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 $P_i, Q_i, V_i, \delta_i \ \forall$ 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

...

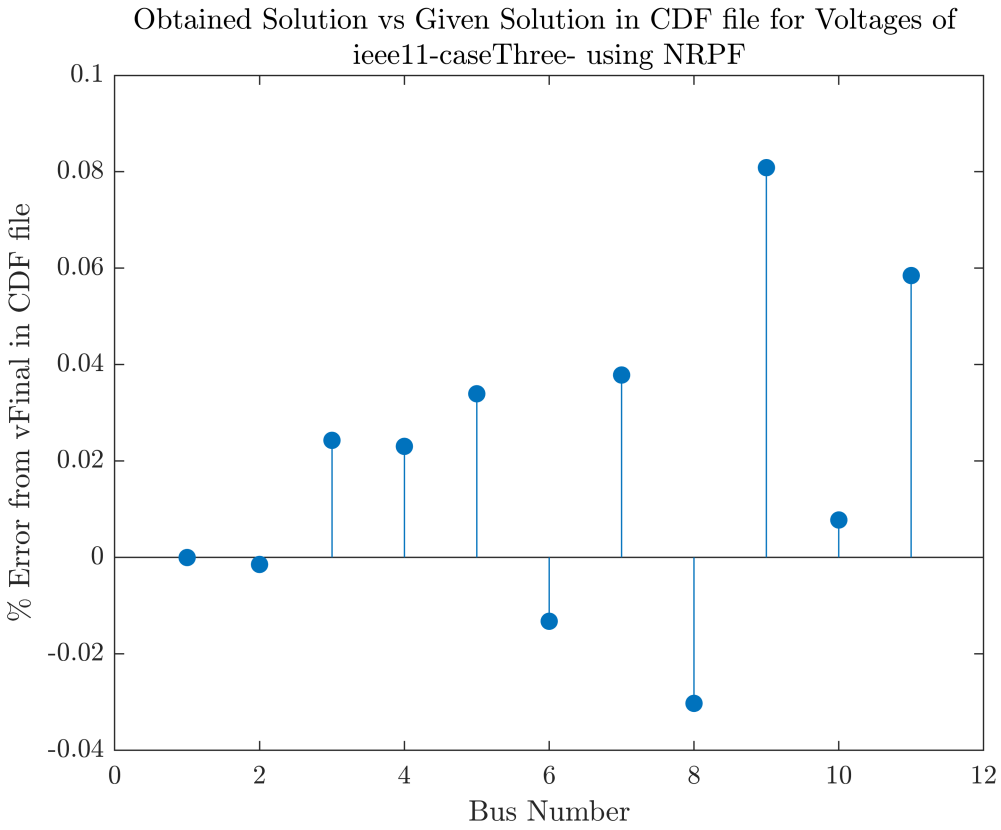
	$delta_2$	$delta_3$	$delta_4$	$delta_5$	$delta_6$	$delta_7$
1 P_2	60.9049	0	0	0	-60.9049	0
2 P_3	0	62.3526	0	0	0	0
3 P_4	0	0	60.2614	0	0	0
4 P_5	0	0	0	103.6630	-40.9984	0
5 P_6	-60.9049	0	0	-39.6341	203.3114	-102.7723
6 P_7	0	0	0	0	-100.0124	127.9735
7 P_8	0	0	0	0	0	-27.1844
8 P_9	0	0	0	0	0	0
9 P_10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

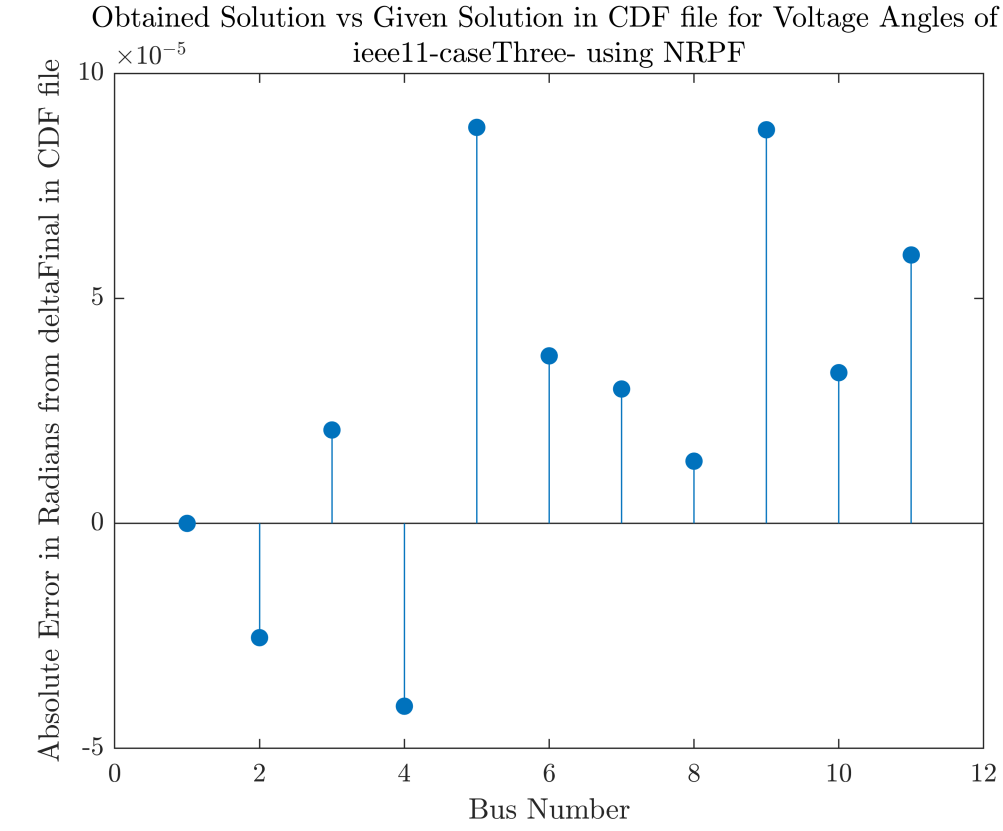
	$delta_2$	$delta_3$	$delta_4$	$delta_5$	$delta_6$	$delta_7$
12 Q_3	0	7.1900	0	0	0	0
13 Q_4	0	0	7	0	0	0
14 Q_5	0	0	0	-4.1232	-2.7895	0
15 Q_6	7	0	0	10.8527	-14.1923	-3.6604
16 Q_7	0	0	0	0	23.9389	-22.8180
17 Q_8	0	0	0	0	0	6.6400
18 Q_9	0	0	0	0	0	0
19 Q_10	0	0	7	0	0	0
20 Q_11	0	7.1900	0	0	0	0

```
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.