

APPENDIX

IEEE RTS 24-bus Test system data

Bus data of IEEE RTS 24-bus

Bus No.	Area	Code	Voltage Magnitude	Angle Degree	Load		Generator				Injected MVAR	Vmin (p.u.)	Vmax (p.u.)	Pg min (MW)	Pg max (MW)	Pd min (MW)	Pd max (MW)
					MW	MVAR	MW	MVAR	Qmin	Qmax							
1	1	2	1.035	0	108	22	172	28.2	-50	80	0	0.9	1.1	0	192	108	216
2	1	2	1.035	0	97	20	172	14	-50	80	0	0.9	1.1	0	192	97	194
3	2	0	1	0	180	37	0	0	0	0	0	0.9	1.1	0	0	180	360
4	2	0	1	0	74	15	0	0	0	0	0	0.9	1.1	0	0	74	148
5	2	0	1	0	71	14	0	0	0	0	0	0.9	1.1	0	0	71	142
6	2	0	1	0	136	28	0	0	0	0	-100	0.9	1.1	0	0	136	272
7	1	2	1.025	0	125	25	240	51.6	0	180	0	0.9	1.1	0	400	125	250
8	2	0	1	0	171	35	0	0	0	0	0	0.9	1.1	0	0	171	342
9	2	0	1	0	175	36	0	0	0	0	0	0.9	1.1	0	0	175	350
10	2	0	1	0	195	40	0	0	0	0	0	0.9	1.1	0	0	195	390
11	2	0	1	0	0	0	0	0	0	0	0	0.9	1.1	0	0	0	0

12	2	0	1	0	0	0	0	0	0	0	0	0.9	1.1	0	0	0	0
13	1	1	1.02	0	265	54	285	122.1	0	240	0	0.9	1.1	0	788	265	530
14	2	2	0.98	0	194	39	0	13.7	-50	200	0	0.9	1.1	0	0	194	388
15	1	2	1.014	0	317	64	215	0.05	-50	110	0	0.9	1.1	0	370	317	634
16	1	2	1.017	0	100	20	155	25.22	-50	80	0	0.9	1.1	0	465	100	200
17	2	0	1	0	0	0	0	0	0	0	0	0.9	1.1	0	0	0	0
18	1	2	1.05	0	333	68	400	137.4	-50	200	0	0.9	1.1	0	800	333	666
19	2	0	1	0	181	37	0	0	0	0	0	0.9	1.1	0	0	181	362
20	2	0	1	0	128	26	0	0	0	0	0	0.9	1.1	0	0	128	256
21	1	2	1.05	0	0	0	400	108.2	-50	200	0	0.9	1.1	0	400	0	0
22	1	2	1.05	0	0	0	300	-29.76	-60	96	0	0.9	1.1	0	300	0	0
23	1	2	1.05	0	0	0	660	135.4	-125	310	0	0.9	1.1	0	660	0	0
24	2	0	1	0	0	0	0	0	0	0	0	0.9	1.1	0	0	0	0

Line data of IEEE RTS 24-bus

Line no.	From Bus	To Bus	R (p.u.)	X (p.u.)	branch admittance (p.u.)	Transformer tap setting	Rating (MVAR)
1	1	2	0.003	0.014	0.2305	1	175
2	1	3	0.055	0.211	0.0285	1	175
3	1	5	0.022	0.085	0.0115	1	175
4	2	4	0.033	0.127	0.017	1	175
5	2	6	0.05	0.192	0.026	1	175
6	3	9	0.031	0.119	0.016	1	175
7	3	24	0.002	0.084	0	1.015	400
8	4	9	0.027	0.104	0.014	1	175
9	5	10	0.023	0.088	0.012	1	175
10	6	10	0.014	0.061	1.2295	1	175
11	7	8	0.016	0.061	0.0085	1	175
12	8	9	0.043	0.165	0.0225	1	175
13	8	10	0.043	0.165	0.0225	1	175
14	9	11	0.002	0.084	0	1.03	400
15	9	12	0.002	0.084	0	1.03	400
16	10	11	0.002	0.084	0	1.015	400
17	10	12	0.002	0.084	0	1.015	400
18	11	13	0.006	0.048	0.05	1	500
19	12	13	0.006	0.048	0.05	1	500
20	12	23	0.012	0.097	0.1015	1	500
21	13	23	0.011	0.087	0.091	1	500
22	14	16	0.005	0.059	0.041	1	500
23	15	16	0.002	0.017	0.018	1	500
24	15	21	0.006	0.049	0.0515	1	500
25	15	21	0.006	0.049	0.0515	1	500

26	15	24	0.007	0.052	0.0545	1	500
27	16	17	0.003	0.026	0.0275	1	500
28	16	19	0.003	0.023	0.0245	1	500
29	17	18	0.002	0.014	0.015	1	500
30	17	22	0.014	0.105	0.1105	1	500
31	18	21	0.003	0.026	0.0275	1	500
32	18	21	0.003	0.026	0.0275	1	500
33	19	20	0.005	0.04	0.0415	1	500
34	19	20	0.005	0.04	0.0415	1	500
35	21	22	0.009	0.068	0.071	1	500
36	20	23	0.003	0.022	0.023	1	500
37	20	23	0.003	0.022	0.023	1	500

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IEEE 30-bus Test system data

Bus data of IEEE 30-bus

Bus No.	Area	Code	Voltage Magnitude	Angle Degree	Load		Generator				Injected MVAR	Vmin (p.u.)	Vmax (p.u.)	Pg min (MW)	Pg max (MW)	Pd min (MW)	Pd max (MW)
					MW	MVAR	MW	MVAR	Qmin	Qmax							
1	1	1	1.05	0	0	0	44	-1.1	-20	150	0	0.95	1.05	0	80	0	0
2	1	2	1.047	-0.723	21.7	12.7	58	22.89	-20	60	0	0.95	1.1	0	80	21.7	65.1
3	2	0	1.034	-2.044	2.4	1.2	0	0	0	0	0	0.95	1.05	0	0	2.4	7.2
4	2	0	1.031	-2.432	7.6	1.6	0	0	0	0	0	0.95	1.05	0	0	7.6	22.8
5	2	0	1.032	-2.225	0	0	0	0	0	0	0.19	0.95	1.05	0	0	0	0
6	2	0	1.025	-2.794	0	0	0	0	0	0	0	0.95	1.05	0	0	0	0
7	2	0	1.019	-3.062	22.8	10.9	0	0	0	0	0	0.95	1.05	0	0	22.8	68.4
8	2	0	1.013	-3.203	30	30	0	0	0	0	0	0.95	1.05	0	0	30	90
9	2	0	1.031	-3.731	0	0	0	0	0	0	0	0.95	1.05	0	0	0	0
10	2	0	1.035	-4.217	5.8	2	0	0	0	0	0	0.95	1.05	0	0	5.8	17.4
11	2	0	1.031	-3.731	0	0	0	0	0	0	0	0.95	1.05	0	0	0	0
12	2	0	1.05	-3.973	11.2	7.5	0	0	0	0	0	0.95	1.05	0	0	11.2	33.6
13	1	2	1.084	-2.751	0	0	17	26.73	-15	44.7	0	0.95	1.1	0	40	0	0
14	2	0	1.039	-4.505	6.2	1.6	0	0	0	0	0	0.95	1.05	0	0	6.2	18.6
15	2	0	1.041	-4.306	8.2	2.5	0	0	0	0	0	0.95	1.05	0	0	8.2	24.6
16	2	0	1.037	-4.356	3.5	1.8	0	0	0	0	0	0.95	1.05	0	0	3.5	10.5
17	2	0	1.03	-4.461	9	5.8	0	0	0	0	0	0.95	1.05	0	0	9	27
18	2	0	1.027	-4.974	3.2	0.9	0	0	0	0	0	0.95	1.05	0	0	3.2	9.6
19	2	0	1.022	-5.187	9.5	3.4	0	0	0	0	0	0.95	1.05	0	0	9.5	28.5
20	2	0	1.024	-4.997	2.2	0.7	0	0	0	0	0	0.95	1.05	0	0	2.2	6.6
21	2	0	1.041	-4.209	17.5	11.2	0	0	0	0	0	0.95	1.05	0	0	17.5	52.5
22	1	2	1.046	-4.087	0	0	23	28.94	-15	62.5	0	0.95	1.1	0	50	0	0
23	1	2	1.054	-3.346	3.2	1.6	17	7.05	-10	40	0	0.95	1.1	0	30	3.2	9.6
24	2	0	1.041	-3.594	8.7	6.7	0	0	0	0	0.04	0.95	1.05	0	0	8.7	26.1
25	2	0	1.05	-2.172	0	0	0	0	0	0	0	0.95	1.05	0	0	0	0

26	2	0	1.033	-2.571	3.5	2.3	0	0	0	0	0	0.95	1.05	0	0	3.5	10.5
27	1	2	1.064	-1.045	0	0	33	14.37	-15	48.7	0	0.95	1.1	0	55	0	0
28	2	0	1.028	-2.766	0	0	0	0	0	0	0	0.95	1.05	0	0	0	0
29	2	0	1.045	-2.191	2.4	0.9	0	0	0	0	0	0.95	1.1	0	0	2.4	7.2
30	2	0	1.034	-2.992	10.6	1.9	0	0	0	0	0	0.95	1.05	0	0	10.6	31.8



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Line data of IEEE 30-bus

Line no.	From Bus	To Bus	R (p.u.)	X (p.u.)	1/2 B (p.u.)	Transformer tap setting	Rating (MVAR)
1	1	2	0.02	0.06	0.015	1	130
2	1	3	0.05	0.19	0.01	1	130
3	2	4	0.06	0.17	0.01	1	65
4	3	4	0.01	0.04	0	1	130
5	2	5	0.05	0.2	0.01	1	130
6	2	6	0.06	0.18	0.01	1	65
7	4	6	0.01	0.04	0	1	90
8	5	7	0.05	0.12	0.005	1	70
9	6	7	0.03	0.08	0.005	1	130
10	6	8	0.01	0.04	0	1	35
11	6	9	0	0.21	0	1	65
12	6	10	0	0.56	0	1	32
13	9	11	0	0.21	0	1	65
14	9	10	0	0.11	0	1	65
15	4	12	0	0.26	0	1	65
16	12	13	0	0.14	0	1	65
17	12	14	0.12	0.26	0	1	32
18	12	15	0.07	0.13	0	1	32
19	12	16	0.09	0.2	0	1	32
20	14	15	0.22	0.2	0	1	16
21	16	17	0.08	0.19	0	1	16
22	15	18	0.11	0.22	0	1	16
23	18	19	0.06	0.13	0	1	16
24	19	20	0.03	0.07	0	1	32
25	10	20	0.09	0.21	0	1	32

26	10	17	0.03	0.08	0	1	32
27	10	21	0.03	0.07	0	1	32
28	10	22	0.07	0.15	0	1	32
29	21	22	0.01	0.02	0	1	32
30	15	23	0.1	0.2	0	1	16
31	22	24	0.12	0.18	0	1	16
32	23	24	0.13	0.27	0	1	16
33	24	25	0.19	0.33	0	1	16
34	25	26	0.25	0.38	0	1	16
35	25	27	0.11	0.21	0	1	16
36	28	27	0	0.4	0	1	65
37	27	29	0.22	0.42	0	1	16
38	27	30	0.32	0.6	0	1	16
39	29	30	0.24	0.45	0	1	16
40	8	28	0.06	0.2	0.01	1	32
41	6	28	0.02	0.06	0.005	1	32

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IEEE 118-bus Test system data

Bus data of IEEE 118-bus

Bus No.	Area	Code	Voltage Magnitude	Angle Degree	Load		Generator				Injected MVAR	Vmin (p.u.)	Vmax (p.u.)	Pg min (MW)	Pg max (MW)	Pd min (MW)	Pd max (MW)
					MW	MVAR	MW	MVAR	Qmin	Qmax							
1	3	2	0.955	0	51	27	0	0	-5	15	0	0.94	1.06	0	100	51	102
2	3	0	0.971	0	20	9	0	0	0	0	0	0.94	1.06	0	0	20	40
3	3	0	0.968	0	39	10	0	0	0	0	0	0.94	1.06	0	0	39	78
4	3	2	0.998	0	39	12	0	0	-300	300	0	0.94	1.06	0	100	39	78
5	3	0	1.002	0	0	0	0	0	0	0	-40	0.94	1.06	0	0	0	0
6	3	2	0.99	0	52	22	0	0	-13	50	0	0.94	1.06	0	100	52	104
7	3	0	0.989	0	19	2	0	0	0	0	0	0.94	1.06	0	0	19	38
8	3	2	1.015	0	28	0	0	0	-300	300	0	0.94	1.06	0	100	28	56
9	3	0	1.043	0	0	0	0	0	0	0	0	0.94	1.06	0	0	0	0
10	3	2	1.05	0	0	0	450	0	-147	200	0	0.94	1.06	0	550	0	0
11	3	0	0.985	0	70	23	0	0	0	0	0	0.94	1.06	0	0	70	140
12	3	2	0.99	0	47	10	85	0	-35	120	0	0.94	1.06	0	185	47	94
13	3	0	0.968	0	34	16	0	0	0	0	0	0.94	1.06	0	0	34	68
14	3	0	0.984	0	14	1	0	0	0	0	0	0.94	1.06	0	0	14	28
15	3	2	0.97	0	90	30	0	0	-10	30	0	0.94	1.06	0	100	90	180
16	3	0	0.984	0	25	10	0	0	0	0	0	0.94	1.06	0	0	25	50
17	3	0	0.995	0	11	3	0	0	0	0	0	0.94	1.06	0	0	11	22
18	3	2	0.973	0	60	34	0	0	-16	50	0	0.94	1.06	0	100	60	120
19	3	2	0.963	0	45	25	0	0	-12	24	0	0.94	1.06	0	100	45	90
20	3	0	0.958	0	18	3	0	0	0	0	0	0.94	1.06	0	0	18	36
21	3	0	0.959	0	14	8	0	0	0	0	0	0.94	1.06	0	0	14	28
22	3	0	0.97	0	10	5	0	0	0	0	0	0.94	1.06	0	0	10	20
23	3	0	1	0	7	3	0	0	0	0	0	0.94	1.06	0	0	7	14
24	3	2	0.992	0	13	0	0	0	-300	300	0	0.94	1.06	0	100	13	26
25	3	2	1.05	0	0	0	220	0	-47	140	0	0.94	1.06	0	320	0	0

26	3	2	1.015	0	0	0	314	0	-1000	1000	0	0.94	1.06	0	414	0	0
27	3	2	0.968	0	71	13	0	0	-300	300	0	0.94	1.06	0	100	71	142
28	3	0	0.962	0	17	7	0	0	0	0	0	0.94	1.06	0	0	17	34
29	3	0	0.963	0	24	4	0	0	0	0	0	0.94	1.06	0	0	24	48
30	3	0	0.968	0	0	0	0	0	0	0	0	0.94	1.06	0	0	0	0
31	3	2	0.967	0	43	27	7	0	-300	300	0	0.94	1.06	0	107	43	86
32	3	2	0.964	0	59	23	0	0	-14	42	0	0.94	1.06	0	100	59	118
33	2	0	0.972	0	23	9	0	0	0	0	0	0.94	1.06	0	0	23	46
34	2	2	0.986	0	59	26	0	0	-8	24	14	0.94	1.06	0	100	59	118
35	2	0	0.981	0	33	9	0	0	0	0	0	0.94	1.06	0	0	33	66
36	2	2	0.98	0	31	17	0	0	-8	24	0	0.94	1.06	0	100	31	62
37	2	0	0.992	0	0	0	0	0	0	0	-25	0.94	1.06	0	0	0	0
38	2	0	0.962	0	0	0	0	0	0	0	0	0.94	1.06	0	0	0	0
39	2	0	0.97	0	27	11	0	0	0	0	0	0.94	1.06	0	0	27	54
40	2	2	0.97	0	66	23	0	0	-300	300	0	0.94	1.06	0	100	66	132
41	2	0	0.967	0	37	10	0	0	0	0	0	0.94	1.06	0	0	37	74
42	2	2	0.985	0	96	23	0	0	-300	300	0	0.94	1.06	0	100	96	192
43	2	0	0.978	0	18	7	0	0	0	0	0	0.94	1.06	0	0	18	36
44	2	0	0.985	0	16	8	0	0	0	0	10	0.94	1.06	0	0	16	32
45	1	0	0.987	0	53	22	0	0	0	0	10	0.94	1.06	0	0	53	106
46	1	2	1.005	0	28	10	19	0	-100	100	10	0.94	1.06	0	119	28	56
47	1	0	1.017	0	34	0	0	0	0	0	0	0.94	1.06	0	0	34	68
48	1	0	1.021	0	20	11	0	0	0	0	15	0.94	1.06	0	0	20	40
49	1	2	1.025	0	87	30	204	0	-85	210	0	0.94	1.06	0	304	87	174
50	3	0	1.001	0	17	4	0	0	0	0	0	0.94	1.06	0	0	17	34
51	1	0	0.967	0	17	8	0	0	0	0	0	0.94	1.06	0	0	17	34
52	1	0	0.957	0	18	5	0	0	0	0	0	0.94	1.06	0	0	18	36
53	3	0	0.946	0	23	11	0	0	0	0	0	0.94	1.06	0	0	23	46
54	3	2	0.955	0	113	32	48	0	-300	300	0	0.94	1.06	0	148	113	226
55	3	2	0.952	0	63	22	0	0	-8	23	0	0.94	1.06	0	100	63	126

56	3	2	0.954	0	84	18	0	0	-8	15	0	0.94	1.06	0	100	84	168
57	3	0	0.971	0	12	3	0	0	0	0	0	0.94	1.06	0	0	12	24
58	3	0	0.959	0	12	3	0	0	0	0	0	0.94	1.06	0	0	12	24
59	3	2	0.985	0	277	113	155	0	-60	180	0	0.94	1.06	0	255	277	554
60	3	0	0.993	0	78	3	0	0	0	0	0	0.94	1.06	0	0	78	156
61	3	2	0.995	0	0	0	160	0	-100	300	0	0.94	1.06	0	260	0	0
62	3	2	0.998	0	77	14	0	0	-20	20	0	0.94	1.06	0	100	77	154
63	3	0	0.969	0	0	0	0	0	0	0	0	0.94	1.06	0	0	0	0
64	3	0	0.984	0	0	0	0	0	0	0	0	0.94	1.06	0	0	0	0
65	1	2	1.005	0	0	0	391	0	-67	200	0	0.94	1.06	0	591	0	0
66	1	2	1.05	0	39	18	392	0	-67	200	0	0.94	1.06	0	592	39	78
67	1	0	1.02	0	28	7	0	0	0	0	0	0.94	1.06	0	0	28	56
68	1	0	1.003	0	0	0	0	0	0	0	0	0.94	1.06	0	0	0	0
69	1	1	1.035	0	0	0	516.4	0	-300	300	0	0.94	1.06	0	805.2	0	0
70	3	2	0.984	0	66	20	0	0	-10	32	0	0.94	1.06	0	100	66	132
71	3	0	0.987	0	0	0	0	0	0	0	0	0.94	1.06	0	0	0	0
72	3	2	0.98	0	12	0	0	0	-100	100	0	0.94	1.06	0	100	12	24
73	3	2	0.991	0	6	0	0	0	-100	100	0	0.94	1.06	0	100	6	12
74	3	2	0.958	0	68	27	0	0	-6	9	12	0.94	1.06	0	100	68	136
75	3	0	0.967	0	47	11	0	0	0	0	0	0.94	1.06	0	0	47	94
76	3	2	0.943	0	68	36	0	0	-8	23	0	0.94	1.06	0	100	68	136
77	3	2	1.006	0	61	28	0	0	-20	70	0	0.94	1.06	0	100	61	122
78	3	0	1.003	0	71	26	0	0	0	0	0	0.94	1.06	0	0	71	142
79	3	0	1.009	0	39	32	0	0	0	0	20	0.94	1.06	0	0	39	78
80	3	2	1.04	0	130	26	477	0	-165	280	0	0.94	1.06	0	577	130	260
81	3	0	0.997	0	0	0	0	0	0	0	0	0.94	1.06	0	0	0	0
82	3	0	0.989	0	54	27	0	0	0	0	20	0.94	1.06	0	0	54	108
83	3	0	0.985	0	20	10	0	0	0	0	10	0.94	1.06	0	0	20	40
84	3	0	0.98	0	11	7	0	0	0	0	0	0.94	1.06	0	0	11	22
85	3	2	0.985	0	24	15	0	0	-8	23	0	0.94	1.06	0	100	24	48

86	3	0	0.987	0	21	10	0	0	0	0	0	0.94	1.06	0	0	21	42
87	3	2	1.015	0	0	0	4	0	-100	1000	0	0.94	1.06	0	104	0	0
88	3	0	0.987	0	48	10	0	0	0	0	0	0.94	1.06	0	0	48	96
89	3	2	1.005	0	0	0	607	0	-210	300	0	0.94	1.06	0	707	0	0
90	3	2	0.985	0	163	42	0	0	-300	300	0	0.94	1.06	0	100	163	326
91	3	2	0.98	0	10	0	0	0	-100	100	0	0.94	1.06	0	100	10	20
92	3	2	0.993	0	65	10	0	0	-3	9	0	0.94	1.06	0	100	65	130
93	3	0	0.987	0	12	7	0	0	0	0	0	0.94	1.06	0	0	12	24
94	3	0	0.991	0	30	16	0	0	0	0	0	0.94	1.06	0	0	30	60
95	3	0	0.981	0	42	31	0	0	0	0	0	0.94	1.06	0	0	42	84
96	3	0	0.993	0	38	15	0	0	0	0	0	0.94	1.06	0	0	38	76
97	3	0	1.011	0	15	9	0	0	0	0	0	0.94	1.06	0	0	15	30
98	3	0	1.024	0	34	8	0	0	0	0	0	0.94	1.06	0	0	34	68
99	3	2	1.01	0	42	0	0	0	-100	100	0	0.94	1.06	0	100	42	84
100	3	2	1.017	0	37	18	252	0	-50	155	0	0.94	1.06	0	352	37	74
101	3	0	0.993	0	22	15	0	0	0	0	0	0.94	1.06	0	0	22	44
102	3	0	0.991	0	5	3	0	0	0	0	0	0.94	1.06	0	0	5	10
103	3	2	1.001	0	23	16	40	0	-15	45	0	0.94	1.06	0	140	23	46
104	3	2	0.971	0	38	25	0	0	-8	23	0	0.94	1.06	0	100	38	76
105	3	2	0.965	0	31	26	0	0	-15	23	20	0.94	1.06	0	100	31	62
106	3	0	0.962	0	43	16	0	0	0	0	0	0.94	1.06	0	0	43	86
107	3	2	0.952	0	50	12	0	0	-200	200	6	0.94	1.06	0	100	50	100
108	3	0	0.967	0	2	1	0	0	0	0	0	0.94	1.06	0	0	2	4
109	3	0	0.967	0	8	3	0	0	0	0	0	0.94	1.06	0	0	8	16
110	3	2	0.973	0	39	30	0	0	-8	23	6	0.94	1.06	0	100	39	78
111	3	2	0.98	0	0	0	36	0	-100	1000	0	0.94	1.06	0	136	0	0
112	3	2	0.975	0	68	13	0	0	-100	1000	0	0.94	1.06	0	100	68	136
113	3	2	0.993	0	6	0	0	0	-100	200	0	0.94	1.06	0	100	6	12
114	3	0	0.96	0	8	3	0	0	0	0	0	0.94	1.06	0	0	8	16
115	3	0	0.96	0	22	7	0	0	0	0	0	0.94	1.06	0	0	22	44

116	1	2	1.005	0	184	0	0	0	- 1000	1000	0	0.94	1.06	0	100	184	368
117	3	0	0.974	0	20	8	0	0	0	0	0	0.94	1.06	0	0	20	40
118	3	0	0.949	0	33	15	0	0	0	0	0	0.94	1.06	0	0	33	66



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Line data of IEEE 118-bus

Line no.	From Bus	To Bus	R (p.u.)	X (p.u.)	branch admittance (p.u.)	Transformer tap setting	Rating (MVAR)
1	1	2	0.0303	0.0999	0.0127	1	100
2	1	3	0.0129	0.0424	0.00541	1	100
3	4	5	0.00176	0.00798	0.00105	1	200
4	3	5	0.0241	0.108	0.0142	1	130
5	5	6	0.0119	0.054	0.00713	1	130
6	6	7	0.00459	0.0208	0.00275	1	100
7	8	9	0.00244	0.0305	0.581	1	650
8	8	5	0	0.0267	0	0.985	650
9	9	10	0.00258	0.0322	0.615	1	650
10	4	11	0.0209	0.0688	0.00874	1	130
11	5	11	0.0203	0.0682	0.00869	1	130
12	11	12	0.00595	0.0196	0.00251	1	100
13	2	12	0.0187	0.0616	0.00786	1	100
14	3	12	0.0484	0.16	0.0203	1	100
15	7	12	0.00862	0.034	0.00437	1	100
16	11	13	0.02225	0.0731	0.00938	1	100
17	12	14	0.0215	0.0707	0.00908	1	100
18	13	15	0.0744	0.2444	0.03134	1	100
19	14	15	0.0595	0.195	0.0251	1	130
20	12	16	0.0212	0.0834	0.0107	1	130
21	15	17	0.0132	0.0437	0.0222	1	200
22	16	17	0.0454	0.1801	0.0233	1	130
23	17	18	0.0123	0.0505	0.00649	1	130
24	18	19	0.01119	0.0493	0.00571	1	300
25	19	20	0.0252	0.117	0.0149	1	300

26	15	19	0.012	0.0394	0.00505	1	300
27	20	21	0.0183	0.0849	0.0108	1	300
28	21	22	0.0209	0.097	0.0123	1	300
29	22	23	0.0342	0.159	0.0202	1	300
30	23	24	0.0135	0.0492	0.0249	1	600
31	23	25	0.0156	0.08	0.0432	1	300
32	26	25	0	0.0382	0	0.96	600
33	25	27	0.0318	0.163	0.0882	1	300
34	27	28	0.01913	0.0855	0.0108	1	100
35	28	29	0.0237	0.0943	0.0119	1	100
36	30	17	0	0.0388	0	0.96	600
37	8	30	0.00431	0.0504	0.257	1	600
38	26	30	0.00799	0.086	0.454	1	600
39	17	31	0.0474	0.1563	0.01995	1	130
40	29	31	0.0108	0.0331	0.00415	1	100
41	23	32	0.0317	0.1153	0.05865	1	300
42	31	32	0.0298	0.0985	0.01255	1	100
43	27	32	0.0229	0.0755	0.00963	1	130
44	15	33	0.038	0.1244	0.01597	1	300
45	19	34	0.0752	0.247	0.0316	1	300
46	35	36	0.00224	0.0102	0.00134	1	100
47	35	37	0.011	0.0497	0.00659	1	100
48	33	37	0.0415	0.142	0.0183	1	300
49	34	36	0.00871	0.0268	0.00284	1	100
50	34	37	0.00256	0.0094	0.00492	1	300
51	38	37	0	0.0375	0	0.935	600
52	37	39	0.0321	0.106	0.0135	1	130
53	37	40	0.0593	0.168	0.021	1	130
54	30	38	0.00464	0.054	0.211	1	600
55	39	40	0.0184	0.0605	0.00776	1	130

56	40	41	0.0145	0.0487	0.00611	1	130
57	40	42	0.0555	0.183	0.0233	1	100
58	41	42	0.041	0.135	0.0172	1	100
59	43	44	0.0608	0.2454	0.03034	1	130
60	34	43	0.0413	0.1681	0.02113	1	130
61	44	45	0.0224	0.0901	0.0112	1	130
62	45	46	0.04	0.1356	0.0166	1	100
63	46	47	0.038	0.127	0.0158	1	100
64	46	48	0.0601	0.189	0.0236	1	100
65	47	49	0.0191	0.0625	0.00802	1	130
66	42	49	0.0715	0.323	0.043	1	130
67	42	49	0.0715	0.323	0.043	1	130
68	45	49	0.0684	0.186	0.0222	1	130
69	48	49	0.0179	0.0505	0.00629	1	130
70	49	50	0.0267	0.0752	0.00937	1	130
71	49	51	0.0486	0.137	0.0171	1	130
72	51	52	0.0203	0.0588	0.00698	1	100
73	52	53	0.0405	0.1635	0.02029	1	100
74	53	54	0.0263	0.122	0.0155	1	100
75	49	54	0.073	0.289	0.0369	1	100
76	49	54	0.0869	0.291	0.0365	1	100
77	54	55	0.0169	0.0707	0.0101	1	100
78	54	56	0.00275	0.00955	0.00366	1	100
79	55	56	0.00488	0.0151	0.00187	1	100
80	56	57	0.0343	0.0966	0.0121	1	100
81	50	57	0.0474	0.134	0.0166	1	100
82	56	58	0.0343	0.0966	0.0121	1	100
83	51	58	0.0255	0.0719	0.00894	1	100
84	54	59	0.0503	0.2293	0.0299	1	100
85	56	59	0.0825	0.251	0.02845	1	100

86	56	59	0.0803	0.239	0.0268	1	100
87	55	59	0.04739	0.2158	0.02823	1	100
88	59	60	0.0317	0.145	0.0188	1	100
89	59	61	0.0328	0.15	0.0194	1	130
90	60	61	0.00264	0.0135	0.00728	1	300
91	60	62	0.0123	0.0561	0.00734	1	100
92	61	62	0.00824	0.0376	0.0049	1	100
93	63	59	0	0.0386	0	0.96	300
94	63	64	0.00172	0.02	0.108	1	300
95	64	61	0	0.0268	0	0.985	300
96	38	65	0.00901	0.0986	0.523	1	600
97	64	65	0.00269	0.0302	0.19	1	600
98	49	66	0.018	0.0919	0.0124	1	300
99	49	66	0.018	0.0919	0.0124	1	300
100	62	66	0.0482	0.218	0.0289	1	100
101	62	67	0.0258	0.117	0.0155	1	100
102	65	66	0	0.037	0	0.935	100
103	66	67	0.0224	0.1015	0.01341	1	100
104	65	68	0.00138	0.016	0.319	1	600
105	47	69	0.0844	0.2778	0.03546	1	130
106	49	69	0.0985	0.324	0.0414	1	130
107	68	69	0	0.037	0	0.935	600
108	69	70	0.03	0.127	0.061	1	300
109	24	70	0.00221	0.4115	0.05099	1	300
110	70	71	0.00882	0.0355	0.00439	1	300
111	24	72	0.0488	0.196	0.0244	1	300
112	71	72	0.0446	0.18	0.02222	1	300
113	71	73	0.00866	0.0454	0.00589	1	100
114	70	74	0.0401	0.1323	0.01684	1	300
115	70	75	0.0428	0.141	0.018	1	300

116	69	75	0.0405	0.122	0.062	1	300
117	74	75	0.0123	0.0406	0.00517	1	300
118	76	77	0.0444	0.148	0.0184	1	130
119	69	77	0.0309	0.101	0.0519	1	300
120	75	77	0.0601	0.1999	0.02489	1	300
121	77	78	0.00376	0.0124	0.00632	1	100
122	78	79	0.00546	0.0244	0.00324	1	130
123	77	80	0.017	0.0485	0.0236	1	300
124	77	80	0.0294	0.105	0.0114	1	300
125	79	80	0.0156	0.0704	0.00935	1	130
126	68	81	0.00175	0.0202	0.404	1	300
127	81	80	0	0.037	0	0.935	300
128	77	82	0.0298	0.0853	0.04087	1	100
129	82	83	0.0112	0.03665	0.01898	1	130
130	83	84	0.0625	0.132	0.0129	1	100
131	83	85	0.043	0.148	0.0174	1	130
132	84	85	0.0302	0.0641	0.00617	1	100
133	85	86	0.035	0.123	0.0138	1	130
134	86	87	0.02828	0.2074	0.02225	1	130
135	85	88	0.02	0.102	0.0138	1	130
136	85	89	0.0239	0.173	0.0235	1	130
137	88	89	0.0139	0.0712	0.00967	1	200
138	89	90	0.0518	0.188	0.0264	1	200
139	89	90	0.0238	0.0997	0.053	1	130
140	90	91	0.0254	0.0836	0.0107	1	130
141	89	92	0.0099	0.0505	0.0274	1	300
142	89	92	0.0393	0.1581	0.0207	1	300
143	91	92	0.0387	0.1272	0.01634	1	100
144	92	93	0.0258	0.0848	0.0109	1	130
145	92	94	0.0481	0.158	0.0203	1	130

146	93	94	0.0223	0.0732	0.00938	1	100
147	94	95	0.0132	0.0434	0.00555	1	100
148	80	96	0.0356	0.182	0.0247	1	130
149	82	96	0.0162	0.053	0.0272	1	100
150	94	96	0.0269	0.0869	0.0115	1	100
151	80	97	0.0183	0.0934	0.0127	1	130
152	80	98	0.0238	0.108	0.0143	1	130
153	80	99	0.0454	0.206	0.0273	1	130
154	92	100	0.0648	0.295	0.0236	1	130
155	94	100	0.0178	0.058	0.0302	1	130
156	95	96	0.0171	0.0547	0.00737	1	100
157	96	97	0.0173	0.0885	0.012	1	100
158	98	100	0.0397	0.179	0.0238	1	100
159	99	100	0.018	0.0813	0.0108	1	100
160	100	101	0.0277	0.1262	0.0164	1	100
161	92	102	0.0123	0.0559	0.00732	1	100
162	101	102	0.0246	0.112	0.0147	1	100
163	100	103	0.016	0.0525	0.0268	1	300
164	100	104	0.0451	0.204	0.02705	1	130
165	103	104	0.0466	0.1584	0.02035	1	130
166	103	105	0.0535	0.1625	0.0204	1	130
167	100	106	0.0605	0.229	0.031	1	130
168	104	105	0.00994	0.0378	0.00493	1	130
169	105	106	0.014	0.0547	0.00717	1	100
170	105	107	0.053	0.183	0.0236	1	100
171	105	108	0.0261	0.0703	0.00922	1	100
172	106	107	0.053	0.183	0.0236	1	100
173	108	109	0.0105	0.0288	0.0038	1	100
174	103	110	0.03906	0.1813	0.02305	1	130
175	109	110	0.0278	0.0762	0.0101	1	100

176	110	111	0.022	0.0755	0.01	1	100
177	110	112	0.0247	0.064	0.031	1	130
178	17	113	0.00913	0.0301	0.00384	1	130
179	32	113	0.0615	0.203	0.0259	1	130
180	32	114	0.0135	0.0612	0.00814	1	100
181	27	115	0.0164	0.0741	0.00986	1	100
182	114	115	0.0023	0.0104	0.00138	1	100
183	68	116	0.00034	0.00405	0.082	1	300
184	12	117	0.0329	0.14	0.0179	1	100
185	75	118	0.0145	0.0481	0.00599	1	130
186	76	118	0.0164	0.0544	0.00678	1	130

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IEEE Thai Power 160-bus Test system data

Bus data of Thai Power 160-bus

Bus No.	Area	Code	Voltage Magnitude	Angle Degree	Load		Generator				Injected MVAR	Vmin (p.u.)	Vmax (p.u.)	Pg min (MW)	Pg max (MW)	Pd min (MW)	Pd max (MW)
					MW	MVAR	MW	MVAR	Qmin	Qmax							
1	1	2	0.985	0	41.96	25.19	500	0	-200	600	0	0.95	1.05	240	600	41.96	83.92
2	1	2	0.98064	0	0	0	500	0	-200	600	0	0.95	1.05	240	600	0	0
3	1	2	0.98044	0	8.81	4.84	500	0	-74	90	0	0.95	1.05	160	800	8.81	17.62
4	1	2	0.98161	0	0.74	0.44	400	0	-150	200	0	0.95	1.05	100	500	0.74	1.48
5	1	2	0.95274	0	16.57	17.42	150	0	-90	240	0	0.95	1.05	80	200	16.57	33.14
6	1	2	0.95166	0	0	0	150	0	-90	240	0	0.95	1.05	80	200	0	0
7	1	2	0.95666	0	23.15	23.6	225	0	-270	690	0	0.95	1.05	186	310	23.15	46.3
8	1	2	0.95674	0	0	0	225	0	-270	690	0	0.95	1.05	186	310	0	0
9	1	2	0.95706	0	0	0	225	0	-270	690	0	0.95	1.05	186	310	0	0
10	1	2	0.9521	0	26.13	13.47	250	0	-185	360	0	0.95	1.05	120	335	26.13	52.26
11	1	2	0.95164	0	0	0	450	0	-185	360	0	0.95	1.05	120	623	0	0
12	1	2	0.95359	0	0.98	0.39	90	0	-60	80	0	0.95	1.05	18	90	0.98	1.96
13	1	2	0.96805	0	0.98	0.39	90	0	-80	80	0	0.95	1.05	18	90	0.98	1.96
14	1	2	1.0021	0	1.36	0.18	450	0	-186	300	0	0.95	1.05	160	800	1.36	2.72
15	1	2	0.99875	0	0.38	0.18	100	0	-222	141	0	0.95	1.05	48	240	0.38	0.76
16	1	2	0.99889	0	24.26	11.88	300	0	-186	396	0	0.95	1.05	220	550	24.26	48.52
17	1	2	0.99889	0	0	0	300	0	-186	396	0	0.95	1.05	220	550	0	0
18	1	2	1.0255	0	0.55	0.27	150	0	-90	120.2	0	0.95	1.05	100	500	0.55	1.1
19	1	2	1.057	0	0.28	0.27	200	0	-90	150.8	0	0.95	1.05	75	375	0.28	0.56
20	1	2	1.01741	0	22.61	9.97	150	0	-150	270	0	0.95	1.05	120	150	22.61	45.22
21	1	2	1.01741	0	0	0	150	0	-150	270	0	0.95	1.05	120	150	0	0
22	1	2	1.0174	0	0	0	150	0	-150	270	0	0.95	1.05	120	150	0	0
23	1	2	0.98199	0	0	0	500	0	-240	660	0	0.95	1.05	220	550	0	0
24	1	2	0.98199	0	0	0	500	0	-240	660	0	0.95	1.05	220	550	0	0
25	1	2	0.97677	0	36.46	22.18	250	0	-370	600	0	0.95	1.05	200	350	36.46	72.92
26	1	2	0.97677	0	0	0	250	0	-370	600	0	0.95	1.05	200	350	0	0

27	1	2	0.97677	0	0	0	250	0	-370	600	0	0.95	1.05	200	350	0	0
28	1	2	0.975	0	60.64	29.37	550	0	-200	600	0	0.95	1.05	320	800	60.64	121.28
29	1	1	0.975	0	0	0	550	0	-200	800	0	0.95	1.05	-320	1500	0	0
30	1	2	1.02	0	23.29	13.63	550	0	-223.2	360	0	0.95	1.05	120	600	23.29	46.58
31	1	2	1.02	0	0	0	550	0	-223.2	360	0	0.95	1.05	120	600	0	0
32	1	2	1.026	0	0.23	1.18	200	0	-90	150	0	0.95	1.05	72	360	0.23	0.46
33	1	2	1.0011	0	0.08	0.05	300	0	-95	216	0	0.95	1.05	72	360	0.08	0.16
34	1	2	1.04	0	0.18	0.1	200	0	-90	150	0	0.95	1.05	60	300	0.18	0.36
35	1	2	1.02233	0	0	0	0	0	-90	100	0	0.95	1.05	0	100	0	0
36	1	2	0.9953	0	98.05	60.99	325	0	-450	500	0	0.95	1.05	200	450	98.05	196.1
37	1	2	0.9953	0	0	0	325	0	-450	500	0	0.95	1.05	200	450	0	0
38	1	2	0.9953	0	0	0	325	0	-450	500	0	0.95	1.05	200	450	0	0
39	1	2	0.99351	0	0	0	325	0	-450	500	0	0.95	1.05	200	450	0	0
40	1	2	0.99934	0	9.6	6.5	75	0	-450	200	0	0.95	1.05	60	75	9.6	19.2
41	1	2	0.99982	0	0	0	75	0	-450	200	0	0.95	1.05	60	75	0	0
42	1	2	0.99858	0	0	0	87	0	-450	200	0	0.95	1.05	60	87.5	0	0
43	2	0	1	0	51.51	30.47	0	0	0	0	0	0.85	1.15	0	0	51.51	103.02
44	2	0	1	0	553.3	105.7	0	0	0	0	195.0078	0.85	1.15	0	0	553.3	1106.6
45	2	0	1	0	0	0	0	0	0	0	137.703112	0.85	1.15	0	0	0	0
46	2	0	1	0	0	0	0	0	0	0	185.804534	0.85	1.15	0	0	0	0
47	2	0	1	0	0	0	0	0	0	0	0	0.85	1.15	0	0	0	0
48	2	0	1	0	0	0	0	0	0	0	0	0.85	1.15	0	0	0	0
49	2	0	1	0	0	0	0	0	0	0	0	0.85	1.15	0	0	0	0
50	2	0	1	0	0	0	0	0	0	0	0	0.85	1.15	0	0	0	0
51	2	0	1	0	0	0	0	0	0	0	0	0.85	1.15	0	0	0	0
52	2	0	1	0	0	0	0	0	0	0	0	0.85	1.15	0	0	0	0
53	2	0	1	0	0	0	0	0	0	0	0	0.85	1.15	0	0	0	0
54	2	0	1	0	0	0	0	0	0	0	0	0.85	1.15	0	0	0	0
55	2	0	1	0	0	0	0	0	0	0	0	0.85	1.15	0	0	0	0
56	2	0	1	0	0	0	0	0	0	0	0	0.85	1.15	0	0	0	0
57	2	0	1	0	0	0	0	0	0	0	0	0.85	1.15	0	0	0	0

58	2	0	1	0	0	0	0	0	0	0	0	0.85	1.15	0	0	0	0
59	2	0	1	0	0	0	0	0	0	0	0	0.85	1.15	0	0	0	0
60	2	0	1	0	297.8	8.5	0	0	0	0	131.752306	0.85	1.15	0	0	297.8	595.6
61	2	0	1	0	640.4	120.4	0	0	0	0	0	0.85	1.15	0	0	640.4	1280.8
62	2	0	1	0	662.5	97	0	0	0	0	262.881178	0.85	1.15	0	0	662.5	1325
63	2	0	1	0	837.5	189.4	0	0	0	0	65.1805501	0.85	1.15	0	0	837.5	1675
64	2	0	1	0	359.4	97.9	0	0	0	0	0	0.85	1.15	0	0	359.4	718.8
65	2	0	1	0	486.9	181.7	0	0	0	0	129.634431	0.85	1.15	0	0	486.9	973.8
66	2	0	1	0	340.8	-25.5	0	0	0	0	133.958473	0.85	1.15	0	0	340.8	681.6
67	2	0	1	0	0	0	0	0	0	0	0	0.85	1.15	0	0	0	0
68	2	0	1	0	0	0	0	0	0	0	0	0.85	1.15	0	0	0	0
69	2	0	1	0	241.5	-0.3	0	0	0	0	0	0.85	1.15	0	0	241.5	483
70	2	0	1	0	0	0	0	0	0	0	0	0.85	1.15	0	0	0	0
71	2	0	1	0	0	0	0	0	0	0	0	0.85	1.15	0	0	0	0
72	2	0	1	0	0	0	0	0	0	0	0	0.85	1.15	0	0	0	0
73	2	0	1	0	0	0	0	0	0	0	0	0.85	1.15	0	0	0	0
74	2	0	1	0	0	0	0	0	0	0	0	0.85	1.15	0	0	0	0
75	2	0	1	0	0	0	0	0	0	0	0	0.85	1.15	0	0	0	0
76	2	0	1	0	0	0	0	0	0	0	0	0.85	1.15	0	0	0	0
77	2	0	1	0	0	0	0	0	0	0	0	0.85	1.15	0	0	0	0
78	2	0	1	0	0	0	0	0	0	0	100	0.85	1.15	0	0	0	0
79	2	0	1	0	0	0	0	0	0	0	0	0.85	1.15	0	0	0	0
80	2	0	1	0	29.3	16.8	0	0	0	0	0	0.85	1.15	0	0	29.3	58.6
81	2	0	1	0	0	0	0	0	0	0	0	0.85	1.15	0	0	0	0
82	2	0	1	0	0	0	0	0	0	0	0	0.85	1.15	0	0	0	0
83	2	0	1	0	0	0	0	0	0	0	0	0.85	1.15	0	0	0	0
84	2	0	1	0	0	0	0	0	0	0	0	0.85	1.15	0	0	0	0
85	2	0	1	0	0	0	0	0	0	0	0	0.85	1.15	0	0	0	0
86	2	0	1	0	49.6	21	0	0	0	0	124.781632	0.85	1.15	0	0	49.6	99.2
87	2	0	1	0	0	0	0	0	0	0	124.90632	0.85	1.15	0	0	0	0
88	2	0	1	0	0	0	0	0	0	0	0	0.85	1.15	0	0	0	0
89	2	0	1	0	0	0	0	0	0	0	0	0.85	1.15	0	0	0	0

90	2	0	1	0	0	0	0	0	0	0	0	0.85	1.15	0	0	0	0
91	2	0	1	0	0	0	0	0	0	0	0	0.85	1.15	0	0	0	0
92	2	0	1	0	0	0	0	0	0	0	65.4150586	0.85	1.15	0	0	0	0
93	2	0	1	0	0	0	0	0	0	0	0	0.85	1.15	0	0	0	0
94	2	0	1	0	0	0	0	0	0	0	0	0.85	1.15	0	0	0	0
95	2	0	1	0	0	0	0	0	0	0	0	0.85	1.15	0	0	0	0
96	2	0	1	0	0	0	0	0	0	0	0	0.85	1.15	0	0	0	0
97	2	0	1	0	0	0	0	0	0	0	0	0.85	1.15	0	0	0	0
98	2	0	1	0	0	0	0	0	0	0	0	0.85	1.15	0	0	0	0
99	2	0	1	0	0	0	0	0	0	0	0	0.85	1.15	0	0	0	0
100	2	0	1	0	0	0	0	0	0	0	0	0.85	1.15	0	0	0	0
101	2	0	1	0	122.1	21.6	0	0	0	0	0	0.85	1.15	0	0	122.1	244.2
102	2	0	1	0	121.9	11.9	0	0	0	0	0	0.85	1.15	0	0	121.9	243.8
103	2	0	1	0	48.2	-130.5	0	0	0	0	0	0.85	1.15	0	0	48.2	96.4
104	2	0	1	0	151.7	120.8	0	0	0	0	0	0.85	1.15	0	0	151.7	303.4
105	2	0	1	0	231.4	-0.6	0	0	0	0	0	0.85	1.15	0	0	231.4	462.8
106	2	0	1	0	177.8	-12.6	0	0	0	0	0	0.85	1.15	0	0	177.8	355.6
107	2	0	1	0	-27.3	-11.1	0	0	0	0	0	0.85	1.15	0	0	-27.3	-54.6
108	2	0	1	0	72.8	9.1	0	0	0	0	0	0.85	1.15	0	0	72.8	145.6
109	2	0	1	0	29.8	6.4	0	0	0	0	0	0.85	1.15	0	0	29.8	59.6
110	2	0	1	0	30.2	6.6	0	0	0	0	0	0.85	1.15	0	0	30.2	60.4
111	2	0	1	0	249.4	123	0	0	0	0	0	0.85	1.15	0	0	249.4	498.8
112	2	0	1	0	80.5	42.1	0	0	0	0	0	0.85	1.15	0	0	80.5	161
113	2	0	1	0	248	33	0	0	0	0	0	0.85	1.15	0	0	248	496
114	2	0	1	0	137.2	77.2	0	0	0	0	0	0.85	1.15	0	0	137.2	274.4
115	2	0	1	0	42.2	-12.1	0	0	0	0	0	0.85	1.15	0	0	42.2	84.4
116	2	0	1	0	3.3	1.8	0	0	0	0	0	0.85	1.15	0	0	3.3	6.6
117	2	0	1	0	42.8	4.6	0	0	0	0	0	0.85	1.15	0	0	42.8	85.6
118	2	0	1	0	198	-347.1	0	0	0	0	0	0.85	1.15	0	0	198	396
119	2	0	1	0	161	-147.8	0	0	0	0	0	0.85	1.15	0	0	161	322
120	2	0	1	0	341.1	-7.5	0	0	0	0	0	0.85	1.15	0	0	341.1	682.2
121	2	0	1	0	69.7	-2.4	0	0	0	0	0	0.85	1.15	0	0	69.7	139.4

122	2	0	1	0	280.2	14.6	0	0	0	0	0	0.85	1.15	0	0	280.2	560.4
123	2	0	1	0	238.2	-15.9	0	0	0	0	0	0.85	1.15	0	0	238.2	476.4
124	2	0	1	0	180.3	25.8	0	0	0	0	0	0.85	1.15	0	0	180.3	360.6
125	2	0	1	0	137.6	-8.2	0	0	0	0	0	0.85	1.15	0	0	137.6	275.2
126	2	0	1	0	87.9	-26.8	0	0	0	0	0	0.85	1.15	0	0	87.9	175.8
127	2	0	1	0	245.4	-30.3	0	0	0	0	0	0.85	1.15	0	0	245.4	490.8
128	2	0	1	0	119.3	69.6	0	0	0	0	0	0.85	1.15	0	0	119.3	238.6
129	2	0	1	0	50.8	7.2	0	0	0	0	0	0.85	1.15	0	0	50.8	101.6
130	2	0	1	0	50.5	7.2	0	0	0	0	0	0.85	1.15	0	0	50.5	101
131	2	0	1	0	45.8	79.3	0	0	0	0	0	0.85	1.15	0	0	45.8	91.6
132	2	0	1	0	45.6	27	0	0	0	0	0	0.85	1.15	0	0	45.6	91.2
133	2	0	1	0	196	9.6	0	0	0	0	0	0.85	1.15	0	0	196	392
134	2	0	1	0	208.8	-91.8	0	0	0	0	0	0.85	1.15	0	0	208.8	417.6
135	2	0	1	0	86	93.6	0	0	0	0	0	0.85	1.15	0	0	86	172
136	2	0	1	0	184.5	-22.2	0	0	0	0	0	0.85	1.15	0	0	184.5	369
137	2	0	1	0	462.4	78	0	0	0	0	0	0.85	1.15	0	0	462.4	924.8
138	2	0	1	0	168.6	91.8	0	0	0	0	0	0.85	1.15	0	0	168.6	337.2
139	2	0	1	0	302.1	139.2	0	0	0	0	0	0.85	1.15	0	0	302.1	604.2
140	2	0	1	0	60.9	40.5	0	0	0	0	0	0.85	1.15	0	0	60.9	121.8
141	2	0	1	0	110.4	36.3	0	0	0	0	0	0.85	1.15	0	0	110.4	220.8
142	2	0	1	0	146.2	24.6	0	0	0	0	0	0.85	1.15	0	0	146.2	292.4
143	2	0	1	0	281.4	91.2	0	0	0	0	0	0.85	1.15	0	0	281.4	562.8
144	2	0	1	0	126.6	6	0	0	0	0	0	0.85	1.15	0	0	126.6	253.2
145	2	0	1	0	70	8.6	0	0	0	0	0	0.85	1.15	0	0	70	140
146	2	0	1	0	95.9	13.3	0	0	0	0	0	0.85	1.15	0	0	95.9	191.8
147	2	0	1	0	515.2	159.6	0	0	0	0	0	0.85	1.15	0	0	515.2	1030.4
148	2	0	1	0	0	0	0	0	0	0	0	0.85	1.15	0	0	0	0
149	2	0	1	0	0	0	0	0	0	0	80.2954874	0.85	1.15	0	0	0	0
150	2	0	1	0	0	0	0	0	0	0	80.2954874	0.85	1.15	0	0	0	0
151	2	0	1	0	0	0	0	0	0	0	-150.015	0.85	1.15	0	0	0	0
152	2	0	1	0	0	0	0	0	0	0	-150.015	0.85	1.15	0	0	0	0
153	2	0	1	0	0	0	0	0	0	0	-109.9989	0.85	1.15	0	0	0	0

154	2	0	1	0	0	0	0	0	0	0	-109.9989	0.85	1.15	0	0	0	0
155	2	0	1	0	0	0	0	0	0	0	-109.9989	0.85	1.15	0	0	0	0
156	2	0	1	0	0	0	0	0	0	0	-109.9989	0.85	1.15	0	0	0	0
157	2	0	1	0	0	0	0	0	0	0	-90.0009	0.85	1.15	0	0	0	0
158	2	0	1	0	0	0	0	0	0	0	-90.0009	0.85	1.15	0	0	0	0
159	2	0	1	0	177.1	104.9	0	0	0	0	33.7040782	0.85	1.15	0	0	177.1	354.2
160	2	0	1	0	0	0	0	0	0	0	0	0.85	1.15	0	0	0	0



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Line data of Thai Power 160-bus

Line no.	From Bus	To Bus	R (p.u.)	X (p.u.)	branch admittance (p.u.)	Transformer tap setting	Rating (MVAR)
1	1	1	0	0.0174	0	0.95	680
2	43	2	0	0.0174	0	0.95	680
3	43	3	0	0.0326	0	0.95	500
4	43	4	0	0.02766	0	1	500
5	43	94	0.0002	0.0021	0.0173	1	1000
6	44	5	0	0.0383	0	0.95	225
7	44	6	0	0.0383	0	0.95	225
8	44	7	0	0.0317	0	0.95	370
9	44	8	0	0.0317	0	0.95	370
10	44	9	0	0.0317	0	0.95	370
11	44	10	0	0.02608	0	0.95	425
12	44	11	0	0.02608	0	0.95	500
13	44	64	0.00026	0.0027	0.0501	1	1500
14	44	101	0.0006	0.0645	0	1	200
15	44	102	0.0006	0.0645	0	1	200
16	45	12	0	0.12987	0	1	125
17	45	66	0.0012	0.0087	0.0393	1	500
18	45	87	0.0035	0.0251	0.1129	1	500
19	45	96	0.0026	0.021	0.0791	1	500
20	45	103	0.0006	0.0705	0	0.9	300
21	46	13	0	0.06523	0	0.95	170
22	46	55	0.0021	0.0222	0.0453	1	750
23	46	94	0.0017	0.0179	0.0365	1	500
24	46	104	0.0006	0.0705	0	0.9244	300
25	47	14	0	0.013	0	0.95	850

26	47	105	0.0003	0.03255	0	0.9625	300
27	48	15	0	0.0442	0	0.95	270
28	48	75	0.0025	0.0214	0.0759	1	500
29	48	106	0.0003	0.0364	0	1.05	200
30	49	16	0	0.04246	0	0.95	425
31	49	17	0	0.04246	0	0.95	425
32	49	76	0.0048	0.0383	0.1444	1	750
33	49	107	0.0014	0.131	0	1.075	100
34	50	18	0	0.01738	0	0.975	696
35	50	80	0.0054	0.0438	0.0406	1	500
36	50	81	0.0107	0.0833	0.3253	1	500
37	50	108	0.0014	0.1417	0	1.025	100
38	51	19	0	0.03613	0	1	450
39	51	83	0.009	0.0454	0.1671	1	500
40	51	109	0.0014	0.1685	0	1.025	66.7
41	51	110	0.0014	0.1535	0	1.025	66.7
42	52	20	0	0.0731	0	0.95	171
43	52	21	0	0.0731	0	0.95	171
44	52	22	0	0.0731	0	0.95	171
45	52	85	0.0058	0.0424	0.1867	1	500
46	52	111	0.0003	0.03376	0	0.95	400
47	52	112	0.0014	0.17583	0	0.9025	200
48	53	23	0	0.01276	0	1	750
49	53	24	0	0.01276	0	1	750
50	53	67	0.00127	0.0172	0.03588	1	500
51	54	25	0	0.01956	0	0.95	570
52	54	26	0	0.01956	0	0.95	570
53	54	27	0	0.01956	0	0.95	570
54	54	93	0.0022	0.0159	0.0715	1	500
55	54	113	0.00012	0.0137	0	0.9875	1000

56	55	28	0	0.0174	0	1.1	750
57	55	29	0	0.0174	0	1.1	1600
58	55	30	0	0.02174	0	0.95	750
59	55	31	0	0.02174	0	0.95	750
60	55	114	0.0003	0.02629	0	1	400
61	56	32	0	0.02805	0	0.97	300
62	56	33	0	0.0291	0	0.95	440
63	56	57	0.0041	0.0325	0.1228	1	500
64	56	115	0.0014	0.14283	0	1.025	100
65	57	34	0	0.03077	0	0.975	333.3
66	57	116	0.0014	0.16447	0	1.025	66.7
67	58	35	0	0.0397	0	0.975	300
68	58	117	0.0003	0.03625	0	1	400
69	59	36	0	0.0317	0	0.975	370
70	59	37	0	0.0317	0	0.975	370
71	59	38	0	0.0317	0	0.975	370
72	59	39	0	0.0317	0	0.975	370
73	59	52	0.0014	0.0208	0	1.052	900
74	60	61	0.0007	0.005	0.0052	1	500
75	60	65	0.0018	0.0146	0.0134	1	500
76	60	66	0.0019	0.014	0.0145	1	500
77	61	62	0.0002	0.0027	0.0223	1	1000
78	61	66	0.0017	0.0128	0.0132	1	500
79	62	68	0.0001	0.0012	0.0389	1	2000
80	62	69	0.0002	0.0011	0.0044	1	500
81	63	43	0.0011	0.0116	0.0945	1	1500
82	63	44	0.0004	0.0041	0.0347	1	750
83	63	68	0.0005	0.0041	0.0184	1	500
84	64	65	0.0001	0.0018	0.0149	1	750
85	64	100	0.0009	0.0102	0.0215	1	500

86	65	45	0.00147	0.01429	0.03442	1	500
87	65	100	0.0005	0.006	0.0127	1	500
88	66	46	0.0019	0.0214	0.0397	1	500
89	66	67	0.0019	0.0214	0.0397	1	500
90	66	118	0.0002	0.0215	0	1.01	600
91	67	55	0.0021	0.0222	0.0453	1	750
92	67	68	0.0009	0.0096	0.0196	1	750
93	67	94	0.0017	0.0179	0.0365	1	500
94	67	119	0.0006	0.0705	0	1.0882	300
95	68	46	0.0009	0.0096	0.0196	1	500
96	68	55	0.0024	0.0148	0.1212	1	1500
97	70	71	0.0052	0.0372	0.1673	1	500
98	70	88	0.0059	0.0432	0.1892	1	500
99	70	120	0.0002	0.0217	0	0.975	600
100	71	72	0.0049	0.0347	0.1557	1	500
101	71	82	0.0079	0.0584	0.2629	1	500
102	71	121	0.0006	0.0651	0	0.975	200
103	72	47	0.0008	0.0088	0.0738	1	500
104	72	73	0.0057	0.0413	0.0196	1	500
105	72	74	0.0005	0.0036	0.0158	1	500
106	72	84	0.0087	0.0632	0.2797	1	500
107	73	122	0.0003	0.03255	0	0.9625	400
108	74	123	0.0002	0.022	0	0.9875	600
109	75	49	0.0038	0.03	0.1132	1	500
110	75	58	0.014	0.1032	0.4603	1	500
111	75	124	0.00047	0.04683	0	1.0375	300
112	76	77	0.0044	0.0352	0.1325	1	500
113	76	125	0.0003	0.0364	0	0.9875	300
114	77	78	0.0044	0.0346	0.1303	1	500
115	77	126	0.0006	0.07279	0	1	200

116	78	127	0.0002	0.02426	0	1	600
117	79	148	0.0014	0.02231	0	1.0165	600
118	79	149	0.0014	0.02231	0	1.0165	600
119	79	150	0.0014	0.02231	0	1.0165	500
120	79	151	0	0.0001	0	1	500
121	79	152	0	0.0001	0	1	500
122	79	153	0	0.0001	0	1	500
123	79	155	0	0.0001	0	1	500
124	79	157	0	0.0001	0	1	500
125	80	81	0.0159	0.1284	0.1189	1	500
126	81	82	0.0024	0.0277	0.0718	1	500
127	81	83	0.0107	0.0538	0.1982	1	500
128	81	87	0.0049	0.0381	0.1503	1	500
129	81	128	0.0014	0.063	0	1.025	200
130	82	53	0.0041	0.077	0.1956	1	500
131	82	86	0.0072	0.0525	0.2354	1	500
132	82	90	0.0032	0.0341	0.2784	1	500
133	82	129	0.0006	0.0651	0	1	200
134	82	130	0.0006	0.066	0	1	200
135	83	52	0.0079	0.0593	0.2428	1	500
136	83	84	0.006	0.045	0.1841	1	500
137	83	131	0.0014	0.063	0	1	200
138	84	132	0.0014	0.1417	0	1.025	100
139	85	133	0	0.03255	0	0.9875	400
140	86	89	0.0024	0.0176	0.0788	1	500
141	86	134	0.0003	0.03377	0	1.03342	400
142	87	90	0.0025	0.0185	0.0829	1	500
143	87	135	0.0003	0.03103	0	0.96386	400
144	88	90	0.0015	0.011	0.0494	1	500
145	88	136	0.0002	0.02251	0	0.988	600

146	89	53	0.0006	0.0068	0.0556	1	1000
147	89	137	0.00015	0.01688	0	0.9505	800
148	90	138	0.0002	0.0217	0	0.975	600
149	91	46	0.0014	0.0208	0	1	500
150	91	67	0.0014	0.0208	0	1	500
151	92	54	0.0025	0.0184	0.0828	1	500
152	92	55	0.0026	0.0192	0.0877	1	500
153	92	93	0.0014	0.0103	0.0463	1	500
154	92	139	0.0002	0.02092	0	1	600
155	93	140	0.0002	0.02092	0	0.9875	600
156	94	141	0.0002	0.02092	0	1	600
157	95	55	0.0018	0.0197	0.1667	1	500
158	95	142	0.0003	0.03138	0	0.9625	400
159	96	97	0.002	0.0163	0.0617	1	500
160	96	143	0	0.02417	0	1.0125	600
161	97	56	0.0027	0.0213	0.3219	1	750
162	97	98	0.0196	0.1545	0.1456	1	500
163	97	99	0.0111	0.0883	0.0886	1	500
164	97	144	0.0003	0.03582	0	0.975	400
165	98	58	0.0029	0.0216	0.0945	1	500
166	98	145	0.0007	0.06675	0	0.9875	200
167	99	98	0.0084	0.0689	0.0673	1	500
168	99	146	0.0006	0.0725	0	0.964	200
169	100	147	0.00015	0.01813	0	0.925	800
170	148	82	0	0.02514	0	1.05217	600
171	149	82	0	0.02514	0	1.05217	600
172	150	82	0	0.02514	0	1.05217	500
173	151	91	0.00169	0.02298	1.06595	1	500
174	152	91	0.00169	0.02298	1.06595	1	500
175	153	154	0.0026	0.0326	1.75205	1	500

176	154	59	0	0.0001	0	1	500
177	155	156	0.0026	0.0326	1.75205	1	500
178	156	59	0	0.0001	0	1	500
179	157	158	0.00265	0.03589	1.67202	1	500
180	158	59	0	0.0001	0	1	500
181	159	40	0	0.11	0	0.975	90
182	159	41	0	0.1144	0	0.975	90
183	159	42	0	0.1133	0	0.975	105
184	159	60	0.0006	0.07246	0	1.025	200
185	159	160	0	0.00721	0	1.0507	200

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CURRICULUM VITAE

Name	Mr. Suppakarn Chansareewittaya
Date of Birth	1 Jan 1979
Education	2000 Bachelor of Engineering, Electrical Engineering, King Mongkut's Institute of Technology Ladkrabang 2007 Master of Engineering, Electrical Engineering, Chiang Mai University
Scholarship	The Energy Policy and Planning Office (EPPO), Ministry of Energy, Thailand financial support partial throughout this Ph.D. Course.
Publications	S. Chansareewittaya and P. Jirapong, "Power Transfer Capability Enhancement with Multitype FACTS Controller Using Particle Swarm Optimization", Proceedings of the IEEE TENCON 2010 - 2010 IEEE Region10 Conference, Fukuoka, Japan, November, 2010. S. Chansareewittaya and P. Jirapong, "Power Transfer Capability Enhancement with Optimal Maximum Number of FACTS Controllers Using Evolutionary Programming," Proceedings of the 37rd Annual Conference of the IEEE Industrial Electronics Society (IEEE-IECON), Melbourne, Australia, November 2011. S. Chansareewittaya and P. Jirapong, "Power Transfer Capability Enhancement with Optimal Number of FACTS Controllers Using Hybrid TSSA," Proceedings of the IEEE SouthEastCon 2012 – 2012 IEEE Region3 Conference, Orlando, Florida, USA, March 2012. S. Chansareewittaya and P. Jirapong, "Total Transfer Capability Enhancement with Optimal Number of UPFC Using Hybrid TSSA," Proceedings of the IEEE ECTI-CON 2012, Cha-am, Phetchaburi, Thailand, May 2012.

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