

Appendix A

Data for IEEE 14-Bus System

The IEEE 14-bus system is shown in Figure A.1. IEEE 14-bus system has 2 generators (at bus numbers 1 and 2), 3 synchronous condensers (at bus numbers 3, 6 and 8) and 20 transmission lines including 3 transformers. The system has a zero-injection bus at bus number 7. The data for IEEE 14-bus system is taken from Reference [134] and are presented in Tables A.1 and A.2. All parameters are in p.u. and on 100 MVA base.

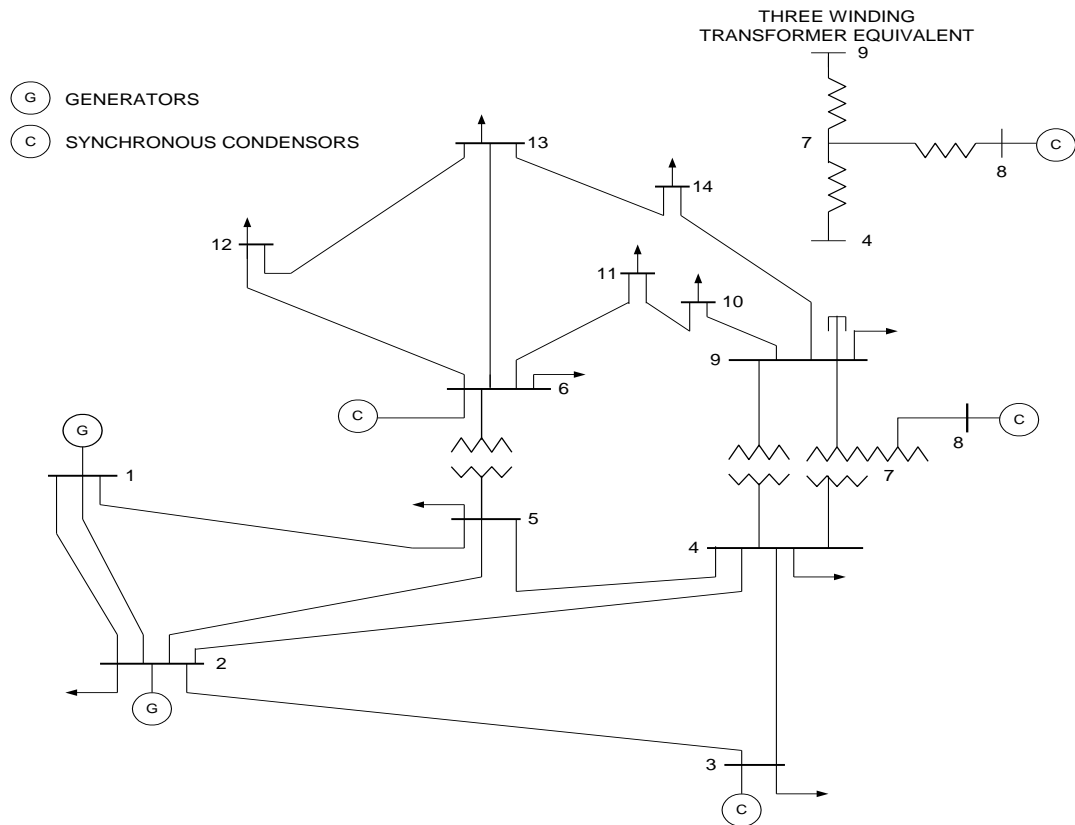


Figure A.1: Single line diagram of the IEEE 14-bus system

Table A.1: Bus data for the IEEE-14 bus system

Bus No.	Bus Type	Voltage Magnitude	Angle (Degrees)	Load		Generator			
				MW	MVAR	MW	MVAR	Max. Reactive Power Limit	Min. Reactive Power Limit
1	SWING	1.060	0	0	0	232.4	-16.9	0	0
2	PV	1.045	-4.98	21.7	12.7	40.0	42.4	50.0	-40.0
3	PV	1.010	-12.72	94.2	19.0	0	23.4	40.0	0
4	PQ	1.019	-10.33	47.8	-3.9	0	0	0	0
5	PQ	1.020	-8.78	7.6	1.6	0	0	0	0
6	PV	1.070	-14.22	11.2	7.5	0	12.2	24	-6
7	PQ	1.062	-13.37	0	0	0	0	0	0
8	PV	1.090	-13.36	0	0	0	17.4	24	-6
9	PQ	1.056	-14.94	29.5	16.6	0	0	0	0
10	PQ	1.051	-15.10	9.0	5.8	0	0	0	0
11	PQ	1.057	-14.79	3.5	1.8	0	0	0	0
12	PQ	1.055	-15.07	6.1	1.6	0	0	0	0
13	PQ	1.050	-15.16	13.5	5.8	0	0	0	0
14	PQ	1.036	-16.04	14.9	5.0	0	0	0	0

Table A.2: Line data for the IEEE-14 bus system

S. No.	Sending bus	Receiving bus	Resistance p.u.	Reactance p.u.	Half Susceptance p.u.	Transformer tap ratio
1	1	2	0.01938	0.05917	0.0264	1
2	2	3	0.04699	0.19797	0.0219	1
3	2	4	0.05811	0.17632	0.0187	1
4	1	5	0.05403	0.22304	0.0246	1
5	2	5	0.05695	0.17388	0.017	1
6	3	4	0.06701	0.17103	0.0173	1
7	4	5	0.01335	0.04211	0.0064	1
8	5	6	0	0.25202	0	0.932
9	4	7	0	0.20912	0	0.978
10	7	8	0	0.17615	0	1
11	4	9	0	0.55618	0	0.969
12	7	9	0	0.11001	0	1
13	9	10	0.03181	0.0845	0	1
14	6	11	0.09498	0.1989	0	1
15	6	12	0.12291	0.25581	0	1
16	6	13	0.06615	0.13027	0	1
17	9	14	0.12711	0.27038	0	1
18	10	11	0.08205	0.19207	0	1
19	12	13	0.22092	0.19988	0	1
20	13	14	0.17093	0.34802	0	1

Appendix B

Data for New England 39-Bus System

The New England 39-bus system is shown in Figure B.1. The New England 39-bus system has 10 generators and 46 transmission lines/transformers. It has 12 zero-injection buses at bus numbers 1, 2, 5, 6, 9, 10, 11, 13, 14, 17, 19 and 22. The data for New England 39-bus system is taken from Reference [135] and are presented in Tables B.1 and B.2. All parameters are in p.u. and on 100 MVA base.

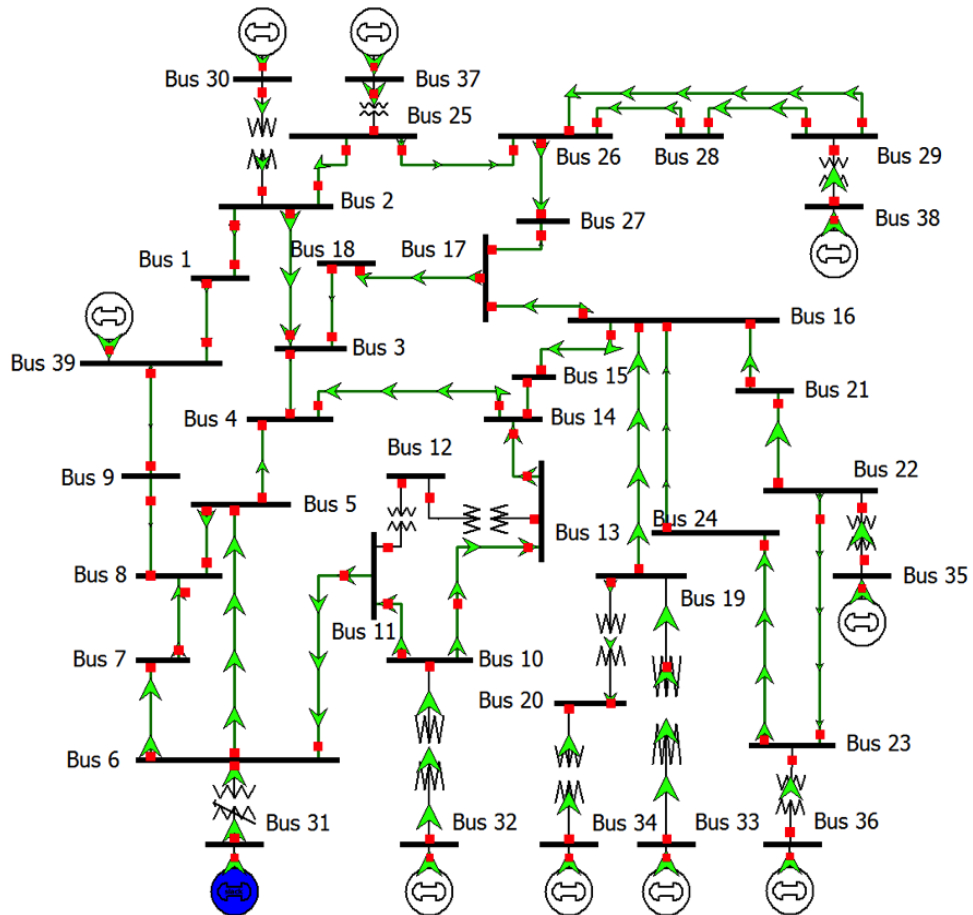


Figure B.1: Single line diagram of the 39-bus New England system

Table B.1: Bus data for New England 39-bus system

Bus No.	Bus Type	Voltage Magnitude	Active power		Reactive power load	Reactive Limits		Shunt MVAR
			Generation	Load		Maximum	Minimum	
1	PQ	1.04814	0.0000	0.0000	0.0000	0.0000	0.0000	0.0
2	PQ	1.05050	0.0000	0.0000	0.0000	0.0000	0.0000	0.0
3	PQ	1.03411	0.0000	3.2200	0.0240	0.0000	0.0000	0.0
4	PQ	1.01161	0.0000	5.0000	1.8400	0.0000	0.0000	0.0
5	PQ	1.01647	0.0000	0.0000	0.0000	0.0000	0.0000	0.0
6	PQ	1.01725	0.0000	0.0000	0.0000	0.0000	0.0000	0.0
7	PQ	1.00668	0.0000	2.3380	0.8400	0.0000	0.0000	0.0
8	PQ	1.00570	0.0000	5.2200	1.7600	0.0000	0.0000	0.0
9	PQ	1.03220	0.0000	0.0000	0.0000	0.0000	0.0000	0.0
10	PQ	1.02346	0.0000	0.0000	0.0000	0.0000	0.0000	0.0
11	PQ	1.02012	0.0000	0.0000	0.0000	0.0000	0.0000	0.0
12	PQ	1.00721	0.0000	0.0850	0.8800	0.0000	0.0000	0.0
13	PQ	1.02066	0.0000	0.0000	0.0000	0.0000	0.0000	0.0
14	PQ	1.01808	0.0000	0.0000	0.0000	0.0000	0.0000	0.0
15	PQ	1.01937	0.0000	3.2000	1.5300	0.0000	0.0000	0.0
16	PQ	1.03457	0.0000	3.2940	0.3230	0.0000	0.0000	0.0
17	PQ	1.03648	0.0000	0.0000	0.0000	0.0000	0.0000	0.0
18	PQ	1.03427	0.0000	1.5800	0.3000	0.0000	0.0000	0.0
19	PQ	1.05086	0.0000	0.0000	0.0000	0.0000	0.0000	0.0
20	PQ	0.99142	0.0000	6.8000	1.0300	0.0000	0.0000	0.0
21	PQ	1.03373	0.0000	2.7400	1.1500	0.0000	0.0000	0.0
22	PQ	1.05085	0.0000	0.0000	0.0000	0.0000	0.0000	0.0
23	PQ	1.04588	0.0000	2.4750	0.8460	0.0000	0.0000	0.0
24	PQ	1.03986	0.0000	3.0860	-0.9220	0.0000	0.0000	0.0
25	PQ	1.05869	0.0000	2.2400	0.4720	0.0000	0.0000	0.0
26	PQ	1.05359	0.0000	1.3900	0.1700	0.0000	0.0000	0.0
27	PQ	1.03990	0.0000	2.8100	0.7550	0.0000	0.0000	0.0
28	PQ	1.05091	0.0000	2.0600	0.2760	0.0000	0.0000	0.0
29	PQ	1.05048	0.0000	2.8350	1.2690	0.0000	0.0000	0.0
30	PV	1.04750	2.5000	0.0000	0.0000	1.8000	-0.5000	0.0
31	SWING	0.98200	2.3240	0.0920	0.0460	4.0000	-20.0000	0.0
32	PV	0.98310	6.5000	0.0000	0.0000	2.7000	-1.3000	0.0
33	PV	0.99720	6.3200	0.0000	0.0000	2.3000	-1.0000	0.0
34	PV	1.01230	5.0800	0.0000	0.0000	2.5000	-1.2000	0.0
35	PV	1.0493	6.5000	0.0000	0.0000	2.5000	-1.3000	0.0
36	PV	1.06350	5.6000	0.0000	0.0000	2.5000	-1.1000	0.0
37	PV	1.02780	5.4000	0.0000	0.0000	2.2000	-1.1000	0.0
38	PV	1.02650	8.3000	0.0000	0.0000	3.2000	-1.7000	0.0
39	PV	1.03000	10.0000	11.0400	2.5000	2.0000	-1.5000	0.0

Table B.2: Line data for the New England 39-bus system

Line No.	From bus	To bus	Series Impedance		Shunt susceptance	Tap ratio	Line rating
			Resistance	Reactance			
1	11	12	0.0035	0.0411	0.6987	0.000	4.0
2	11	1	0.0010	0.0250	0.7500	0.000	4.0
3	12	13	0.0013	0.0151	0.2572	0.000	5.0
4	12	25	0.0070	0.0086	0.1460	0.000	3.0
5	13	14	0.0013	0.0213	0.2214	0.000	4.0
6	13	38	0.0011	0.0133	0.2138	0.000	4.0
7	14	15	0.0008	0.0128	0.1342	0.000	4.0
8	14	34	0.0008	0.0129	0.1382	0.000	2.5
9	15	16	0.0002	0.0026	0.0434	0.000	5.0
10	15	18	0.0008	0.0112	0.1476	0.000	4.0
11	16	17	0.0006	0.0092	0.1130	0.000	5.0
12	16	31	0.0007	0.0082	0.1389	0.000	4.0
13	17	18	0.0004	0.0046	0.0780	0.000	4.0
14	18	19	0.0023	0.0363	0.3804	0.000	4.0
15	19	1	0.0010	0.0250	1.2000	0.000	4.0
16	20	31	0.0004	0.0043	0.0729	0.000	4.0
17	20	33	0.0004	0.0043	0.0729	0.000	4.0
18	33	34	0.0009	0.0101	0.1723	0.000	4.0
19	34	35	0.0018	0.0217	0.3660	0.000	3.0
20	35	36	0.0009	0.0094	0.1710	0.000	4.0
21	36	37	0.0007	0.0089	0.1342	0.000	4.0
22	36	39	0.0016	0.0195	0.3040	0.000	6.0
23	36	21	0.0008	0.0135	0.2548	0.000	4.0
24	36	24	0.0003	0.0059	0.0680	0.000	4.0
25	37	38	0.0007	0.0082	0.1319	0.000	4.0
26	37	27	0.0013	0.0173	0.3216	0.000	4.0
27	21	22	0.0008	0.0140	0.2565	0.000	6.0
28	22	23	0.0006	0.0096	0.1846	0.000	4.0
29	23	24	0.0022	0.0350	0.3610	0.000	4.0
30	25	26	0.0032	0.0323	0.5130	0.000	4.0
31	26	27	0.0014	0.0147	0.2396	0.000	4.0
32	26	28	0.0043	0.0474	0.7802	0.000	4.0
33	26	29	0.0057	0.0625	1.0290	0.000	3.0
34	28	29	0.0014	0.0151	0.2490	0.000	4.0
35	32	31	0.0016	0.0435	0.0000	1.006	3.0
36	32	33	0.0016	0.0435	0.0000	1.006	3.0
37	16	2	0.0000	0.0250	0.0000	1.070	6.0
38	20	3	0.0000	0.0200	0.0000	1.070	7.0
39	39	4	0.0007	0.0142	0.0000	1.070	6.5
40	30	5	0.0009	0.0180	0.0000	1.009	6.5
41	22	6	0.0000	0.0143	0.0000	1.025	7.0

Table B.2: continued in the next page

Table B.2: contd.. from previous page

Line No.	From bus	To bus	Series Impedance		Shunt susceptance	Tap ratio	Line rating
			Resistance	Reactance			
42	23	7	0.0005	0.0272	0.0000	1.000	6.0
43	25	8	0.0006	0.0232	0.0000	1.025	6.0
44	12	10	0.0000	0.0181	0.0000	1.025	4.0
45	29	9	0.0008	0.0156	0.0000	1.025	9.0
46	39	30	0.0007	0.0138	0.0000	1.060	5.0

Appendix C

Data for 246-Bus Northern Region Power Grid of India

The 246-bus NRPG system is shown in Figure C.1. It covers power network of seven states (Jammu and Kashmir, Punjab, Haryana, Himachal Pradesh, Rajasthan, Uttarakhand and Uttar Pradesh) and two union territories (Chandigarh and New Delhi) of India. It has 42 generators, and 376 branches (transformers/lines). It has 15 zero-injection buses at bus numbers 63, 75, 81, 102, 103, 104, 107, 122, 155, 180, 210, 226, 237, 241, and 244. The data for NRPG 246-bus system is taken from Reference [136] and are presented in Tables C.1 and C.2. All parameters are in p.u. and on 100 MVA base.

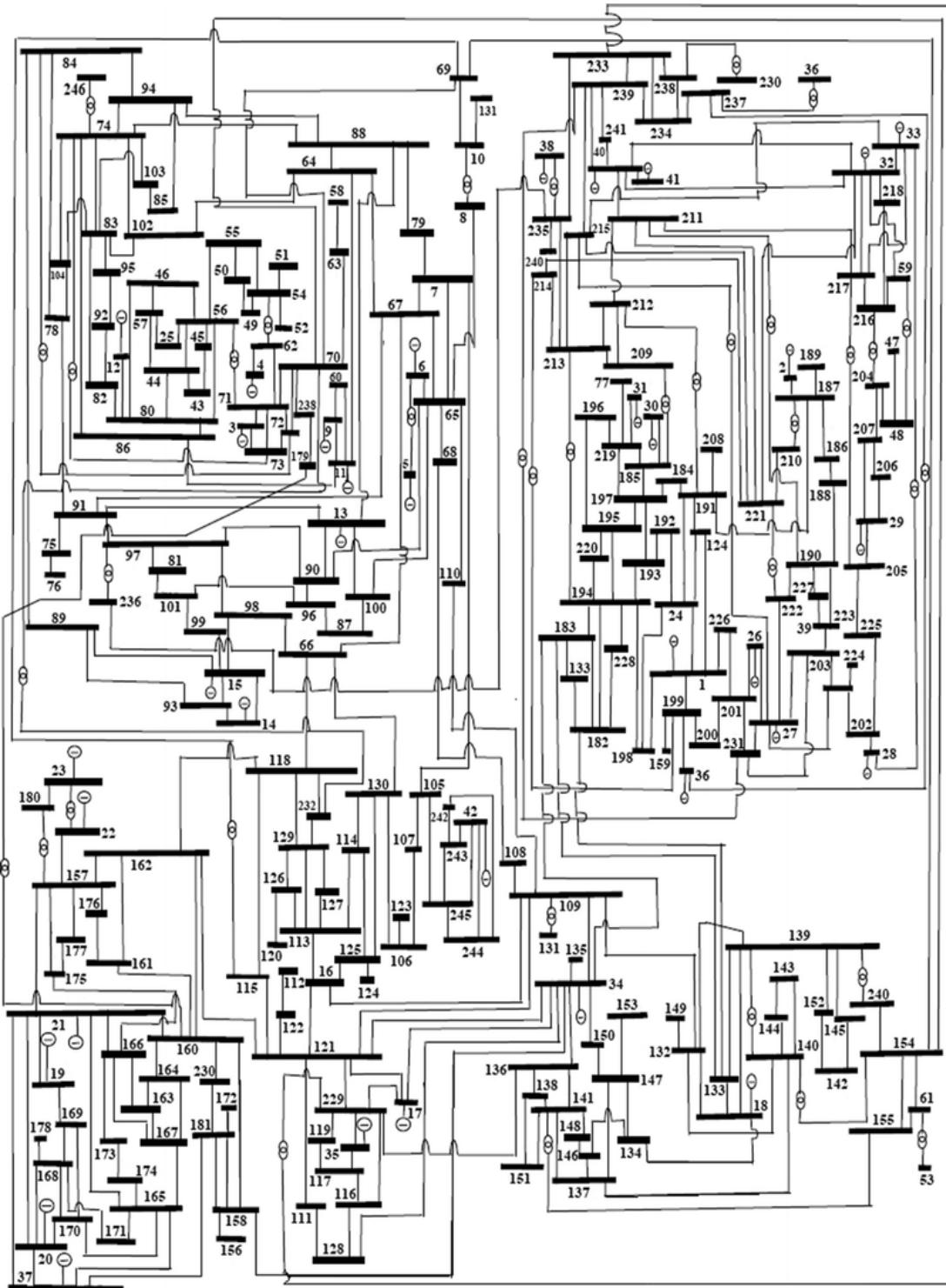


Figure C.1: Single line diagram of the NRP 246-bus system

Table C.1: Bus data for NRPG 246-bus system

Bus No.	Bus Type	Voltage Magnitude	P _G	Q _G	P _L	Q _L	Q _{GM} _{AX}	Q _{GMI} _N	Shunt MVAR
1	SWING	1.0052	3.852	-0.4175	2.141	0.0754	2.427	-2.0717	-1.54
2	PV	1.0319	1.107	0.0132	0	0	0.2130	-0.414	0.00
3	PV	1.0242	3.6	-0.2894	0	0	0.952	-1.8564	-1.00
4	PV	1.0353	3.6	-0.1099	0	0	1.545	-1.72	-1.00
5	PV	1.0320	2	0.3725	0.248	0.082	0.38	-0.74	0.00
6	PV	1.0287	2	-0.1271	0	0	0.38	-0.74	-0.50
7	PV	1.0209	5	0.8543	0	0	1.16	-2.2683	0.00
8	PV	1.0499	3.6	0.4218	0	0	0.871	-1.6995	0.00
9	PV	1.0377	1.2	0.3395	0	0	0.349	-0.6804	0.00
10	PV	1.0519	3	-1.1329	0	0	0.58	-1.133	-1.50
11	PV	1.0183	3	0.271	0.124	0.041	0.633	-1.2354	0.00
12	PV	0.9952	4	-0.594	0	0	1.465	-1.630	-0.80
13	PV	1.0189	10	1.401	0.944	0.298	5.657	-4.8366	0.00
14	PV	1.0027	3.6	0.2649	1.771	0.582	1.977	-1.6892	0.00
15	PV	1.0043	3.8	0.1776	0	0	1.884	-1.6096	0.00
16	PV	1.0274	7.2	2.6917	3.057	1.005	3.861	-3.3009	0.00
17	PV	1.0159	1.2	0.505	4.662	1.532	0.809	-0.6898	0.00
18	PV	1.0180	8.75	4.2745	2.216	0.728	4.66	-3.512	0.00
19	PV	1.0429	2	0.5666	0	0	1.975	-1.6892	0.00
20	PV	1.0495	3.8	0.5954	0	0	1.971	-1.6935	0.00
21	PV	1.0311	7.5	-1.1163	3.862	0.965	3.814	-3.2623	-1.00
22	PV	1.0499	4.5	1.2244	1.659	0.549	2.246	-1.9213	0.00
23	PV	1.0390	4.5	-1.9233	0	0	2.257	-1.9235	-2.00
24	PV	1.0127	3	0.5921	0	0	2.112	-1.8041	0.00
25	PV	1.0203	4.5	-0.6983	0	0	1.013	-1.9756	-0.80
26	PV	1.0329	1.6	0.5433	1.64	0.539	0.989	-0.8446	0.00
27	PV	1.0249	1.4	-0.4024	3.016	1.254	0.989	-0.8446	-1.00
28	PV	1.0500	4	1.8732	-0.432	0.209	2.022	-1.7311	0.00
29	PV	1.0368	2.6	1.483	0	0	1.483	-1.2668	0.00
30	PV	1.0400	0.6	0.106	0	0	0.106	-0.2070	0.00

31	PV	1.0248	1.74	0.3171	0	0	0.317	-0.6180	0.00
32	PV	1.0350	14	-0.213	0	0	7.321	-6.2647	-0.50
33	PV	1.0300	8	- 2.3954	0	0	4.494	-3.8415	-3.00
34	PV	1.0188	5.5	3.0559	0	0	3.234	-2.7658	0.00
35	PV	1.0243	3.6	0.9468	0	0	1.605	-1.5779	0.00
36	PV	1.0499	5.8	0.0376	0	0	3.948	-2.7847	0.00
37	PV	1.0499	3.6	0.9789	0	0	1.854	-1.5846	0.00
38	PV	1.0447	15	1.6075	0	0	7.441	-6.3594	0.00
39	PV	1.0486	7.2	1.3595	0	0	3.769	-3.2214	0.00
40	PV	1.0380	18	- 4.0049	0	0	8.988	-15.360	-5.23
41	PV	1.0475	9	- 3.9419	12.5 84	-6.34	4.689	-3.9490	-2.00
42	PV	1.0256	2.4	0.4335	0	0	0	0	0.00
43	PQ	1.0089	0	0	0.42 5	0.197	0	0	0.00
44	PQ	1.0094	0	0	0.55 6	0.165	0	0	0.00
45	PQ	1.0111	0	0	0.62 8	0.219	0	0	0.00
46	PQ	1.0163	0	0	0.71	0.173	0	0	0.00
47	PQ	0.9815	0	0	1.45	0.844	0	0	0.00
48	PQ	0.9909	0	0	0.95 8	0.576	0	0	0.00
49	PQ	1.0344	0	0	0.36	0.261	0	0	0.00
50	PQ	1.0342	0	0	- 0.15 5	0.307	0	0	0.00
51	PQ	1.0376	0	0	0	0	0	0	0.00
52	PQ	1.0356	0	0	0.48 9	0.121	0	0	0.00
53	PQ	1.0279	0	0	0	0	0	0	0.00
54	PQ	1.0364	0	0	0	0	0	0	0.00
55	PQ	1.0363	0	0	0.43 5	-0.063	0	0	0.00
56	PQ	1.0203	0	0	0	0	0	0	0.00
57	PQ	1.0120	0	0	1.42 6	0.217	0	0	0.00
58	PQ	1.0456	0	0	0	0	0	0	0.00
59	PQ	1.0037	0	0	0	0.57	0	0	-0.50
60	PQ	1.0181	0	0	1.10 2	0.265	0	0	0.00
61	PQ	1.0279	0	0	0	0	0	0	-1.00
62	PQ	1.0378	0	0	0	0	0	0	-0.63
63	PQ	1.0456	0	0	0	0	0	0	-1.00
64	PQ	0.9945	0	0	0.49 6	0.163	0	0	0.00
65	PQ	1.0233	0	0	0.12 7	0.055	0	0	0.00
66	PQ	0.9972	0	0	1.48 9	0.49	0	0	0.00
67	PQ	0.9944	0	0	4.27 1	1.172	0	0	0.00
68	PQ	1.0068	0	0	-	0.168	0	0	0.00

					0.43				
69	PQ	1.0256	0	0	0	0	0	0	-1.00
70	PQ	1.0285	0	0	0	0	0	0	-2.50
71	PQ	1.0298	0	0	0	0	0	0	-1.89
72	PQ	1.0130	0	0	0	0	0	0	-2.26
73	PQ	1.0151	0	0	0	0	0	0	0.00
74	PQ	0.9989	0	0	0	0	0	0	0.00
75	PQ	0.9906	0	0	0	0	0	0	0.00
76	PQ	0.9854	0	0	0.72 4	0.315	0	0	0.00
77	PQ	1.0146	0	0	1.81	0.306	0	0	0.00
78	PQ	0.9976	0	0	0.29 1	0.066	0	0	0.00
79	PQ	0.9992	0	0	1.39 7	0.418	0	0	0.00
80	PQ	0.9938	0	0	0	0	0	0	0.00
81	PQ	1.0005	0	0	0	0	0	0	0.00
82	PQ	0.9750	0	0	2.81	0.935	0	0	0.00
83	PQ	0.9658	0	0	2.98 6	1.173	0	0	0.00
84	PQ	1.0017	0	0	4.66 2	1.757	0	0	0.00
85	PQ	0.9617	0	0	2.63 4	0.866	0	0	0.00
86	PQ	1.0048	0	0	0	0	0	0	0.00
87	PQ	0.9973	0	0	1.40 1	0.46	0	0	0.00
88	PQ	0.9913	0	0	4.09 5	1.612	0	0	0.00
89	PQ	0.9995	0	0	0.38 7	0.127	0	0	0.00
90	PQ	1.0042	0	0	2.53 4	0.833	0	0	0.00
91	PQ	0.9942	0	0	1.77 3	0.583	0	0	0.00
92	PQ	0.9676	0	0	0.65	0.214	0	0	0.00
93	PQ	0.9955	0	0	1.41 1	0.464	0	0	0.00
94	PQ	0.9797	0	0	0.53 7	0.176	0	0	0.00
95	PQ	0.9652	0	0	0.65	0.214	0	0	0.00
96	PQ	0.9968	0	0	1.66	0.546	0	0	0.00
97	PQ	1.0010	0	0	1.70 8	0.561	0	0	0.00
98	PQ	0.9960	0	0	1.13 6	0.373	0	0	0.00
99	PQ	0.9996	0	0	0.65	0.214	0	0	0.00
100	PQ	1.0072	0	0	1.23 1	0.405	0	0	0.00
101	PQ	0.9989	0	0	0.65	0.214	0	0	0.00
102	PQ	0.9796	0	0	0	0	0	0	0.00
103	PQ	0.9639	0	0	0	0	0	0	0.00
104	PQ	0.9831	0	0	0	0	0	0	0.00
105	PQ	0.9901	0	0	0.70 1	0.23	0	0	0.00

106	PQ	0.9878	0	0	0.46	0.151	0	0	0.00
107	PQ	0.9888	0	0	0	0	0	0	0.00
108	PQ	1.0006	0	0	1.23 5	0.406	0	0	0.00
109	PQ	1.0252	0	0	1.40 1	0.461	0	0	0.00
110	PQ	1.0253	0	0	0.57 3	0.188	0	0	0.00
111	PQ	1.0030	0	0	0.63 7	0.209	0	0	0.00
112	PQ	0.9779	0	0	1.21	0.398	0	0	0.00
113	PQ	1.0120	0	0	1.09 5	0.36	0	0	0.00
114	PQ	1.0062	0	0	0.68 3	0.224	0	0	0.00
115	PQ	1.0151	0	0	0.59 9	0.197	0	0	0.00
116	PQ	1.0096	0	0	1.11 5	0.366	0	0	0.00
117	PQ	1.0171	0	0	1.30 2	0.428	0	0	0.00
118	PQ	1.0151	0	0	1.82 1	0.552	0	0	0.00
119	PQ	1.0166	0	0	0.52 8	0.173	0	0	0.00
120	PQ	1.0028	0	0	0.6	0.213	0	0	0.00
121	PQ	1.0068	0	0	2.31 8	0.762	0	0	0.00
122	PQ	0.9967	0	0	0	0	0	0	0.00
123	PQ	0.9698	0	0	1.65 6	0.544	0	0	0.00
124	PQ	1.0077	0	0	0.36	0.118	0	0	0.00
125	PQ	1.0100	0	0	0.70 5	0.232	0	0	0.00
126	PQ	1.0127	0	0	0	0	0	0	0.00
127	PQ	1.0130	0	0	0.47 5	0.156	0	0	0.00
128	PQ	1.0046	0	0	0.34 8	0.114	0	0	0.00
129	PQ	1.0167	0	0	0	0	0	0	0.00
130	PQ	1.0013	0	0	0.34 8	0.114	0	0	0.00
131	PQ	1.0352	0	0	0	0	0	0	0.00
132	PQ	1.0061	0	0	2.55 2	0.839	0	0	0.00
133	PQ	1.0135	0	0	2.20 2	0.724	0	0	0.00
134	PQ	1.0171	0	0	0.74 3	0.244	0	0	0.00
135	PQ	1.0177	0	0	0.88 3	0.29	0	0	0.00
136	PQ	1.0099	0	0	3.23 9	1.065	0	0	0.00
137	PQ	1.0045	0	0	3.32 3	1.092	0	0	0.00
138	PQ	1.0093	0	0	0.70 1	0.23	0	0	0.00

139	PQ	1.0102	0	0	1.23 4	0.406	0	0	0.00
140	PQ	1.0072	0	0	0.47 7	0.157	0	0	0.00
141	PQ	1.0097	0	0	0.85 5	0.281	0	0	0.00
142	PQ	1.0070	0	0	0.71 5	0.235	0	0	0.00
143	PQ	1.0036	0	0	1.36	0.447	0	0	0.00
144	PQ	1.0035	0	0	1.65 5	0.544	0	0	0.00
145	PQ	1.0071	0	0	2.00 5	0.659	0	0	0.00
146	PQ	1.0135	0	0	0.92	0.302	0	0	0.00
147	PQ	1.0167	0	0	0	0	0	0	0.00
148	PQ	1.0106	0	0	0.91	0.299	0	0	0.00
149	PQ	1.0003	0	0	1.27 6	0.419	0	0	0.00
150	PQ	1.0177	0	0	1.19 2	0.392	0	0	0.00
151	PQ	1.0087	0	0	0.68	0.223	0	0	0.00
152	PQ	1.0073	0	0	0.96 8	0.318	0	0	0.00
153	PQ	1.0159	0	0	0.74 3	0.244	0	0	0.00
154	PQ	1.0247	0	0	0	0	0	0	-1.00
155	PQ	1.0220	0	0	0	0	0	0	0.00
156	PQ	0.8723	0	0	2.69 8	0.887	0	0	0.00
157	PQ	1.0308	0	0	0.83 5	0.275	0	0	0.00
158	PQ	0.9128	0	0	1.74 7	0.624	0	0	0.00
159	PQ	0.9824	0	0	0.79 9	0.263	0	0	0.00
160	PQ	0.9986	0	0	2.53 2	0.832	0	0	0.00
161	PQ	1.0019	0	0	0.96 8	0.318	0	0	0.00
162	PQ	0.9999	0	0	2.09 4	0.688	0	0	0.00
163	PQ	0.9683	0	0	1.23 5	0.406	0	0	0.00
164	PQ	0.9835	0	0	0.88 4	0.29	0	0	0.00
165	PQ	1.0080	0	0	0.50 8	0.183	0	0	0.00
166	PQ	0.9948	0	0	1.38 1	0.459	0	0	0.00
167	PQ	0.9953	0	0	0	0	0	0	0.00
168	PQ	0.9780	0	0	2.3	0.888	0	0	0.00
169	PQ	0.9926	0	0	1.18 9	0.338	0	0	0.00
170	PQ	0.9992	0	0	1.33 6	0.469	0	0	0.00
171	PQ	0.9535	0	0	1.37 5	0.469	0	0	0.00

172	PQ	0.9576	0	0	0.94 5	0.342	0	0	0.00
173	PQ	0.9407	0	0	0.48 6	0.183	0	0	0.00
174	PQ	0.9133	0	0	1.69 8	0.676	0	0	0.00
175	PQ	1.0371	0	0	0	0	0	0	0.00
176	PQ	1.0085	0	0	1.38	0.454	0	0	0.00
177	PQ	1.0273	0	0	0.59 3	0.195	0	0	0.00
178	PQ	1.0062	0	0	- 0.71	-0.106	0	0	0.00
179	PQ	1.0070	0	0	0	0	0	0	0.00
180	PQ	1.0355	0	0	0	0	0	0	0.00
181	PQ	0.9876	0	0	0.71 4	0.235	0	0	0.00
182	PQ	1.0096	0	0	1.14 7	0.377	0	0	0.00
183	PQ	1.0131	0	0	0	0	0	0	0.00
184	PQ	0.9947	0	0	0.25 8	0.114	0	0	0.00
185	PQ	1.0245	0	0	0.8	0.287	0	0	0.00
186	PQ	1.0044	0	0	0.43	0.096	0	0	0.00
187	PQ	1.0176	0	0	2.2	0.216	0	0	0.00
188	PQ	0.9741	0	0	1.52 4	0.556	0	0	0.00
189	PQ	1.0137	0	0	0.28 1	0.092	0	0	0.00
190	PQ	1.0093	0	0	4.07 9	1.198	0	0	0.00
191	PQ	1.0098	0	0	1.23 1	0.351	0	0	0.00
192	PQ	0.9856	0	0	0.86	0.283	0	0	0.00
193	PQ	0.9865	0	0	1.52 8	0.616	0	0	0.00
194	PQ	1.0057	0	0	2.68 7	1.292	0	0	0.00
195	PQ	0.9890	0	0	1.97 4	0.671	0	0	0.00
196	PQ	1.0043	0	0	- 0.13 1	0.252	0	0	0.00
197	PQ	0.9895	0	0	1.80 7	0.613	0	0	0.00
198	PQ	1.0026	0	0	1.85 3	0.535	0	0	0.00
199	PQ	0.9895	0	0	3.28 3	1.093	0	0	0.00
200	PQ	0.9908	0	0	0.49	0.161	0	0	0.00
201	PQ	1.0026	0	0	2.11 1	0.694	0	0	0.00
202	PQ	1.0048	0	0	2.37 5	0.813	0	0	0.00
203	PQ	1.0350	0	0	1.38 8	0.222	0	0	0.00
204	PQ	0.9973	0	0	0.88 9	0.347	0	0	0.00

205	PQ	1.0002	0	0	3.64 6	1.237	0	0	0.00
206	PQ	1.0212	0	0	0.38 8	0.127	0	0	0.00
207	PQ	1.0051	0	0	1.27 7	0.646	0	0	0.00
208	PQ	1.0007	0	0	1.14 7	0.552	0	0	0.00
209	PQ	1.0292	0	0	0	0	0	0	0.00
210	PQ	1.0178	0	0	0	0	0	0	-1.00
211	PQ	1.0144	0	0	0	0	0	0	-1.63
212	PQ	1.0217	0	0	0	0	0	0	-0.50
213	PQ	1.0242	0	0	0	0	0	0	-1.00
214	PQ	0.9954	0	0	0	0	0	0	-1.635
215	PQ	1.0335	0	0	0	0	0	0	-1.00
216	PQ	0.9998	0	0	0	0	0	0	-1.00
217	PQ	1.0036	0	0	0	0	0	0	-1.00
218	PQ	1.0020	0	0	1.59 5	0.368	0	0	-0.50
219	PQ	1.0233	0	0	- 0.66 2	-0.208	0	0	0.00
220	PQ	0.9898	0	0	0.95	0.312	0	0	0.00
221	PQ	1.0239	0	0	0	0	0	0	-2.14
222	PQ	1.0212	0	0	0	0	0	0	0.00
223	PQ	1.0387	0	0	0.78	0.256	0	0	0.00
224	PQ	1.0275	0	0	0.35 7	0.117	0	0	0.00
225	PQ	0.9972	0	0	0.7	0.23	0	0	0.00
226	PQ	1.0062	0	0	0	0	0	0	0.00
227	PQ	1.0123	0	0	0.75	0.247	0	0	0.00
228	PQ	1.0049	0	0	0.92	0.302	0	0	0.00
229	PQ	1.0178	0	0	0	0	0	0	0.00
230	PQ	1.0008	0	0	0	0	0	0	0.00
231	PQ	1.0337	0	0	0	0	0	0	0.00
232	PQ	1.0190	0	0	0	0	0	0	0.00
233	PQ	1.0293	0	0	0	0	0	0	-1.80
234	PQ	1.0450	0	0	0	0	0	0	-1.50
235	PQ	1.0411	0	0	- 12.5 84	-7	0	0	-0.63
236	PQ	1.0058	0	0	0	0	0	0	-0.63
237	PQ	1.0536	0	0	0	0	0	0	-0.50
238	PQ	1.0096	0	0	0	0	0	0	-1.50
239	PQ	1.0344	0	0	0	0	0	0	-2.10
240	PQ	1.0276	0	0	0	0	0	0	0.00
241	PQ	1.0559	0	0	0	0	0	0	0.00
242	PQ	0.9725	0	0	0.27 7	0.091	0	0	0.00
243	PQ	1.0160	0	0	0	0	0	0	0.00
244	PQ	1.0186	0	0	0	0	0	0	0.00
245	PQ	0.9864	0	0	2.00 7	0.996	0	0	0.00
246	PQ	1.0037	0	0	- 0.07	0.108	0	0	0.00

where, P_G = Generator active power generation

Q_G = Generator reactive power generation

P_L = Active power load

Q_L = Reactive power load

Q_{GMAX} = Generator maximum reactive power generation limit

Q_{GMIN} = Generator minimum reactive power generation limit

Table C.2: Line data for NRPB 246-bus system

Line No.	From Bus	To Bus	Resistance (R)	Reactance (X)	Suseptance (B_{SH}) (full)	Tap	Line Rating
1	59	48	0	0.0125	0	1	1
2	61	53	0	0.0125	0	1	1
3	62	54	0	0.0125	0	1	1
4	71	56	0	0.0125	0	1	1
5	6	5	0	0.0125	0	1	1
6	10	8	0	0.0125	0	1	1
7	69	115	0	0.0125	0	1	1
8	70	232	0	0.0125	0	1	1
9	72	84	0	0.0125	0	1	1
10	72	84	0	0.00625	0	1	2
11	72	84	0	0.00417	0	1	3
12	73	74	0	0.0125	0	1	1
13	236	97	0	0.0125	0	1	1
14	131	109	0	0.0125	0	1	1
15	240	139	0	0.0125	0	1	1
16	154	140	0	0.0125	0	1	1
17	155	141	0	0.0125	0	1	1
18	180	157	0	0.0125	0	1	1
19	179	160	0	0.0125	0	1	1
20	23	22	0	0.0125	0	1	1
21	209	185	0	0.0125	0	1	1
22	210	187	0	0.0125	0	1	1
23	211	190	0	0.0125	0	1	1
24	212	191	0	0.0125	0	1	1
25	213	194	0	0.0125	0	1	1
26	214	199	0	0.0125	0	1	1
27	215	27	0	0.0125	0	1	1
28	33	28	0	0.0125	0	1	1
29	216	204	0	0.0125	0	1	1
30	217	205	0	0.0125	0	1	1
31	221	222	0	0.0125	0	1	1
32	233	229	0	0.0125	0	1	1
33	238	230	0	0.0125	0	1	1
34	239	231	0	0.0125	0	1	1
35	237	36	0	0.0125	0	1	1

36	235	38	0	0.0125	0	1	1
37	43	44	0.0035	0.01855	0.1278	0	4
38	43	45	0.0035	0.01855	0.1278	0	4
39	44	56	0.00464	0.02475	0.1704	0	4
40	44	57	0.0071	0.0379	0.0653	0	2
41	44	80	0.0071	0.0379	0.0653	0	2
42	45	56	0.00619	0.03299	0.2272	0	4
43	46	56	0.00155	0.00825	0.0568	0	4
44	46	57	0.0077	0.0412	0.071	0	2
45	46	80	0.0192	0.1023	0.1761	0	2
46	47	48	0.00155	0.00825	0.0142	0	1.8
47	59	48	0	0.052	0	0	2.4
48	48	204	0.0161	0.0858	0.1477	0	2
49	49	50	0.00154	0.00825	0.0568	0	4
50	49	54	0.00132	0.00701	0.0482	0	4
51	50	55	0.00232	0.01238	0.0852	0	4
52	51	54	0.00348	0.01856	0.1278	0	4
53	52	54	0.00077	0.00413	0.0284	0	4
54	54	55	0.00038	0.00206	0.0142	0	4
55	55	56	0.01455	0.07755	0.534	0	4
56	56	25	0.00232	0.01238	0.3408	0	9
57	56	80	0.0081	0.0433	0.2982	0	4
58	25	57	0.00479	0.02557	0.1760	0	0
59	2	187	0.0075	0.04315	0.301	0	4
60	63	58	0	0.0198	0	0	6.3
61	59	32	0.00149	0.0166	1.776	0	11
62	59	216	0.0019	0.0207	0.555	0	5.5
63	3	71	0.00186	0.02075	0.555	0	5.5
64	3	73	0.00155	0.0173	1.8538	0	11
65	4	62	0.00086	0.00965	1.0323	0	11
66	61	154	0.00101	0.01439	2.2514	0	16
67	62	71	0.00174	0.0194	2.0757	0	11
68	63	70	0.00151	0.02137	3.3434	0	16
69	6	65	0.00123	0.0066	0.1023	0	6
70	7	65	0.00195	0.0103	0.071	0	4
71	7	67	0.00665	0.03545	0.2442	0	4
72	7	79	0.00395	0.02105	0.1448	0	4
73	7	105	0.01733	0.09239	0.1590	0	2
74	8	65	0.00435	0.0231	0.159	0	4
75	64	67	0.00485	0.026	0.179	0	4
76	64	11	0.00507	0.02693	0.4176	0	6
77	64	88	0.0011	0.00575	0.0398	0	4
78	64	102	0.00773	0.04124	0.071	0	2
79	9	11	0.0149	0.0792	0.1363	0	2
80	9	60	0.00928	0.04949	0.0852	0	2
81	65	67	0.00605	0.03215	0.2216	0	4
82	65	68	0.0248	0.132	0.2272	0	2
83	65	90	0.00605	0.03215	0.2216	0	4
84	65	100	0.00555	0.0297	0.2044	0	4

85	65	110	0.00867	0.0462	0.3180	0	4
86	66	67	0.00605	0.03215	0.2216	0	4
87	66	98	0.0054	0.0289	0.0497	0	2
88	66	118	0.0088	0.047	0.3238	0	4
89	66	130	0.00541	0.02887	0.1988	0	4
90	67	91	0.00155	0.00825	0.0568	0	4
91	68	108	0.0074	0.0396	0.0386	0	2
92	10	69	0.0065	0.0726	1.9425	0	5.5
93	10	131	0.0048	0.0533	1.4263	0	5.5
94	69	70	0.0007	0.0073	0.1943	0	5.5
95	69	154	0.0023	0.0259	0.6937	0	5.5
96	70	72	0.00195	0.0218	2.331	0	11
97	70	154	0.003	0.0332	0.888	0	5.5
98	70	238	0.0052	0.0581	1.554	0	5.5
99	71	72	0.00105	0.02375	3.8058	0	0
100	72	73	0.00065	0.00725	0.777	0	11
101	74	86	0.00885	0.02353	0.1618	0	4
102	74	88	0.00109	0.00577	0.0397	0	4
103	74	104	0.00348	0.01856	0.1278	0	4
104	74	246	0.01006	0.05362	0.3692	0	4
105	75	76	0.0023	0.01235	0.0852	0	4
106	75	91	0.00195	0.0103	0.071	0	4
107	78	84	0.00265	0.014	0.0966	0	4
108	78	91	0.0025	0.0132	0.0908	0	4
109	79	88	0.00365	0.0194	0.1334	0	4
110	11	86	0.0065	0.0346	0.0596	0	2
111	11	60	0.00696	0.03712	0.0639	0	2
112	80	82	0.00147	0.00784	0.4856	0	12
113	80	12	0.00139	0.00743	0.2044	0	8
114	80	86	0.0045	0.0239	0.1648	0	4
115	81	97	0.00232	0.01238	0.0852	0	4
116	81	101	0.00232	0.01238	0.0852	0	4
117	82	83	0.0031	0.0165	0.1136	0	4
118	82	92	0.0027	0.01444	0.0994	0	4
119	83	95	0.00194	0.01031	0.071	0	4
120	83	102	0.00634	0.03382	0.0582	0	2
121	83	103	0.00155	0.00825	0.0568	0	4
122	83	104	0.00348	0.01856	0.1278	0	4
123	84	89	0.0035	0.01855	0.1278	0	4
124	84	94	0.0068	0.0363	0.0625	0	2
125	85	94	0.0031	0.0165	0.1136	0	4
126	85	103	0.00155	0.00825	0.0568	0	4
127	87	96	0.00232	0.01238	0.0852	0	4
128	87	100	0.0027	0.01444	0.0994	0	4
129	88	13	0.0081	0.0433	0.2982	0	4
130	88	94	0.00315	0.0169	0.1164	0	4
131	89	93	0.0027	0.01445	0.0994	0	4
132	89	15	0.00426	0.02269	0.1562	0	4
133	13	90	0.00243	0.013	0.358	0	8

134	13	91	0.0071	0.03795	0.2612	0	4
135	13	100	0.00356	0.01897	0.1306	0	4
136	90	96	0.0025	0.0132	0.0908	0	4
137	90	97	0.00365	0.0194	0.1334	0	4
138	91	97	0.0097	0.052	0.0895	0	2
139	92	95	0.00194	0.01031	0.071	0	4
140	93	14	0.00385	0.0206	0.142	0	4
141	96	101	0.00696	0.03712	0.2556	0	4
142	97	98	0.0085	0.0454	0.0781	0	2
143	98	15	0.00465	0.02475	0.1704	0	4
144	14	15	0.00116	0.00619	0.0426	0	4
145	15	99	0.00332	0.01774	0.1221	0	4
146	99	101	0.00325	0.01733	0.1192	0	4
147	105	107	0.00503	0.02681	0.1846	0	4
148	105	245	0.00534	0.02846	0.1959	0	4
149	106	107	0.00116	0.00619	0.0426	0	4
150	106	123	0.00402	0.02144	0.1476	0	4
151	106	130	0.0031	0.0165	0.1136	0	4
152	108	109	0.0108	0.0577	0.0994	0	2
153	109	16	0.00042	0.00228	0.0624	0	8
154	109	110	0.00967	0.05155	0.355	0	4
155	109	121	0.017	0.0907	0.1562	0	2
156	109	132	0.00299	0.01595	0.2470	0	6
157	16	113	0.0059	0.03135	0.2158	0	4
158	16	125	0.0031	0.0165	0.1136	0	4
159	111	121	0.0091	0.0487	0.0838	0	2
160	111	128	0.00155	0.00825	0.0568	0	4
161	112	122	0.00557	0.0297	0.0511	0	2
162	113	114	0.00285	0.01525	0.105	0	4
163	113	126	0.01006	0.05362	0.0923	0	2
164	113	127	0.00348	0.01856	0.1278	0	4
165	113	129	0.0093	0.0495	0.0852	0	2
166	114	125	0.0031	0.0165	0.1136	0	4
167	114	130	0.0023	0.01235	0.0852	0	4
168	115	118	0.0045	0.0239	0.1648	0	4
169	115	121	0.00135	0.00722	0.1988	0	8
170	116	128	0.0031	0.0165	0.1136	0	4
171	116	229	0.00185	0.0099	0.0682	0	4
172	17	121	0.0181	0.09651	0.1661	0	2
173	17	229	0.00026	0.00137	0.0213	0	6
174	17	34	0.00185	0.0099	0.0682	0	4
175	117	119	0.00115	0.0062	0.0426	0	4
176	117	35	0.00194	0.01031	0.071	0	4
177	118	129	0.0008	0.0041	0.0071	0	2
178	118	162	0.0178	0.0949	0.1633	0	2
179	118	232	0.0011	0.00575	0.0398	0	4
180	119	229	0.00154	0.00825	0.0568	0	4
181	120	126	0.00619	0.033	0.0568	0	2
182	121	122	0.00325	0.01733	0.1192	0	4

183	121	162	0.00649	0.03465	0.2385	0	4
184	121	229	0.01779	0.09486	0.1633	0	2
185	124	125	0.00372	0.0198	0.1363	0	4
186	125	130	0.0031	0.0165	0.1136	0	4
187	126	129	0.00464	0.02475	0.1704	0	4
188	127	129	0.00503	0.02681	0.1846	0	4
189	129	232	0.00075	0.0041	0.0284	0	4
190	132	139	0.00215	0.01155	0.0796	0	4
191	132	140	0.00095	0.00495	0.034	0	4
192	132	149	0.0017	0.00905	0.0624	0	4
193	133	18	0.0003	0.00165	0.0114	0	4
194	133	139	0.0011	0.00575	0.0398	0	4
195	133	182	0.0012	0.0066	0.0114	0	2
196	133	183	0.0002	0.0008	0.0014	0	2
197	18	134	0.0001	0.0004	0.0028	0	4
198	134	146	0.00045	0.00245	0.017	0	4
199	134	147	0.001	0.00535	0.037	0	4
200	135	34	0.00045	0.00245	0.017	0	4
201	136	138	0.0004	0.00205	0.0142	0	4
202	136	141	0.0011	0.00575	0.0398	0	4
203	136	229	0.0023	0.01235	0.0852	0	4
204	136	34	0.0013	0.007	0.0482	0	4
205	137	140	0.0017	0.00905	0.0624	0	4
206	137	141	0.0007	0.0037	0.0256	0	4
207	138	141	0.00031	0.00165	0.0113	0	4
208	138	151	0.00055	0.0029	0.0198	0	4
209	139	145	0.00055	0.0029	0.0198	0	4
210	139	152	0.0007	0.0037	0.0256	0	4
211	140	143	0.00095	0.00495	0.034	0	4
212	140	144	0.00085	0.00455	0.0312	0	4
213	141	148	0.00031	0.00165	0.0113	0	4
214	141	151	0.0014	0.0074	0.0512	0	4
215	142	145	0.00055	0.0029	0.0198	0	4
216	142	152	0.00025	0.00125	0.0086	0	4
217	143	144	0.00045	0.00245	0.017	0	4
218	146	148	0.00055	0.0029	0.0198	0	4
219	147	150	0.00075	0.0041	0.0284	0	4
220	147	153	0.0004	0.00205	0.0142	0	4
221	150	34	0.00025	0.00125	0.0086	0	4
222	154	155	0.00015	0.0026	0.439	0	4
223	154	240	0.00015	0.00195	0.3326	0	4
224	181	158	0.0131	0.0701	0.1207	0	2
225	181	172	0.01083	0.05774	0.0994	0	2
226	181	230	0.0024	0.0125	0.086	0	4
227	181	37	0.01701	0.09074	0.6248	0	0
228	156	158	0.00465	0.02475	0.1704	0	4
229	19	21	0.00385	0.0206	0.142	0	4
230	19	169	0.0223	0.1188	0.2045	0	2
231	20	21	0.00773	0.04124	0.071	0	2

232	20	168	0.03496	0.18643	0.3209	0	2
233	20	170	0.01291	0.06888	0.4742	0	4
234	20	37	0.01702	0.09074	0.1562	0	2
235	157	162	0.0192	0.1023	0.1761	0	2
236	157	175	0.0232	0.1237	0.213	0	2.2
237	157	176	0.00413	0.022	0.3408	0	6
238	157	177	0.0221	0.118	0.2031	0	2
239	157	22	0.01315	0.07011	0.4828	0	4
240	158	160	0.0183	0.0973	0.1676	0	2
241	158	34	0.0227	0.1213	0.2087	0	2
242	159	199	0.0037	0.0198	0.1364	0	4
243	160	161	0.0048	0.02555	0.176	0	4
244	160	162	0.0102	0.05445	0.3748	0	4
245	160	164	0.00485	0.026	0.179	0	4
246	160	21	0.01087	0.05803	0.8988	0	6
247	160	230	0.0024	0.0125	0.086	0	4
248	161	162	0.0131	0.0701	0.1207	0	2
249	161	176	0.00284	0.01512	0.2343	0	6
250	163	164	0.013	0.0693	0.1193	0	2
251	163	167	0.0147	0.07837	0.1349	0	2
252	165	21	0.01045	0.0557	0.3834	0	4
253	165	167	0.01315	0.07012	0.1207	0	2
254	165	170	0.0087	0.0462	0.0795	0	2
255	165	171	0.0316	0.1683	0.2897	0	2
256	165	174	0.0328	0.1749	0.301	0	2
257	165	37	0.0139	0.07425	0.5112	0	4
258	166	21	0.0156	0.0833	0.5736	0	4
259	166	167	0.00464	0.02475	0.1704	0	4
260	166	173	0.01392	0.07424	0.1278	0	2
261	166	175	0.01934	0.10311	0.71	0	4
262	21	37	0.00385	0.0206	0.142	0	4
263	168	169	0.017	0.0907	0.1562	0	2
264	168	170	0.0173	0.0924	0.159	0	2
265	168	171	0.0153	0.0817	0.1406	0	2
266	168	178	0.0119	0.0635	0.4374	0	4
267	169	170	0.0062	0.033	0.0568	0	2
268	173	174	0.01083	0.05774	0.0994	0	2
269	175	177	0.0247	0.1319	0.2272	0	2.2
270	179	238	0.0003	0.0031	0.333	0	11
271	23	180	0.00153	0.01712	1.8315	0	11
272	24	191	0.0139	0.0742	0.1278	0	2
273	24	192	0.0122	0.0652	0.1122	0	2
274	24	198	0.0035	0.01855	0.1278	0	4
275	24	1	0.0054	0.0289	0.0497	0	2
276	182	183	0.0011	0.0058	0.0099	0	2
277	182	194	0.00185	0.0099	0.0682	0	4
278	182	228	0.0039	0.0206	0.0355	0	2
279	183	194	0.00433	0.0231	0.0397	0	2
280	183	34	0.0031	0.0165	0.0284	0	2

281	184	191	0.0105	0.0561	0.0966	0	2
282	184	197	0.00773	0.04124	0.071	0	0
283	185	197	0.00696	0.03712	0.2556	0	0
284	185	30	0.0081	0.0433	0.2982	0	4
285	185	219	0.0127	0.0676	0.1164	0	2
286	186	187	0.0064	0.03425	0.2358	0	4
287	186	188	0.0145	0.0775	0.1335	0	2
288	187	189	0.0064	0.03425	0.0589	0	2
289	187	191	0.00695	0.0371	0.2556	0	4
290	188	190	0.0149	0.0792	0.1363	0	2
291	190	222	0.0031	0.0165	0.1136	0	4
292	190	223	0.0093	0.0495	0.0852	0	2
293	190	227	0.0046	0.0247	0.0426	0	2
294	191	208	0.00232	0.01238	0.0852	0	4
295	192	193	0.0071	0.0379	0.0653	0	2
296	193	194	0.0071	0.0379	0.0653	0	2
297	193	197	0.00187	0.0099	0.1533	0	6
298	194	195	0.0124	0.066	0.1136	0	2
299	194	198	0.0054	0.02885	0.1988	0	4
300	194	220	0.0063	0.0338	0.0582	0	2
301	194	228	0.00077	0.00413	0.0284	0	4
302	195	196	0.00535	0.02845	0.196	0	4
303	195	197	0.00295	0.01565	0.108	0	4
304	195	220	0.0062	0.033	0.0568	0	2
305	196	219	0.00625	0.0334	0.23	0	4
306	198	1	0.0035	0.01855	0.1278	0	4
307	1	199	0.0152	0.0808	0.1392	0	2
308	1	226	0.0058	0.03095	0.213	0	4
309	199	200	0.0046	0.0247	0.0426	0	2
310	199	36	0.0144	0.0767	0.5282	0	4
311	200	201	0.0087	0.0462	0.0795	0	2
312	201	26	0.0165	0.08785	0.605	0	4
313	201	226	0.00465	0.02475	0.1704	0	4
314	201	231	0.01315	0.07011	0.4828	0	4
315	26	27	0.03094	0.16498	0.284	0	2
316	27	203	0.00695	0.0371	0.2556	0	4
317	27	222	0.0023	0.01235	0.0852	0	4
318	27	231	0.00232	0.01238	0.0852	0	4
319	28	202	0.01113	0.0594	0.9201	0	6
320	202	203	0.01005	0.0536	0.3692	0	4
321	202	225	0.0059	0.0313	0.054	0	2
322	203	224	0.0108	0.0577	0.0994	0	2
323	203	39	0.0023	0.01235	0.0852	0	4
324	204	207	0.00554	0.06174	0.1511	0	0
325	205	29	0.0058	0.03095	0.213	0	4
326	205	225	0.0101	0.0536	0.0923	0	2
327	29	206	0.0079	0.0421	0.0724	0	2
328	29	207	0.0116	0.0619	0.1065	0	2
329	206	207	0.0116	0.0619	0.1065	0	2

330	31	219	0.0004	0.00265	0.0164	0	4
331	209	212	0.003	0.0332	0.888	0	5.5
332	209	213	0.00339	0.03777	1.0101	0	0
333	210	221	0.00224	0.0249	2.664	0	11
334	211	212	0.00616	0.06868	1.83705	0	5.5
335	211	217	0.0027	0.0301	0.8047	0	5.5
336	211	221	0.00102	0.01141	0.3052	0	5.5
337	211	40	0.0075	0.084	2.2478	0	5.5
338	212	213	0.0025	0.0274	0.7326	0	5.5
339	213	214	0.00354	0.03943	1.0545	0	5.5
340	213	215	0.0074	0.082	2.1923	0	5.5
341	213	235	0.0009	0.0104	0.2775	0	5.5
342	214	221	0.00466	0.05188	1.3875	0	5.5
343	215	33	0.0072	0.0803	2.1479	0	5.5
344	215	221	0.00074	0.0083	0.222	0	5.5
345	215	239	0.00005	0.00052	0.0555	0	11
346	32	33	0.0007	0.0079	0.2109	0	5.5
347	32	218	0.00493	0.05499	1.4707	0	5.5
348	32	221	0.00286	0.06547	2.6246	0	8
349	32	40	0.0005	0.0056	0.1498	0	5.5
350	33	217	0.0043	0.0477	1.2765	0	5.5
351	216	217	0.0023	0.0259	0.6937	0	5.5
352	216	218	0.00065	0.00726	0.1942	0	5.5
353	219	77	0.0027	0.01444	0.0994	0	4
354	223	227	0.0108	0.0577	0.0994	0	2
355	223	39	0.0013	0.007	0.0482	0	4
356	229	35	0.00132	0.00701	0.0482	0	4
357	231	39	0.0058	0.03094	0.852	0	8
358	233	234	0.0034	0.0373	0.999	0	5.5
359	233	235	0.0005	0.0055	0.5882	0	4
360	233	238	0.00404	0.04503	1.2043	0	0
361	233	239	0.00735	0.0533	2.1922	0	5.5
362	234	237	0.00175	0.0193	2.0646	0	11
363	234	238	0.0048	0.0537	1.4374	0	5.5
364	234	239	0.0047	0.0519	1.3875	0	5.5
365	40	239	0.00819	0.0913	2.442	0	5.5
366	40	41	0.0004	0.00435	0.4662	0	11
367	40	241	0.00217	0.02412	2.5807	0	11
368	235	236	0.00577	0.06433	1.7205	0	5.5
369	235	240	0.00025	0.00365	0.6118	0	4
370	239	241	0.00217	0.02412	2.5807	0	11
371	42	243	0.00418	0.02227	0.0383	0	2
372	42	244	0.00773	0.04124	0.071	0	0
373	42	245	0.02027	0.10806	0.1860	0	2
374	243	242	0	0.3968	0	0	0.31
375	243	245	0.01702	0.09074	0.1562	0	2
376	244	245	0.02119	0.11301	0.1945	0	0

LIST OF PUBLICATIONS

JOURNALS

1. Pankaj Sahu and M. K. Verma, "An Approach for Voltage Stability Estimation of Real Time Systems Using Phasor Measurements," *Journal of Advance Research in Dynamical and Control Systems*, pp. 854-863, vol. 10, no. 2, May 2018.
2. Pankaj Sahu and M. K. Verma, "Online Monitoring of Voltage Stability Margin and its Control through STATCOM," *COMPUSOFT: An International Journal of Advanced Computer Technology*, pp. 3324-3335, vol. 8, issue 8, August 2019.
3. Pankaj Sahu and M. K. Verma, "Online Monitoring of Voltage Stability Margin using PMU Measurements," *International Journal of Electrical and Computer Engineering (IJECE)*, pp.1156-1168, vo. 10, no. 2, April 2020.

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2. Pankaj Sahu and M. K. Verma, "Optimal Placement of PMUs in Power System Network for Voltage Stability Estimation Under Contingencies," *6th IEEE International Conference on Computer Applications In Electrical Engineering-Recent Advances (CERA)*, pp. 365-370, 5-7 October 2017, Roorkee, India.