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
```

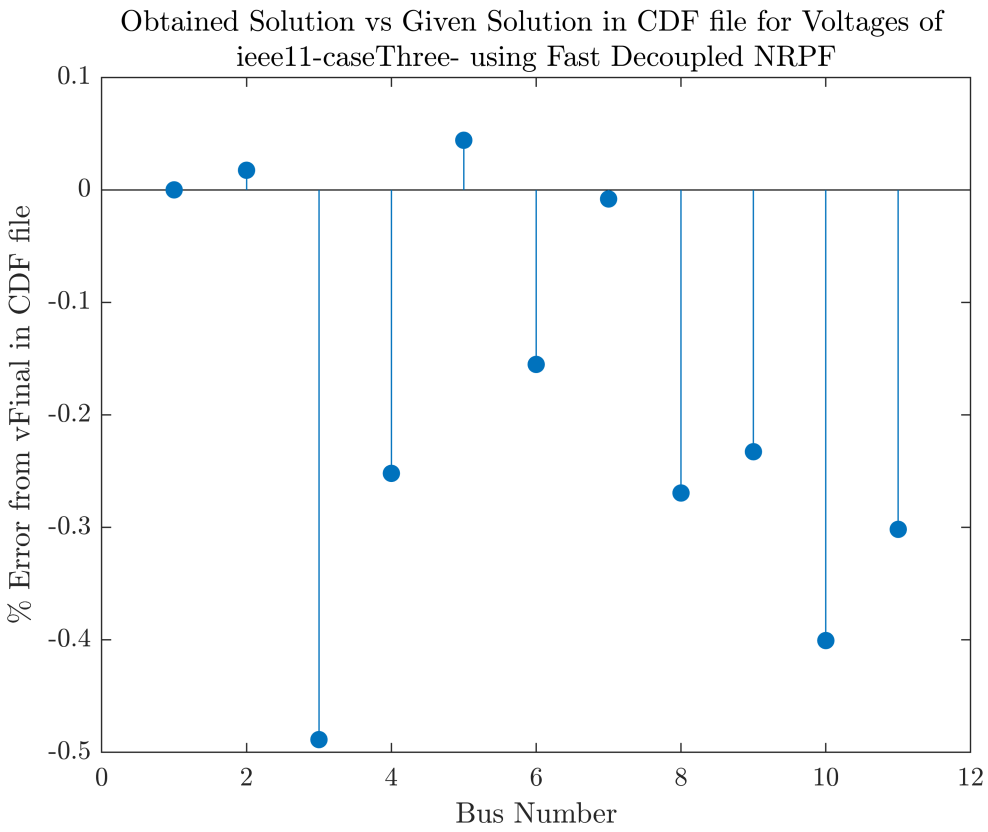
...

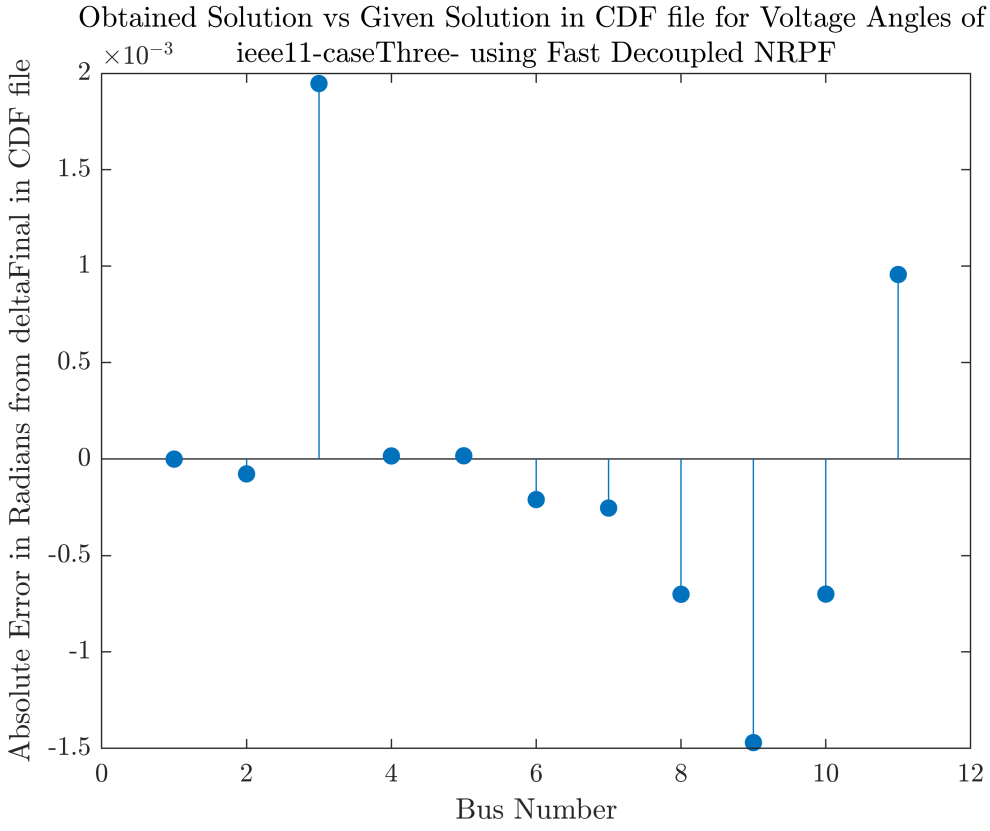
	$DeltaVByV_2$	$DeltaVByV_3$	$DeltaVByV_4$	$DeltaVByV_5$
1 Q_2	61.1525	0	0	0
2 Q_3	0	64.5755	0	0
3 Q_4	0	0	61.6367	0
4 Q_5	0	0	0	103.8961
5 Q_6	-7.0151	0	0	-6.9243
6 Q_7	0	0	0	0
7 Q_8	0	0	0	0
8 Q_9	0	0	0	0
9 Q_10	0	0	-7.0155	0
10 Q_11	0	-7.2058	0	0

```
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.