_5$	$delta_6$	$delta_7$
2 P_3	0	62.3488	0	0	0	0
3 P_4	0	0	60.3130	0	0	0
4 P_5	0	0	0	104.2394	-41.3837	0
5 P_6	-61.4066	0	0	-41.3837	205.3215	-103.6812
6 P_7	0	0	0	0	-103.6812	138.7363
7 P_8	0	0	0	0	0	-28.2386
8 P_9	0	0	0	0	0	0
9 P_10	0	0	-60.7179	0	0	0
10 P_11	0	-62.7617	0	0	0	0

```
Iteration Number 9 Jacobians:
J22Table = 7×7 table
```

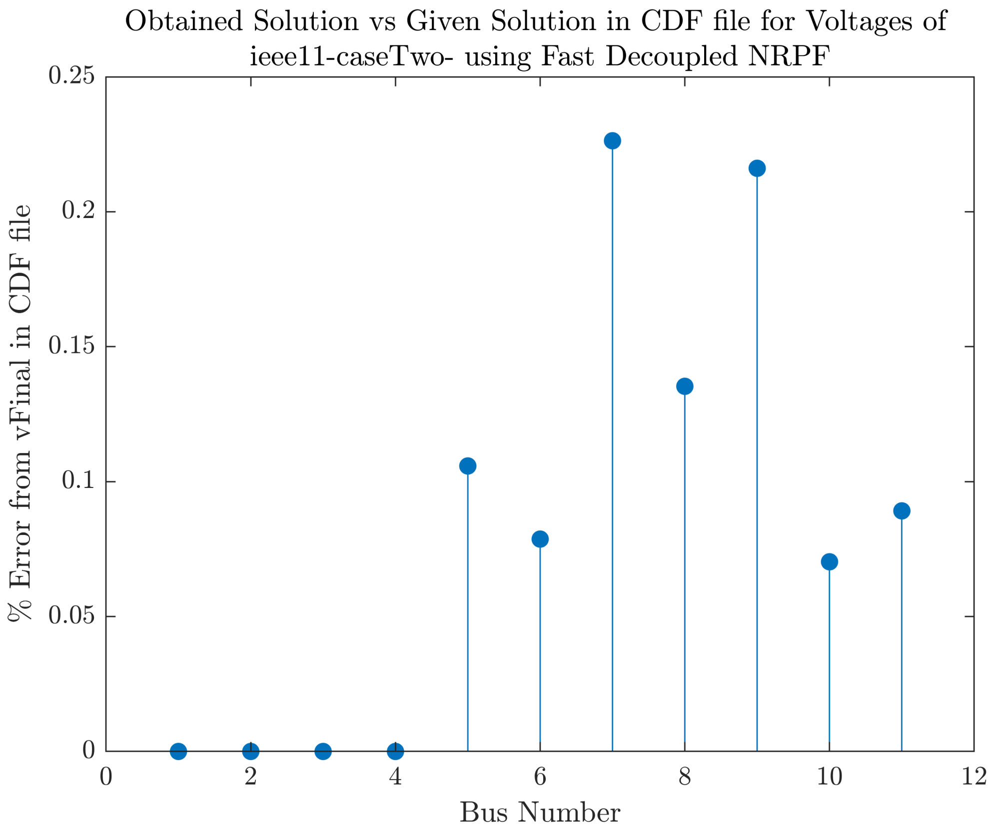
...

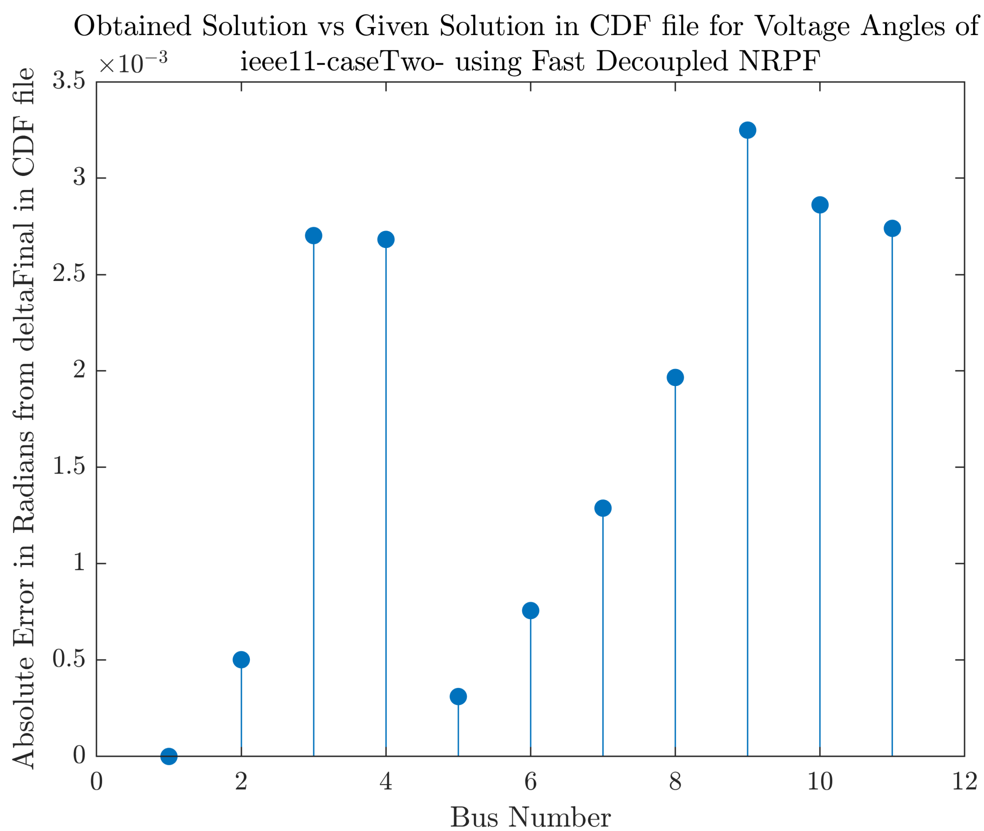
	$DeltaVByV_5$	$DeltaVByV_6$	$DeltaVByV_7$	$DeltaVByV_8$
1 Q_5	104.1891	6.9154	0	0
2 Q_6	-6.9154	205.6041	13.9691	0
3 Q_7	0	-13.9691	136.6367	3.9286
4 Q_8	0	0	-3.9286	47.1064
5 Q_9	0	0	0	-3.8918
6 Q_10	0	0	0	0
7 Q_11	0	0	0	0

```
Convergence using Fast Decoupled NRPF achieved in 9 iterations.
resultTable = 11×4 table
```

	P	Q	V	delta
1 Bus_1	6.9017	0.9474	1.0300	0
2 Bus_2	6.9998	0.1874	1.0100	-0.1625
3 Bus_3	7.1895	1.2928	1.0300	-0.3293
4 Bus_4	6.9995	0.8806	1.0100	-0.5049
5 Bus_5	-0.0001	-0.0239	1.0211	-0.1096
6 Bus_6	-0.0001	0.1430	1.0128	-0.2768
7 Bus_7	-9.6661	-1.0495	1.0233	-0.4115
8 Bus_8	0.0006	0.0417	1.0114	-0.5506
9 Bus_9	-17.6635	-1.0188	1.0042	-0.7612
10 Bus_10	-0.0014	0.0888	1.0017	-0.6204
11 Bus_11	-0.0003	-0.0111	1.0159	-0.4441

Compare obtained snapshot values of V_i and δ_i against the ones given in the CDF file.





Economic Dispatch and Optimal Power Flow Calculations:

```
Elapsed time is 2.560879 seconds.
```

Have a nice day!

In case you encounter a Java Heap Memory error, delete the above gif, or go to `Preferences->General->Java Heap Memory` and increase the allocated size.

EE 521 Power System Analysis and EE 523 Power System Stability and Control Algorithms

Preamble and Control Inputs

```
systemName =
"ieee11-caseThree-"

powerFlowMethod =
"NRPF"
```

Read CDF file and store the data in neat MATLAB `tables`: `busData` and `branchData`.

```
busData = 11×18 table
```

...

	bus	busName	loadFlowArea	lossZone	busType	vFinal
1	1	"Bus 1 HV"	1	1	3	1.0300
2	2	"Bus 2 HV"	1	1	0	1.0100
3	3	"Bus 3 HV"	2	1	0	1.0300
4	4	"Bus 4 HV"	2	1	0	1.0100
5	5	"Bus 5 HV"	1	1	0	1.0200
6	6	"Bus 6 LV"	1	1	0	1.0120
7	7	"Bus 7 ZV"	1	1	0	1.0210
8	8	"Bus 8 TV"	3	1	0	1.0100
9	9	"Bus 9 LV"	2	1	0	1.0020
10	10	"Bus 10 LV"	2	1	0	1.0010
11	11	"Bus 11 LV"	2	1	0	1.0150

```
branchData = 10×15 table
```

...

	i	j	loadFlowArea	lossZone	ckt	type	R
1	1	5	1	1	1	0	0
2	2	6	1	1	1	0	0
3	3	11	2	1	1	0	0
4	4	10	2	1	1	0	0
5	5	6	1	1	1	0	0.0025
6	6	7	1	1	1	0	0.0010
7	7	8	1	1	1	0	0.0037
8	8	9	2	1	1	0	0.0055
9	9	10	2	1	1	0	0.0010
10	10	11	2	1	1	0	0.0025

```
N = 11
numBranch = 10
```

Extract Y_{Bus}, Adjacency List E from the `branchData table.`

```
ybusTable = 11×11 table
```

...

	1	2	3	4	5
1 1	0.0000 -59.9880i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 +59.9880i
2 2	0.0000 + 0.0000i	0.0000 -59.9880i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i
3 3	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 -59.9880i	0.0000 + 0.0000i	0.0000 + 0.0000i
4 4	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 -59.9880i	0.0000 + 0.0000i
5 5	0.0000 +59.9880i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	3.9604 -99.5701i
6 6	0.0000 + 0.0000i	0.0000 +59.9880i	0.0000 + 0.0000i	0.0000 + 0.0000i	-3.9604 +39.6040i
7 7	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i
8 8	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i
9 9	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i
10 10	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 +59.9880i	0.0000 + 0.0000i
11 11	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 +59.9880i	0.0000 + 0.0000i	0.0000 + 0.0000i

Run Newton Raphson Power Flow and obtain a steady state snapshot of the system variables P_i, Q_i, V_i, δ_i $\forall$ buses $i \in [1, N], i \in \mathbb{N}$

```
Iteration Number 1 Jacobian:
JTable = 20×20 table
```

...

	$delta_2$	$delta_3$	$delta_4$	$delta_5$	$delta_6$	$delta_7$
1 P_2	60.3989	0	0	0	-60.3989	0
2 P_3	0	60.8939	0	0	0	0
3 P_4	0	0	60.1657	0	0	0
4 P_5	0	0	0	102.3984	-40.2170	0
5 P_6	-60.3989	0	0	-39.7473	200.6702	-100.5240
6 P_7	0	0	0	0	-99.5758	126.9689
7 P_8	0	0	0	0	0	-27.1258
8 P_9	0	0	0	0	0	0
9 P_10	0	0	-60.1657	0	0	0
10 P_11	0	-60.8939	0	0	0	0
11 Q_2	2.4204	0	0	0	-2.4204	0
12 Q_3	0	2.4494	0	0	0	0
13 Q_4	0	0	2.4377	0	0	0

	$delta_2$	$delta_3$	$delta_4$	$delta_5$	$delta_6$	$delta_7$
14 Q_5	0	0	0	-4.0424	1.6500	0
15 Q_6	2.4204	0	0	6.3465	-14.0310	5.2642
16 Q_7	0	0	0	0	14.7457	-16.1386
17 Q_8	0	0	0	0	0	4.0635
18 Q_9	0	0	0	0	0	0
19 Q_10	0	0	2.4377	0	0	0
20 Q_11	0	2.4494	0	0	0	0

```
Iteration Number 2 Jacobian:
JTable = 20×20 table
```

...

	$delta_2$	$delta_3$	$delta_4$	$delta_5$	$delta_6$	$delta_7$
1 P_2	38.1877	0	0	0	-38.1877	0
2 P_3	0	8.9792	0	0	0	0
3 P_4	0	0	7.6318	0	0	0
4 P_5	0	0	0	87.5629	-29.8789	0
5 P_6	-38.1877	0	0	-28.8854	126.8167	-59.7435
6 P_7	0	0	0	0	-57.9441	69.7455
7 P_8	0	0	0	0	0	-11.4375
8 P_9	0	0	0	0	0	0
9 P_10	0	0	-7.6318	0	0	0
10 P_11	0	-8.9792	0	0	0	0
11 Q_2	5.0718	0	0	0	-5.0718	0
12 Q_3	0	1.5173	0	0	0	0
13 Q_4	0	0	1.2967	0	0	0
14 Q_5	0	0	0	-4.3102	-2.0291	0
15 Q_6	5.0718	0	0	7.9055	-9.8645	-3.1128
16 Q_7	0	0	0	0	14.8816	-14.2264
17 Q_8	0	0	0	0	0	2.9810
18 Q_9	0	0	0	0	0	0
19 Q_10	0	0	1.2967	0	0	0
20 Q_11	0	1.5173	0	0	0	0

```
Iteration Number 3 Jacobian:
JTable = 20×20 table
```

...

	$delta_2$	$delta_3$	$delta_4$	$delta_5$	$delta_6$	$delta_7$
1 P_2	78.4372	0	0	0	-78.4372	0

	$delta_2$	$delta_3$	$delta_4$	$delta_5$	$delta_6$	$delta_7$
2 P_3	0	65.0761	0	0	0	0
3 P_4	0	0	72.6642	0	0	0
4 P_5	0	0	0	115.0481	-48.9592	0
5 P_6	-78.4372	0	0	-47.6987	260.6417	-134.5059
6 P_7	0	0	0	0	-132.4269	170.5106
7 P_8	0	0	0	0	0	-37.6205
8 P_9	0	0	0	0	0	0
9 P_10	0	0	-72.6642	0	0	0
10 P_11	0	-65.0761	0	0	0	0
11 Q_2	5.3958	0	0	0	-5.3958	0
12 Q_3	0	14.6921	0	0	0	0
13 Q_4	0	0	14.9692	0	0	0
14 Q_5	0	0	0	-4.9957	-1.4698	0
15 Q_6	5.3958	0	0	11.1356	-19.4832	2.9518
16 Q_7	0	0	0	0	23.7414	-25.2155
17 Q_8	0	0	0	0	0	6.1025
18 Q_9	0	0	0	0	0	0
19 Q_10	0	0	14.9692	0	0	0
20 Q_11	0	14.6921	0	0	0	0

```
Iteration Number 4 Jacobian:
JTable = 20×20 table
```

...

	$delta_2$	$delta_3$	$delta_4$	$delta_5$	$delta_6$	$delta_7$
1 P_2	60.8149	0	0	0	-60.8149	0
2 P_3	0	48.3427	0	0	0	0
3 P_4	0	0	47.3917	0	0	0
4 P_5	0	0	0	103.6065	-40.9387	0
5 P_6	-60.8149	0	0	-39.6409	202.4846	-102.0288
6 P_7	0	0	0	0	-99.5520	126.3970
7 P_8	0	0	0	0	0	-26.2116
8 P_9	0	0	0	0	0	0
9 P_10	0	0	-47.3917	0	0	0
10 P_11	0	-48.3427	0	0	0	0
11 Q_2	6.4324	0	0	0	-6.4324	0
12 Q_3	0	8.3519	0	0	0	0

	$delta_2$	$delta_3$	$delta_4$	$delta_5$	$delta_6$	$delta_7$
13 Q_4	0	0	8.3153	0	0	0
14 Q_5	0	0	0	-4.3067	-2.4602	0
15 Q_6	6.4324	0	0	10.5182	-14.6457	-2.3048
16 Q_7	0	0	0	0	22.4629	-21.9538
17 Q_8	0	0	0	0	0	5.8192
18 Q_9	0	0	0	0	0	0
19 Q_10	0	0	8.3153	0	0	0
20 Q_11	0	8.3519	0	0	0	0

```
Iteration Number 5 Jacobian:
JTable = 20×20 table
```

...

	$delta_2$	$delta_3$	$delta_4$	$delta_5$	$delta_6$	$delta_7$
1 P_2	57.9353	0	0	0	-57.9353	0
2 P_3	0	57.1683	0	0	0	0
3 P_4	0	0	54.7002	0	0	0
4 P_5	0	0	0	101.6541	-39.6051	0
5 P_6	-57.9353	0	0	-38.2573	193.5509	-97.3583
6 P_7	0	0	0	0	-94.6278	120.7135
7 P_8	0	0	0	0	0	-25.3213
8 P_9	0	0	0	0	0	0
9 P_10	0	0	-54.7002	0	0	0
10 P_11	0	-57.1683	0	0	0	0
11 Q_2	6.9631	0	0	0	-6.9631	0
12 Q_3	0	6.7927	0	0	0	0
13 Q_4	0	0	6.6685	0	0	0
14 Q_5	0	0	0	-4.0560	-2.8459	0
15 Q_6	6.9631	0	0	10.6321	-13.5424	-4.0529
16 Q_7	0	0	0	0	23.2515	-22.0050
17 Q_8	0	0	0	0	0	6.3914
18 Q_9	0	0	0	0	0	0
19 Q_10	0	0	6.6685	0	0	0
20 Q_11	0	6.7927	0	0	0	0

```
Iteration Number 6 Jacobian:
JTable = 20×20 table
```

...

	$delta_2$	$delta_3$	$delta_4$	$delta_5$	$delta_6$	$delta_7$
1 P_2	60.9375	0	0	0	-60.9375	0
2 P_3	0	62.1710	0	0	0	0
3 P_4	0	0	60.1199	0	0	0
4 P_5	0	0	0	103.6850	-41.0133	0
5 P_6	-60.9375	0	0	-39.6503	203.4097	-102.8219
6 P_7	0	0	0	0	-100.0673	128.0324
7 P_8	0	0	0	0	0	-27.1910
8 P_9	0	0	0	0	0	0
9 P_10	0	0	-60.1199	0	0	0
10 P_11	0	-62.1710	0	0	0	0
11 Q_2	6.9882	0	0	0	-6.9882	0
12 Q_3	0	7.1865	0	0	0	0
13 Q_4	0	0	6.9849	0	0	0
14 Q_5	0	0	0	-4.1280	-2.7816	0
15 Q_6	6.9882	0	0	10.8480	-14.2075	-3.6287
16 Q_7	0	0	0	0	23.9176	-22.8102
17 Q_8	0	0	0	0	0	6.6276
18 Q_9	0	0	0	0	0	0
19 Q_10	0	0	6.9849	0	0	0
20 Q_11	0	7.1865	0	0	0	0

```
Iteration Number 7 Jacobian:
JTable = 20×20 table
```

...

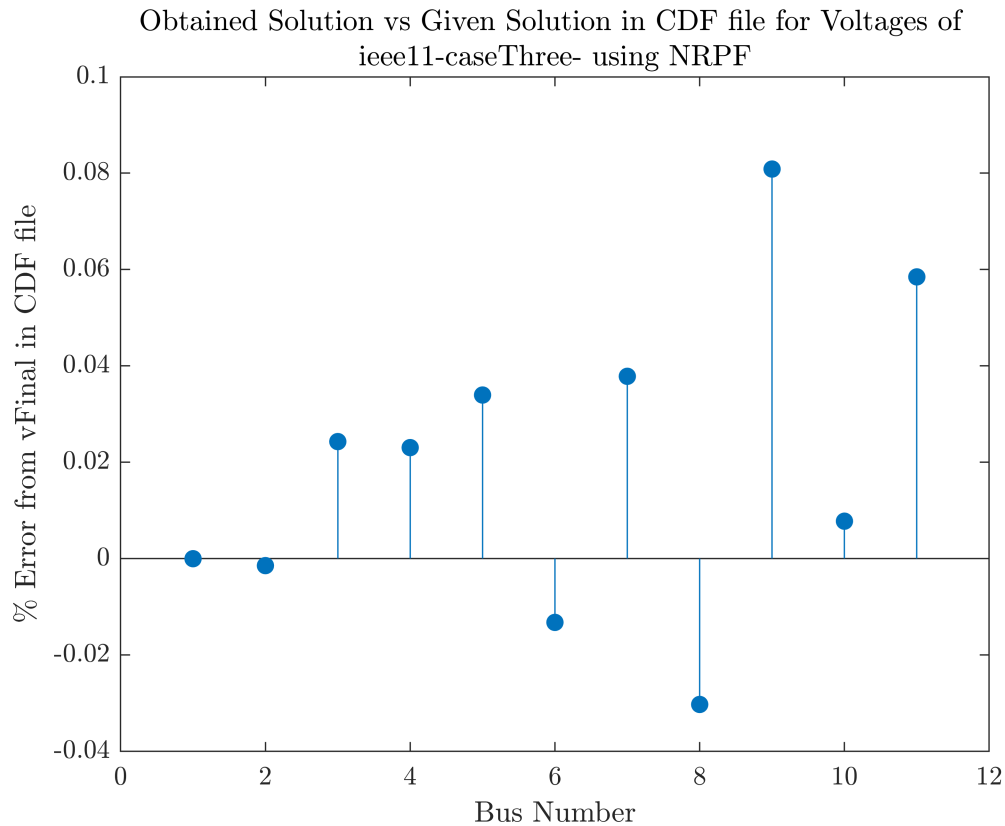
	$delta_2$	$delta_3$	$delta_4$	$delta_5$	$delta_6$	$delta_7$
1 P_2	60.9049	0	0	0	-60.9049	0
2 P_3	0	62.3526	0	0	0	0
3 P_4	0	0	60.2614	0	0	0
4 P_5	0	0	0	103.6630	-40.9984	0
5 P_6	-60.9049	0	0	-39.6341	203.3114	-102.7723
6 P_7	0	0	0	0	-100.0124	127.9735
7 P_8	0	0	0	0	0	-27.1844
8 P_9	0	0	0	0	0	0
9 P_10	0	0	-60.2614	0	0	0
10 P_11	0	-62.3526	0	0	0	0
11 Q_2	7	0	0	0	-7	0

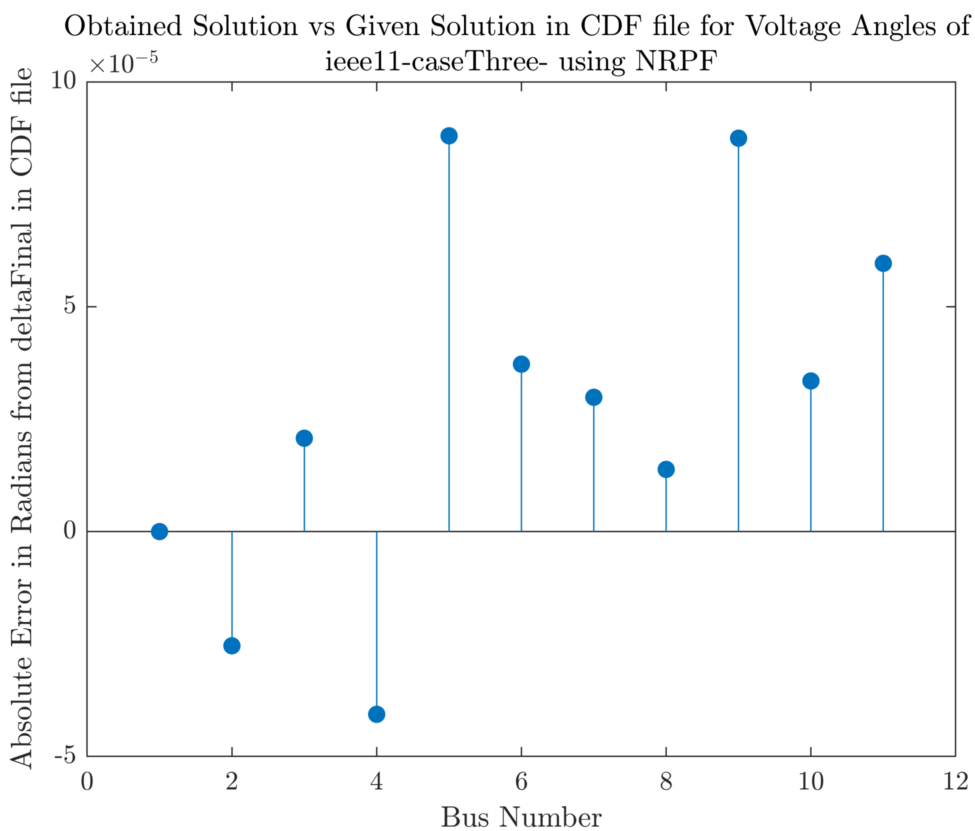
	$delta_2$	$delta_3$	$delta_4$	$delta_5$	$delta_6$	$delta_7$
12 Q_3	0	7.1900	0	0	0	0
13 Q_4	0	0	7	0	0	0
14 Q_5	0	0	0	-4.1232	-2.7895	0
15 Q_6	7	0	0	10.8527	-14.1923	-3.6604
16 Q_7	0	0	0	0	23.9389	-22.8180
17 Q_8	0	0	0	0	0	6.6400
18 Q_9	0	0	0	0	0	0
19 Q_10	0	0	7	0	0	0
20 Q_11	0	7.1900	0	0	0	0

```
Convergence using NRPF achieved in 7 iterations.
resultTable = 11×4 table
```

	P	Q	V	delta
1 Bus_1	6.9127	0.9766	1.0300	0
2 Bus_2	7	0.2870	1.0100	-0.1630
3 Bus_3	7.1900	1.3190	1.0303	-0.3319
4 Bus_4	7	0.9600	1.0102	-0.5076
5 Bus_5	-0	0	1.0203	-0.1099
6 Bus_6	-0	0	1.0119	-0.2775
7 Bus_7	-9.6700	-1	1.0214	-0.4127
8 Bus_8	0	0	1.0097	-0.5526
9 Bus_9	-17.6701	-1	1.0028	-0.7644
10 Bus_10	0.0001	0	1.0011	-0.6232
11 Bus_11	0	0	1.0156	-0.4467

Compare obtained snapshot values of V_i and δ_i against the ones given in the CDF file.





Economic Dispatch and Optimal Power Flow Calculations:

```
Elapsed time is 1.796283 seconds.
```

Have a nice day!

In case you encounter a Java Heap Memory error, delete the above gif, or go to `Preferences->General->Java Heap Memory` and increase the allocated size.

EE 521 Power System Analysis and EE 523 Power System Stability and Control Algorithms

Preamble and Control Inputs

```
systemName =
"ieee11-caseThree-"

powerFlowMethod =
"Fast Decoupled NRPF"
```

Read CDF file and store the data in neat MATLAB `tables`: `busData` and `branchData`.

```
busData = 11×18 table
```

...

	bus	busName	loadFlowArea	lossZone	busType	vFinal
1	1	"Bus 1 HV"	1	1	3	1.0300
2	2	"Bus 2 HV"	1	1	0	1.0100
3	3	"Bus 3 HV"	2	1	0	1.0300
4	4	"Bus 4 HV"	2	1	0	1.0100
5	5	"Bus 5 HV"	1	1	0	1.0200
6	6	"Bus 6 LV"	1	1	0	1.0120
7	7	"Bus 7 ZV"	1	1	0	1.0210
8	8	"Bus 8 TV"	3	1	0	1.0100
9	9	"Bus 9 LV"	2	1	0	1.0020
10	10	"Bus 10 LV"	2	1	0	1.0010
11	11	"Bus 11 LV"	2	1	0	1.0150

```
branchData = 10×15 table
```

...

	i	j	loadFlowArea	lossZone	ckt	type	R
1	1	5	1	1	1	0	0
2	2	6	1	1	1	0	0
3	3	11	2	1	1	0	0
4	4	10	2	1	1	0	0
5	5	6	1	1	1	0	0.0025
6	6	7	1	1	1	0	0.0010
7	7	8	1	1	1	0	0.0037
8	8	9	2	1	1	0	0.0055
9	9	10	2	1	1	0	0.0010
10	10	11	2	1	1	0	0.0025

```
N = 11
numBranch = 10
```

Extract Y_{Bus}, Adjacency List E from the `branchData table.`

```
ybusTable = 11×11 table
```

...

	1	2	3	4	5
1 1	0.0000 -59.9880i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 +59.9880i
2 2	0.0000 + 0.0000i	0.0000 -59.9880i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i
3 3	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 -59.9880i	0.0000 + 0.0000i	0.0000 + 0.0000i
4 4	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 -59.9880i	0.0000 + 0.0000i
5 5	0.0000 +59.9880i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	3.9604 -99.5701i
6 6	0.0000 + 0.0000i	0.0000 +59.9880i	0.0000 + 0.0000i	0.0000 + 0.0000i	-3.9604 +39.6040i
7 7	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i
8 8	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i
9 9	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i
10 10	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 +59.9880i	0.0000 + 0.0000i
11 11	0.0000 + 0.0000i	0.0000 + 0.0000i	0.0000 +59.9880i	0.0000 + 0.0000i	0.0000 + 0.0000i

Run Newton Raphson Power Flow and obtain a steady state snapshot of the system variables $P_i, Q_i, V_i, \delta_i\ \forall$ buses $i \in [1, N], i \in \mathbb{N}$

```
Iteration Number 1 Jacobian J11:
J11Table = 10×10 table
```

...

	$delta_2$	$delta_3$	$delta_4$	$delta_5$	$delta_6$	$delta_7$
1 P_2	60.3989	0	0	0	-60.4474	0
2 P_3	0	60.8939	0	0	0	0
3 P_4	0	0	60.1657	0	0	0
4 P_5	0	0	0	102.8444	-40.4516	0
5 P_6	-60.4474	0	0	-40.4516	202.1296	-101.1638
6 P_7	0	0	0	0	-101.1638	136.9721
7 P_8	0	0	0	0	0	-27.5655
8 P_9	0	0	0	0	0	0
9 P_10	0	0	-60.2150	0	0	0
10 P_11	0	-60.9431	0	0	0	0

```
Iteration Number 1 Jacobians:
J22Table = 10×10 table
```

...

	$DeltaVByV_2$	$DeltaVByV_3$	$DeltaVByV_4$	$DeltaVByV_5$
1 Q_2	60.7750	0	0	0
2 Q_3	0	61.9899	0	0
3 Q_4	0	0	61.0087	0
4 Q_5	0	0	0	100.0669
5 Q_6	-7.0016	0	0	-3.7653
6 Q_7	0	0	0	0
7 Q_8	0	0	0	0
8 Q_9	0	0	0	0
9 Q_10	0	0	-7	0
10 Q_11	0	-7.1958	0	0

```
Iteration Number 2 Jacobian J11:
J11Table = 10×10 table
```

...

	$delta_2$	$delta_3$	$delta_4$	$delta_5$	$delta_6$	$delta_7$
1 P_2	59.9417	0	0	0	-60.3461	0
2 P_3	0	61.0236	0	0	0	0
3 P_4	0	0	59.9303	0	0	0
4 P_5	0	0	0	104.2100	-40.9895	0
5 P_6	-60.3461	0	0	-40.9895	203.1079	-102.1870
6 P_7	0	0	0	0	-102.1870	137.6700
7 P_8	0	0	0	0	0	-28.0876
8 P_9	0	0	0	0	0	0
9 P_10	0	0	-60.3375	0	0	0
10 P_11	0	-61.4515	0	0	0	0

```
Iteration Number 2 Jacobians:
J22Table = 10×10 table
```

...

	$DeltaVByV_2$	$DeltaVByV_3$	$DeltaVByV_4$	$DeltaVByV_5$
1 Q_2	60.5719	0	0	0
2 Q_3	0	63.8213	0	0
3 Q_4	0	0	62.4294	0
4 Q_5	0	0	0	104.4135
5 Q_6	-6.9894	0	0	-5.4047
6 Q_7	0	0	0	0
7 Q_8	0	0	0	0
8 Q_9	0	0	0	0

	$DeltaVByV_2$	$DeltaVByV_3$	$DeltaVByV_4$	$DeltaVByV_5$
9 Q_10	0	0	-6.9404	0
10 Q_11	0	-7.1264	0	0

```
Iteration Number 3 Jacobian J11:
J11Table = 10×10 table
```

...

	$delta_2$	$delta_3$	$delta_4$	$delta_5$	$delta_6$	$delta_7$
1 P_2	60.2360	0	0	0	-60.6423	0
2 P_3	0	61.1251	0	0	0	0
3 P_4	0	0	59.8639	0	0	0
4 P_5	0	0	0	104.1119	-41.1578	0
5 P_6	-60.6423	0	0	-41.1578	203.8668	-102.8322
6 P_7	0	0	0	0	-102.8322	138.0203
7 P_8	0	0	0	0	0	-28.1478
8 P_9	0	0	0	0	0	0
9 P_10	0	0	-60.2622	0	0	0
10 P_11	0	-61.5384	0	0	0	0

```
Iteration Number 3 Jacobians:
J22Table = 10×10 table
```

...

	$DeltaVByV_2$	$DeltaVByV_3$	$DeltaVByV_4$	$DeltaVByV_5$
1 Q_2	59.9946	0	0	0
2 Q_3	0	63.3770	0	0
3 Q_4	0	0	61.2930	0
4 Q_5	0	0	0	103.6666
5 Q_6	-7.0019	0	0	-6.2605
6 Q_7	0	0	0	0
7 Q_8	0	0	0	0
8 Q_9	0	0	0	0
9 Q_10	0	0	-6.9866	0
10 Q_11	0	-7.1766	0	0

```
Iteration Number 4 Jacobian J11:
J11Table = 10×10 table
```

...

	$delta_2$	$delta_3$	$delta_4$	$delta_5$	$delta_6$	$delta_7$
1 P_2	60.5710	0	0	0	-60.9770	0
2 P_3	0	61.3724	0	0	0	0
3 P_4	0	0	59.9733	0	0	0

	$delta_2$	$delta_3$	$delta_4$	$delta_5$	$delta_6$	$delta_7$
4 P_5	0	0	0	104.1167	-41.1675	0
5 P_6	-60.9770	0	0	-41.1675	204.1625	-103.0051
6 P_7	0	0	0	0	-103.0051	138.0852
7 P_8	0	0	0	0	0	-28.1384
8 P_9	0	0	0	0	0	0
9 P_10	0	0	-60.3786	0	0	0
10 P_11	0	-61.7921	0	0	0	0

```
Iteration Number 4 Jacobians:
J22Table = 10×10 table
```

...

	$DeltaVByV_2$	$DeltaVByV_3$	$DeltaVByV_4$	$DeltaVByV_5$
1 Q_2	61.3444	0	0	0
2 Q_3	0	63.8386	0	0
3 Q_4	0	0	62.2003	0
4 Q_5	0	0	0	104.3104
5 Q_6	-7.0096	0	0	-6.6193
6 Q_7	0	0	0	0
7 Q_8	0	0	0	0
8 Q_9	0	0	0	0
9 Q_10	0	0	-7.0024	0
10 Q_11	0	-7.1927	0	0

```
Iteration Number 5 Jacobian J11:
J11Table = 10×10 table
```

...

	$delta_2$	$delta_3$	$delta_4$	$delta_5$	$delta_6$	$delta_7$
1 P_2	60.6605	0	0	0	-61.0635	0
2 P_3	0	61.4809	0	0	0	0
3 P_4	0	0	59.9256	0	0	0
4 P_5	0	0	0	104.0507	-41.2493	0
5 P_6	-61.0635	0	0	-41.2493	204.3955	-103.1630
6 P_7	0	0	0	0	-103.1630	138.0736
7 P_8	0	0	0	0	0	-28.1065
8 P_9	0	0	0	0	0	0
9 P_10	0	0	-60.3308	0	0	0
10 P_11	0	-61.8998	0	0	0	0

```
Iteration Number 5 Jacobians:
J22Table = 10×10 table
```

...

	$DeltaVByV_2$	$DeltaVByV_3$	$DeltaVByV_4$	$DeltaVByV_5$
1 Q_2	60.7739	0	0	0
2 Q_3	0	64.0589	0	0
3 Q_4	0	0	61.5943	0
4 Q_5	0	0	0	103.7586
5 Q_6	-7.0126	0	0	-6.8074
6 Q_7	0	0	0	0
7 Q_8	0	0	0	0
8 Q_9	0	0	0	0
9 Q_10	0	0	-7.0095	0
10 Q_11	0	-7.1998	0	0

```
Iteration Number 6 Jacobian J11:
J11Table = 10×10 table
```

...

	$delta_2$	$delta_3$	$delta_4$	$delta_5$	$delta_6$	$delta_7$
1 P_2	60.7852	0	0	0	-61.1882	0
2 P_3	0	61.6054	0	0	0	0
3 P_4	0	0	59.9462	0	0	0
4 P_5	0	0	0	104.0855	-41.2253	0
5 P_6	-61.1882	0	0	-41.2253	204.4326	-103.1526
6 P_7	0	0	0	0	-103.1526	138.0584
7 P_8	0	0	0	0	0	-28.0877
8 P_9	0	0	0	0	0	0
9 P_10	0	0	-60.3531	0	0	0
10 P_11	0	-62.0245	0	0	0	0

```
Iteration Number 6 Jacobians:
J22Table = 10×10 table
```

...

	$DeltaVByV_2$	$DeltaVByV_3$	$DeltaVByV_4$	$DeltaVByV_5$
1 Q_2	61.6277	0	0	0
2 Q_3	0	64.0036	0	0
3 Q_4	0	0	62.1174	0
4 Q_5	0	0	0	104.2834
5 Q_6	-7.0144	0	0	-6.8613
6 Q_7	0	0	0	0
7 Q_8	0	0	0	0

	$DeltaVByV_2$	$DeltaVByV_3$	$DeltaVByV_4$	$DeltaVByV_5$
8 Q_9	0	0	0	0
9 Q_10	0	0	-7.0134	0
10 Q_11	0	-7.2037	0	0

```
Iteration Number 7 Jacobian J11:
J11Table = 10×10 table
```

...

	$delta_2$	$delta_3$	$delta_4$	$delta_5$	$delta_6$	$delta_7$
1 P_2	60.7754	0	0	0	-61.1769	0
2 P_3	0	61.6874	0	0	0	0
3 P_4	0	0	59.8911	0	0	0
4 P_5	0	0	0	104.0475	-41.2705	0
5 P_6	-61.1769	0	0	-41.2705	204.5103	-103.2094
6 P_7	0	0	0	0	-103.2094	138.0317
7 P_8	0	0	0	0	0	-28.0667
8 P_9	0	0	0	0	0	0
9 P_10	0	0	-60.2978	0	0	0
10 P_11	0	-62.1058	0	0	0	0

```
Iteration Number 7 Jacobians:
J22Table = 10×10 table
```

...

	$DeltaVByV_2$	$DeltaVByV_3$	$DeltaVByV_4$	$DeltaVByV_5$
1 Q_2	61.0467	0	0	0
2 Q_3	0	64.4136	0	0
3 Q_4	0	0	61.6455	0
4 Q_5	0	0	0	103.8416
5 Q_6	-7.0147	0	0	-6.9075
6 Q_7	0	0	0	0
7 Q_8	0	0	0	0
8 Q_9	0	0	0	0
9 Q_10	0	0	-7.0145	0
10 Q_11	0	-7.2049	0	0

```
Iteration Number 8 Jacobian J11:
J11Table = 10×10 table
```

...

	$delta_2$	$delta_3$	$delta_4$	$delta_5$	$delta_6$	$delta_7$
1 P_2	60.8295	0	0	0	-61.2316	0
2 P_3	0	61.7379	0	0	0	0

	$delta_2$	$delta_3$	$delta_4$	$delta_5$	$delta_6$	$delta_7$
3 P_4	0	0	59.8913	0	0	0
4 P_5	0	0	0	104.0799	-41.2413	0
5 P_6	-61.2316	0	0	-41.2413	204.4810	-103.1685
6 P_7	0	0	0	0	-103.1685	138.0163
7 P_8	0	0	0	0	0	-28.0597
8 P_9	0	0	0	0	0	0
9 P_10	0	0	-60.2988	0	0	0
10 P_11	0	-62.1557	0	0	0	0

```
Iteration Number 8 Jacobians:
J22Table = 10×10 table
```

...

	$DeltaVByV_2$	$DeltaVByV_3$	$DeltaVByV_4$	$DeltaVByV_5$
1 Q_2	61.6461	0	0	0
2 Q_3	0	64.1457	0	0
3 Q_4	0	0	62.0107	0
4 Q_5	0	0	0	104.2507
5 Q_6	-7.0153	0	0	-6.9067
6 Q_7	0	0	0	0
7 Q_8	0	0	0	0
8 Q_9	0	0	0	0
9 Q_10	0	0	-7.0155	0
10 Q_11	0	-7.2056	0	0

```
Iteration Number 9 Jacobian J11:
J11Table = 10×10 table
```

...

	$delta_2$	$delta_3$	$delta_4$	$delta_5$	$delta_6$	$delta_7$
1 P_2	60.7986	0	0	0	-61.1998	0
2 P_3	0	61.7913	0	0	0	0
3 P_4	0	0	59.8468	0	0	0
4 P_5	0	0	0	104.0488	-41.2702	0
5 P_6	-61.1998	0	0	-41.2702	204.5091	-103.1980
6 P_7	0	0	0	0	-103.1980	137.9928
7 P_8	0	0	0	0	0	-28.0466
8 P_9	0	0	0	0	0	0
9 P_10	0	0	-60.2542	0	0	0
10 P_11	0	-62.2089	0	0	0	0

```
Iteration Number 9 Jacobians:
J22Table = 10×10 table
```

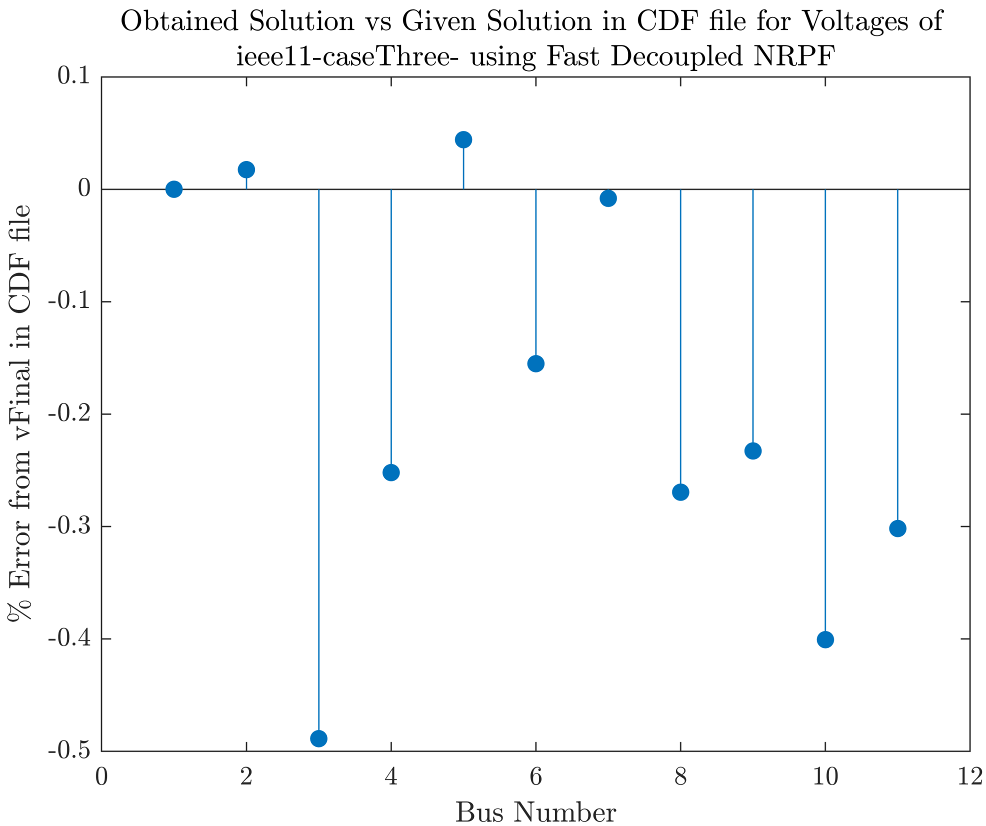
...

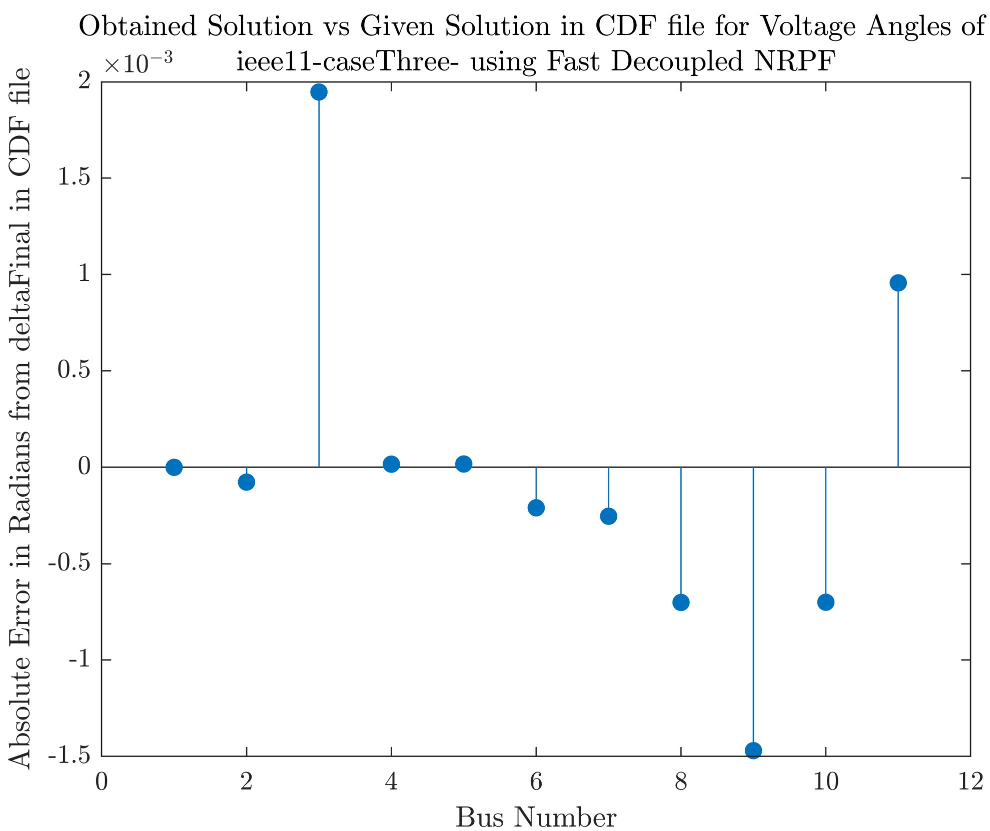
	$DeltaVByV_2$	$DeltaVByV_3$	$DeltaVByV_4$	$DeltaVByV_5$
1 Q_2	61.1525	0	0	0
2 Q_3	0	64.5755	0	0
3 Q_4	0	0	61.6367	0
4 Q_5	0	0	0	103.8961
5 Q_6	-7.0151	0	0	-6.9243
6 Q_7	0	0	0	0
7 Q_8	0	0	0	0
8 Q_9	0	0	0	0
9 Q_10	0	0	-7.0155	0
10 Q_11	0	-7.2058	0	0

```
Convergence using Fast Decoupled NRPF achieved in 9 iterations.
resultTable = 11×4 table
```

	P	Q	V	delta
1 Bus_1	6.9121	1.0222	1.0300	0
2 Bus_2	6.9998	0.1771	1.0102	-0.1631
3 Bus_3	7.1897	1.3917	1.0250	-0.3300
4 Bus_4	6.9996	0.8953	1.0075	-0.5075
5 Bus_5	-0.0001	-0.0752	1.0204	-0.1099
6 Bus_6	0.0001	0.3042	1.0104	-0.2777
7 Bus_7	-9.6692	-1.1596	1.0209	-0.4130
8 Bus_8	0.0006	0.0571	1.0073	-0.5533
9 Bus_9	-17.6669	-1.0855	0.9997	-0.7659
10 Bus_10	-0.0006	0.2508	0.9970	-0.6240
11 Bus_11	-0.0003	-0.1501	1.0119	-0.4458

Compare obtained snapshot values of V_i and δ_i against the ones given in the CDF file.





Economic Dispatch and Optimal Power Flow Calculations:

```
Elapsed time is 2.536898 seconds.
```

Have a nice day!

In case you encounter a Java Heap Memory error, delete the above gif, or go to `Preferences->General->Java Heap Memory` and increase the allocated size.