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

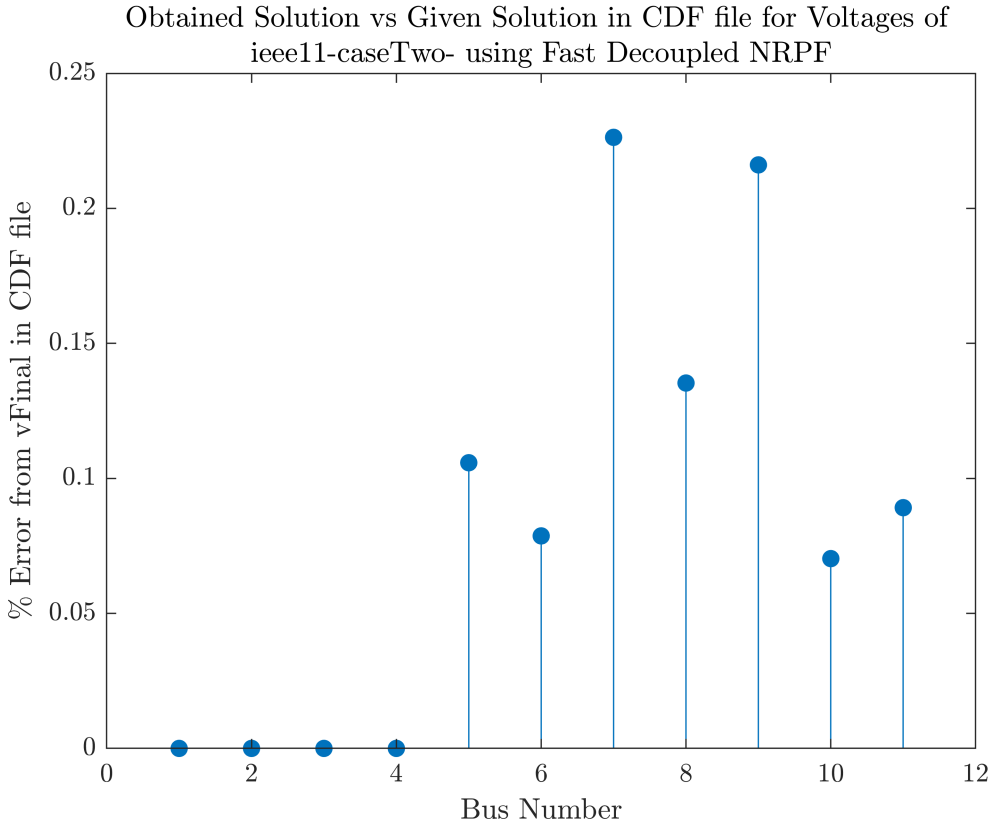
...

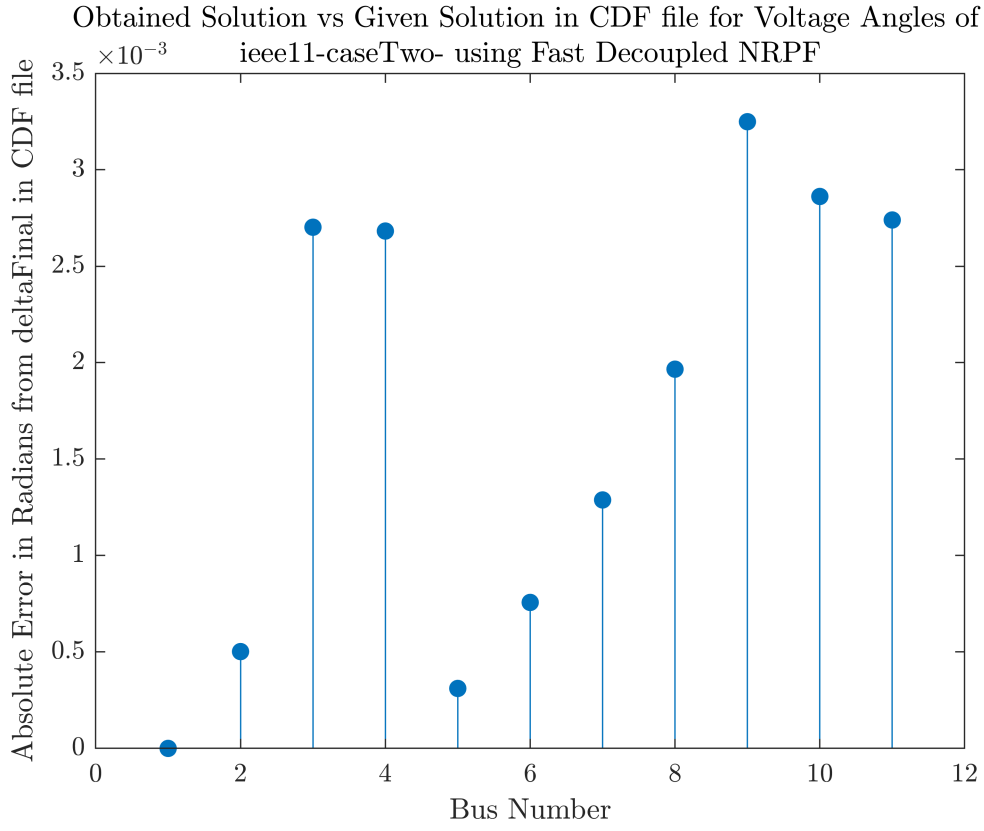
	$DeltaVByV_5$	$DeltaVByV_6$	$DeltaVByV_7$	$DeltaVByV_8$
1 Q_5	104.1891	6.9154	0	0
2 Q_6	-6.9154	205.6041	13.9691	0
3 Q_7	0	-13.9691	136.6367	3.9286
4 Q_8	0	0	-3.9286	47.1064
5 Q_9	0	0	0	-3.8918
6 Q_10	0	0	0	0
7 Q_11	0	0	0	0

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.