

## Appendix – A

# DATA FOR IEEE-30 BUS TEST SYSTEM

The IEEE – 30 bus test system is shown in figure A.1. The system data is taken from references [3]. The generator cost and emission coefficients, load, shunt capacitor data and transmission lines are provided in the Tables A.1, A.2, A.3 and A.4 respectively. The cost coefficients of IEEE-30 bus system are slightly modified to incorporate non-smooth fuel cost functions with ramp rate coefficients as given in Table A.5. The data is on 100 MVA base. For all analysis on this system  $V_i^{\min}$ ,  $V_i^{\max}$ ,  $\phi_i^{\min}$  and  $\phi_i^{\max}$  for bus  $i$  are considered to be 0.9 p.u., 1.1 p.u., -45 degree and +45 degree respectively.

**Table A.1. Generator Cost and Emission Coefficients**

Gen No.	$P_i^{\min}$ (MW)	$P_i^{\max}$ (MW)	$Q_i^{\min}$ (MVar)	$Q_i^{\max}$ (MVar)	$a_i$	$b_i$	$c_i$	$\alpha_i$	$\beta_i$	$\gamma_i$
1.	50	200	-	-	0.00375	2.00	0	0.0126	-1.1000	22.983
2.	20	80	-20	100	0.01750	1.75	0	0.0200	-0.1000	25.313
3.	15	50	-15	80	0.06250	1.00	0	0.0270	-0.0100	25.505
4.	10	35	-15	60	0.00834	3.25	0	0.0291	-0.0050	24.900
5.	10	30	-10	50	0.02500	3.00	0	0.0290	-0.0040	24.700
6.	12	40	-15	60	0.02500	3.00	0	0.0271	-0.0055	25.300

**Table A.2. Load Bus Data**

Bus No.	Load		Bus No.	Load	
	P (MW)	Q (MVar)		P (MW)	Q (MVar)
1	0.00	0.00	16	3.50	1.80
2	21.7	12.7	17	9.00	5.80
3	2.40	1.20	18	3.20	0.90
4	7.60	1.60	19	9.50	3.40
5	94.2	19.0	20	2.20	0.70
6	0.00	0.00	21	17.5	11.2
7	22.8	10.9	22	0.00	0.00
8	30.0	30.0	23	3.20	1.60
9	0.00	0.00	24	8.70	6.70
10	5.80	2.00	25	0.00	0.00
11	0.00	0.00	26	3.50	2.30
12	11.2	7.50	27	0.00	0.00
13	0.00	0.00	28	0.00	0.00
14	6.20	1.60	29	2.40	0.90
15	8.20	2.50	30	10.6	1.90

**Table A.3. Shunt Capacitor Data**

Bus No.	Susceptance
10	19
24	4

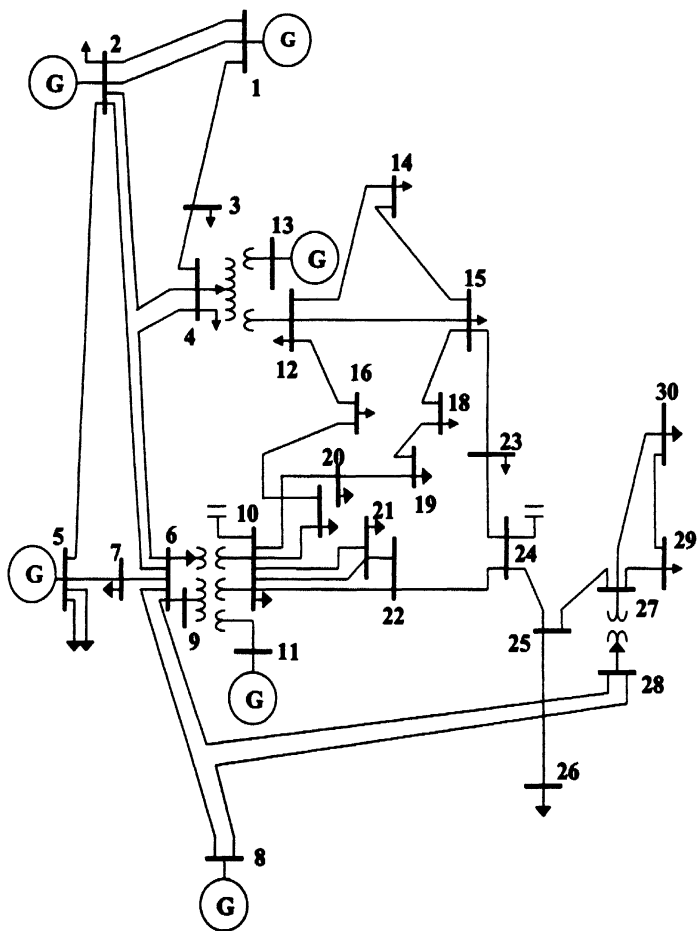


Fig. A.1. One line diagram - IEEE-30 Bus System

Table A.4. Transmission Line Data

Line No.	From Bus	To Bus	Series Impedance (p.u.)		Half Line Charging susceptance (p.u.)	Tap Setting	MVA Rating	Annual Cost (K\$/year)
			R	X				
1.	1	2	0.01920	0.05750	0.02640	-	130	216.6125
2.	1	3	0.04520	0.18520	0.02040	-	130	307.2875
3.	2	4	0.05700	0.17370	0.01840	-	65	509.9500
4.	3	4	0.01320	0.03790	0.00420	-	130	700.0000
5.	2	5	0.04720	0.19830	0.02090	-	130	721.5250
6.	2	6	0.05810	0.17630	0.01870	-	65	168.1750
7.	4	6	0.01190	0.04140	0.00450	-	90	474.3000
8.	5	7	0.04600	0.11600	0.01020	-	70	62.0000
9.	6	7	0.02670	0.08200	0.00850	-	130	130.2000
10.	6	8	0.01200	0.04200	0.00450	-	32	104.6250
11.	6	9	0.00000	0.20800	0.00000	1.0155	65	306.9000
12.	6	10	0.00000	0.55600	0.00000	0.9629	32	20.9250
13.	9	11	0.00000	0.20800	0.00000	-	65	83.7000
14.	9	10	0.00000	0.11000	0.00000	-	65	927.6750
15.	4	12	0.00000	0.25600	0.00000	1.0129	65	554.1250
16.	12	13	0.00000	0.14000	0.00000	-	65	15.1125
17.	12	14	0.12310	0.25590	0.00000	-	32	30.2250
18.	12	15	0.06620	0.13040	0.00000	-	32	97.6500
19.	12	16	0.09450	0.19870	0.00000	-	32	179.0250
20.	14	15	0.22100	0.19970	0.00000	-	16	124.7750
21.	16	17	0.08240	0.19320	0.00000	-	16	146.4750
22.	15	18	0.10700	0.21850	0.00000	-	16	80.6000
23.	18	19	0.06390	0.12920	0.00000	-	16	235.6000
24.	19	20	0.03400	0.06800	0.00000	-	32	186.0000
25.	10	20	0.09360	0.20900	0.00000	-	32	117.8000
26.	10	17	0.03240	0.08450	0.00000	-	32	167.4000
27.	10	21	0.03480	0.07490	0.00000	-	32	160.4250
28.	10	22	0.07270	0.14990	0.00000	-	32	195.3000
29.	21	22	0.01160	0.02360	0.00000	-	32	166.2375
30.	15	23	0.10000	0.20200	0.00000	-	16	100.7500
31.	22	24	0.11500	0.17900	0.00000	-	16	40.3000
32.	23	24	0.13200	0.27000	0.00000	-	16	65.1000
33.	24	25	0.18850	0.32920	0.00000	-	16	210.8000
34.	25	26	0.25440	0.38000	0.00000	-	16	204.6000
35.	25	27	0.10930	0.20870	0.00000	-	16	83.7000
36.	28	27	0.00000	0.36900	0.00000	0.9581	65	223.2000
37.	27	29	0.21980	0.41530	0.00000	-	16	160.4250
38.	27	30	0.32020	0.60270	0.00000	-	16	90.6750
39.	29	30	0.23990	0.45330	0.00000	-	16	216.6125
40.	8	28	0.06360	0.20000	0.02140	-	32	54.2500
41.	6	28	0.01690	0.05990	0.00650	-	32	210.8000

**Table A.5. Modified Generating units coefficients with Ramp rate limits**

Gen. No.	$P_{g_i}^{\min}$	$P_{g_i}^{\max}$	$a_i$	$b_i$	$c_i$	$d_i$	$e_i$	K	$P_{g_i}^0$	$UR_i$	$DR_i$
1	50	63.750	0	3.060	87.5	0	0	0	135	65	85
	63.750	82.875	0	0.000	0.0	0	0	282			
	82.875	93.750	0	8.920	-457	0	0	0			
	93.750	157.500	0	3.700	32	0	0	0			
	157.500	176.625	0	0.000	0	0	0	615			
	176.625	200	0	7.700	-745	0	0	0			
2	25	43	0.010	0.300	35	0	0	0	65	12	22
	43	63	0.020	0.600	60	0	0	0			
3	20	49	0.070	0.095	45	40	0.08	0	35	12	15
4	15	30	0.090	0.025	30	30	0.09	0	25	08	16
5	13	28	0.025	3.000	0	0	0	0	20	06	09
6	14	35	0.025	3.000	0	0	0	0	30	08	16

## Appendix – B

### DATA FOR INDIAN UTILITY- 62 BUS TEST SYSTEM

The Indian utility – 62 bus test system is shown in figure B.1. The system data is taken from reference [114]. The generator cost and emission coefficients, load, sites of the buses and transmission line data are given in the Tables B.1, B.2, B.3 and B.4 respectively. The cost coefficients of Indian utility - 62 bus system are slightly modified to incorporate non-smooth fuel cost functions with ramp rate coefficients are given in Table B.5. The data is on 100 MVA base. For all analysis on this system  $V_i^{\min}$ ,  $V_i^{\max}$ ,  $\phi_i^{\min}$  and  $\phi_i^{\max}$  for bus  $i$  are considered to be 0.9 p.u., 1.1 p.u., -45 degree and +45 degree respectively.

**Table B.1. Generator Cost and Emission Coefficients**

Bus No.	$P_i^{\min}$ (MW)	$P_i^{\max}$ (MW)	$Q_i^{\min}$ (MVar)	$Q_i^{\max}$ (MVar)	$a_i$	$b_i$	$c_i$	$\alpha_i$	$\beta_i$	$\gamma_i$
1.	50	300	0	450	0.0070	6.80	95	0.0180	-1.81	24.300
2.	50	450	0	500	0.0055	4.00	30	0.0330	-2.50	27.023
3.	50	450	-50	500	0.0055	4.00	45	0.0330	-2.50	27.023
4.	0	100	0	150	0.0025	0.85	10	0.0136	-1.30	22.070
5.	50	300	-50	300	0.0060	4.60	20	0.0180	-1.81	24.300
6.	50	450	-50	500	0.0055	4.00	90	0.0330	-2.50	27.023
7.	50	200	-50	250	0.0065	4.70	42	0.0126	-1.36	23.040
8.	50	500	-100	600	0.0075	5.00	46	0.0360	-3.00	29.030
9.	0	600	-100	550	0.0085	6.00	55	0.0400	-3.20	27.050
10.	0	100	0	150	0.0020	0.50	58	0.0136	-1.30	22.070
11.	50	150	-50	200	0.0045	1.60	65	0.0139	-1.25	23.010
12.	0	50	0	75	0.0025	0.85	78	0.0121	-1.27	21.090
13.	50	300	-50	300	0.0050	1.80	75	0.0180	-1.81	24.300
14.	0	150	-50	200	0.0045	1.60	85	0.0140	-1.20	23.060
15.	0	500	-50	550	0.0065	4.70	80	0.0360	-3.00	29.000
16.	50	150	-50	200	0.0045	1.40	90	0.0139	-1.25	23.010
17.	0	100	0	150	0.0025	0.85	10	0.0136	-1.30	22.070
18.	50	300	-50	400	0.0045	1.60	25	0.0180	-1.81	24.300
19.	100	600	-100	600	0.0080	5.50	90	0.0400	-3.00	27.010

**Table B.2. Load Bus Data**

Bus No.	Load		Bus No.	Load	
	P (MW)	Q (MVar)		P (MW)	Q (MVar)
1.	0.0	0.0	32.	0.0	0.0
2.	0.0	0.0	33.	46.0	25.0
3.	40.0	10.0	34.	100.0	70.0
4.	0.0	0.0	35.	107.0	33.0
5.	0.0	0.0	36.	20.0	5.0
6.	0.0	0.0	37.	0.0	0.0
7.	0.0	0.0	38.	166.0	22.0
8.	109.0	78.0	39.	30.0	5.0
9.	66.0	23.0	40.	25.0	5.0
10.	40.0	10.0	41.	92.0	91.0
11.	161.0	93.0	42.	30.0	25.0
12.	155.0	79.0	43.	25.0	5.0
13.	132.0	46.0	44.	109.0	17.0
14.	0.0	0.0	45.	20.0	4.0
15.	155.0	63.0	46.	0.0	0.0
16.	0.0	0.0	47.	0.0	0.0
17.	0.0	0.0	48.	0.0	0.0
18.	121.0	46.0	49.	0.0	0.0
19.	130.0	70.0	50.	0.0	0.0
20.	80.0	70.0	51.	0.0	0.0
21.	0.0	0.0	52.	0.0	0.0
22.	64.0	50.0	53.	248.0	78.0
23.	0.0	0.0	54.	0.0	0.0
24.	58.0	34.0	55.	94.0	29.0
25.	0.0	0.0	56.	0.0	0.0
26.	116.0	52.0	57.	0.0	0.0
27.	85.0	35.0	58.	0.0	0.0
28.	63.0	8.0	59.	0.0	0.0
29.	0.0	0.0	60.	0.0	0.0
30.	77.0	41.0	61.	0.0	0.0
31.	51.0	25.0	62.	93.0	23.0

**Table B.3. Sites of different buses in Tamilnadu State**

<b>Bus No.</b>	<b>City</b>	<b>Bus No.</b>	<b>City</b>
1.	NMTPS	32.	TTPS
2.	ETPS	33.	NAGERKOIL
3.	MANALI	34.	KAYATHAR
4.	KORATUR	35.	TTPAUTO
5.	BBGAS	36.	TUTICORIN(SIPCOT)
6.	TONPET	37.	MADURAI 1
7.	PARRYS	38.	ANNUPANKALAM
8.	MYLAPORE	39.	ALGARKOIL
9.	G POONDI	40.	PUDUKOTTAI
10.	MOSUR	41.	TRICHY
11.	TVALAM	42.	ALUNDUR
12.	SPET	43.	THANJAVUR
13.	ARANI	44.	PUGALUR
14.	SPUDUR	45.	SAMYAPURAM
15.	KOYAMBEDU	46.	MADURAI 2
16.	SPKOIL	47.	SEMBATTY
17.	MAPS	48.	UDUMALPET 2
18.	KADAPERI	49.	KADAMPARAI
19.	THARAMANI	50.	UDUMALPET
20.	TV MALAI	51.	KUNDAH
21.	VILLUPURAM	52.	GOPI
22.	CUDDALORE	53.	ARASUR
23.	NLC 1	54.	THUDILYAR
24.	EACHENKADU	55.	INGUR
25.	N2 MIN4	56.	MALCO
26.	VILLIYANUR	57.	MTRT
27.	KADALANKUDI	58.	MTPS
28.	PERAMBALUR	59.	UJANAI
29.	TVARUR	60.	SALEM 2
30.	KARAIKUDI	61.	SALEM 1
31.	PARAMAKUDI	62.	DEVIKURCHI

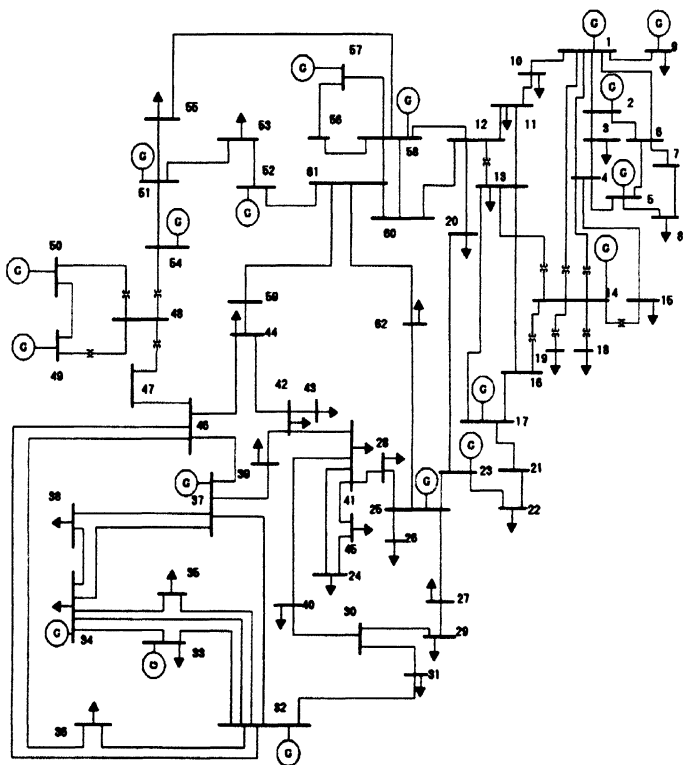
Table B.4. Transmission Line Data

Line No.	From Bus	To Bus	Series Impedance (p.u.)		Half Line Charging susceptance (p.u.)	MVA Rating	Tap Setting
			R	X			
1.	1	2	0.00305	0.01565	0.01445	150	-
2.	1	4	0.00716	0.03678	0.03397	80	-
3.	1	14	0.00548	0.02813	0.10392	180	0.9639
4.	1	10	0.01569	0.08061	0.07443	150	-
5.	1	9	0.00229	0.01174	0.01084	50	-
6.	1	6	0.00411	0.02113	0.01951	100	-
7.	2	6	0.00168	0.00861	0.00795	50	-
8.	2	3	0.00289	0.01487	0.01373	150	-
9.	3	4	0.00381	0.01957	0.01807	100	-
10.	4	15	0.00411	0.02113	0.01951	150	-
11.	14	15	0.00520	0.02669	0.02464	60	0.9530
12.	4	14	0.00411	0.02113	0.01951	150	1.0155
13.	13	14	0.01315	0.06754	0.06237	150	1.0124
14.	12	13	0.01537	0.07897	0.07292	90	0.9621
15.	12	11	0.01905	0.09783	0.09033	50	-
16.	11	10	0.00686	0.03522	0.03252	100	-
17.	4	5	0.00716	0.03678	0.03397	150	-
18.	5	6	0.00575	0.01478	0.00309	90	-
19.	6	7	0.00030	0.00157	0.00578	90	-
20.	7	8	0.00049	0.00168	0.08612	90	-
21.	5	8	0.00575	0.01478	0.00309	100	-
22.	11	16	0.01406	0.07223	0.06670	120	-
23.	16	17	0.00343	0.01761	0.06504	90	-
24.	17	21	0.01850	0.09548	0.08816	150	-
25.	21	22	0.01371	0.07043	0.06504	150	-
26.	22	23	0.00396	0.02035	0.07516	100	-
27.	23	24	0.00305	0.01565	0.01445	240	-
28.	23	25	0.00126	0.00650	0.00600	50	-
29.	25	28	0.01062	0.05554	0.05037	100	-
30.	25	26	0.00941	0.04828	0.04459	150	-
31.	25	27	0.01173	0.06026	0.05565	150	-
32.	27	29	0.00533	0.02739	0.02529	50	-
33.	29	30	0.02058	0.10573	0.09763	50	-
34.	20	23	0.02042	0.10487	0.09684	100	-
35.	12	20	0.01981	0.10174	0.09395	150	-
36.	13	17	0.01563	0.08030	0.07415	100	-
37.	14	19	0.00707	0.03631	0.03353	180	0.9630
38.	14	18	0.00135	0.00693	0.02558	150	1.0121
39.	14	16	0.00396	0.02035	0.01879	90	1.0135
40.	24	45	0.01219	0.06261	0.05781	90	-
41.	24	41	0.01554	0.07993	0.07371	90	-
42.	41	45	0.00335	0.01712	0.01590	90	-
43.	40	41	0.00609	0.03130	0.02891	100	-
44.	41	42	0.00076	0.00391	0.01445	90	-
45.	42	43	0.00914	0.04696	0.04336	50	-



Table B.4. Contd...

Line No.	From Bus	To Bus	Series Impedance (p.u)		Half Line Charging susceptance (p.u.)	MVA Rating	Tap Setting
			R	X			
46.	42	44	0.01417	0.07278	0.06721	90	-
47.	39	42	0.00686	0.03522	0.03252	90	-
48.	39	37	0.00229	0.01174	0.01084	100	-
49.	38	37	0.01044	0.05361	0.04950	130	-
50.	38	34	0.01076	0.05525	0.05102	90	-
51.	34	37	0.01990	0.01022	0.09438	150	-
52.	34	33	0.01737	0.08922	0.08258	30	-
53.	34	35	0.00701	0.03600	0.03324	50	-
54.	35	32	0.00036	0.00184	0.00679	150	-
55.	33	32	0.01676	0.08609	0.07949	50	-
56.	32	31	0.01787	0.09180	0.08477	90	-
57.	30	31	0.00992	0.05095	0.04705	50	-
58.	40	30	0.00716	0.03678	0.03397	90	-
59.	32	36	0.00305	0.01565	0.01445	50	-
60.	32	37	0.02200	0.11301	0.10435	50	-
61.	32	34	0.00396	0.02035	0.07516	90	-
62.	32	46	0.02095	0.10761	0.09937	50	-
63.	36	46	0.01828	0.09391	0.08672	50	-
64.	37	46	0.00104	0.00536	0.01980	150	-
65.	46	44	0.01676	0.08609	0.07949	50	-
66.	44	59	0.00884	0.04539	0.04191	150	-
67.	59	61	0.00922	0.04735	0.04372	150	-
68.	60	61	0.00244	0.01252	0.04625	100	-
69.	61	62	0.01499	0.07701	0.07111	100	-
70.	62	25	0.01383	0.07106	0.06562	100	-
71.	58	61	0.00335	0.01722	0.06359	150	-
72.	58	60	0.00411	0.02113	0.01951	150	-
73.	55	58	0.00670	0.03443	0.03180	50	-
74.	57	58	0.00183	0.00939	0.00867	150	-
75.	57	56	0.00152	0.00783	0.00723	100	-
76.	56	58	0.00259	0.01330	0.01229	90	-
77.	52	61	0.01127	0.05791	0.05348	50	-
78.	52	53	0.01132	0.05815	0.05369	100	-
79.	51	55	0.01417	0.07278	0.06721	100	-
80.	51	53	0.01190	0.06112	0.05644	150	-
81.	51	54	0.00407	0.02090	0.01930	50	-
82.	48	54	0.01254	0.06441	0.05948	50	0.9630
83.	48	50	0.00066	0.00337	0.01242	150	1.0132
84.	49	50	0.00670	0.03443	0.03180	90	-
85.	49	48	0.00366	0.01878	0.06938	150	0.9630
86.	47	48	0.01371	0.07043	0.06504	90	-
87.	47	46	0.00792	0.04070	0.03758	150	-
88.	60	12	0.01365	0.07012	0.06475	150	-
89.	58	12	0.01211	0.06222	0.05745	150	-



**Fig. B.1. One line diagram - Indian Utility-62 Bus System**

Table B.5. Modified Generating units coefficients with Ramp rate limits

Gen. No.	$P_{g, \min}$	$P_{g, \max}$	$a_1$	$b_1$	$c_1$	$d_1$	$e_1$	K	$P_{g, i}^0$	$UR_i$	$DR_i$
1.	100	300	0.0097	6.800	119	90	0.72	0	250	95	150
2.	120	438	0.0055	4.000	90	79	0.05	0	300	138	180
3.	100	250	0.0055	4.000	45	0	0	0	300	100	200
	50	400	0.0065	3.000	25	0	0	0			
4.	8	25	0.0025	0.850	0	0	0	0	20	5	12
5.	50	63.750	0	5.280	0.891	0	0	0	120	80	90
	63.750	82.875	0	0	0	0	0	337			
	82.875	93.750	0	15.296	-930	0	0	0			
	93.750	157.500	0	6.107	-68	0	0	0			
	157.500	176.625	0	0	0	0	0	893			
	176.625	200	0	12.264	-1272	0	0	0			
6.	150	300	0.0080	3.500	110	0	0	0	300	100	150
	300	400	0.0060	4.800	85	0	0	0			
7.	50	63.750	0	5.439	21	0	0	0	130	70	100
	63.750	82.875	0	0	0	0	0	368			
	82.875	93.750	0	15.790	-940	0	0	0			
	93.750	157.500	0	6.330	-53	0	0	0			
	157.500	176.625	0	0	0	0	0	943			
	176.625	200	0	12.770	-1312	0	0	0			
8.	100	500	0.0075	6.000	88	50	0.52	0	600	400	500
9.	200	600	0.0085	6.000	55	0	0	0	500	200	300
10.	15	40	0.0090	5.200	90	0	0	0	30	10	15
11.	50	150	0.0045	1.600	65	0	0	0	100	55	85
12.	25	75	0.0025	0.850	78	58	0.02	0	50	25	25
13.	50	63.750	0	2.550	49	0	0	0	120	80	90
	63.750	82.875	0	0	0	0	0	210			
	82.875	93.750	0	7.137	-381	0	0	0			
	93.750	157.500	0	3.060	0.815	0	0	0			
	157.500	176.625	0	0	0	0	0	482			
	176.625	200	0	6.520	-669	0	0	0			
14.	0	95	0.0045	1.600	85	0	0	0	50	40	45
15.	20	220	0.0065	4.700	80	92	0.75	0	125	95	105
16.	15	80	0.0045	1.400	90	0	0	0	55	25	40
17.	15	80	0.0025	0.850	10	0	0	0	55	25	40
18.	50	230	0.0045	1.600	25	0	0	0	150	80	100
19.	400	500	0.0080	5.500	90	0	0	0	550	100	150
	500	600	0.0070	6.000	75	0	0	0			

## Appendix – C

### DATA FOR INDIAN UTILITY- 146 BUS TEST SYSTEM

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The Indian utility – 146 bus test system is shown in figure C.1. The system data is taken from reference [114]. The generator real and reactive power limits, load, sites of the buses and transmission lines data are given in the tables C.1, C.2, C.3 and C.4 respectively. The data is on 100 MVA base. For all analysis on this system  $V_i^{\min}$ ,  $V_i^{\max}$ ,  $\phi_i^{\min}$  and  $\phi_i^{\max}$  for bus  $i$  are considered to be 0.9 p.u., 1.1 p.u., -45 degree and +45 degree respectively.

**Table C.1. Generator Real and Reactive Power Limits**

Bus No.	$P_i^{\min}$ (MW)	$P_i^{\max}$ (MW)	$Q_i^{\min}$ (MVar)	$Q_i^{\max}$ (MVar)
1.	0	300	62	248
2.	0	100	0	50
3.	100	500	100	420
4.	0	100	0	50
5.	0	100	10	50
6.	0	200	25	100
7.	0	100	0	50
8.	0	100	0	50
9.	0	100	0	50
10.	0	100	0	50
11.	50	300	0	150
12.	60	360	50	240
13.	0	200	0	100
14.	0	200	0	100
15.	0	100	0	50
16.	0	100	0	60
17.	0	200	0	100
18.	0	200	0	100
19.	0	100	0	50
20.	0	100	0	50
21.	50	500	0	400
22.	0	100	0	50
23.	0	100	0	50
24.	0	100	0	50

Table C.2. Load Bus Data

Bus No.	Load		Bus No.	Load	
	P (MW)	Q (MVar)		P (MW)	Q (MVar)
1	163	73	46	48	32
2	86	79	47	0	0
3	40	10	48	248	78
4	67	50	49	130	93
5	0	0	50	0	0
6	149	90	51	66	0
7	0	0	52	124	44
8	44	34	53	93	23
9	0	0	54	0	0
10	0	0	55	0	0
11	0	0	56	0	0
12	130	70	57	0	0
13	121	46	58	60	46
14	0	0	59	0	0
15	109	78	60	210	0
16	109	18	61	0	0
17	70	56	62	0	0
18	125	62	63	149	42
19	40	10	64	111	27
20	0	0	65	127	43
21	0	0	66	92	91
22	161	93	67	0	0
23	0	0	68	0	0
24	132	46	69	20	5
25	0	0	70	0	0
26	0	0	71	83	45
27	95	14	72	25	5
28	0	0	73	77	41
29	0	0	74	0	0
30	74	44	75	0	0
31	81	70	76	0	0
32	0	0	77	30	5
33	22	6	78	0	0
34	0	0	79	0	0
35	0	0	80	5	1
36	17	12	81	145	87
37	10	3	82	0	0
38	42	9	83	0	0
39	60	23	84	0	0
40	46	25	85	0	0
41	0	0	86	0	0
42	0	0	87	0	0
43	0	0	88	88	36
44	0	0	89	0	0
45	94	29	90	0	0

Table C.2. Cond...

Bus No.	Load		Bus No.	Load	
	P (MW)	Q (MVar)		P (MW)	Q (MVar)
91.	0	0	119.	0	0
92.	0	0	120.	0	0
93.	0	0	121.	0	0
94.	0	0	122.	0	0
95.	0	0	123.	0	0
96.	0	0	124.	0	0
97.	0	0	125.	0	0
98.	0	0	126.	0	0
99.	0	0	127.	0	0
100.	0	0	128.	0	0
101.	0	0	129.	0	0
102.	0	0	130.	0	0
103.	0	0	131.	0	0
104.	0	0	132.	0	0
105.	0	0	133.	0	0
106.	0	0	134.	0	0
107.	0	0	135.	0	0
108.	0	0	136.	0	0
109.	0	0	137.	0	0
110.	0	0	138.	0	0
111.	0	0	139.	0	0
112.	0	0	140.	0	0
113.	0	0	141.	0	0
114.	0	0	142.	0	0
115.	0	0	143.	0	0
116.	0	0	144.	0	0
117.	0	0	145.	0	0
118.	0	0	146.	0	0

Table C.3. Sites of different buses in Tamilnadu State

Bus No.	City	Bus No.	City	Bus No.	City	Bus No.	City
1.	ETPS	38.	MOYAR	75.	MADURAI 22	112.	T.PATTI
2.	TONPET	39.	PYKARA	76.	T.PATTUR	113.	SOMANUR
3.	MANALI	40.	GOBI	77.	MADURAI 2	114.	ANNUR
4.	VYPADI	41.	S.NALLA	78.	A.P.KULAM	115.	AVINASI
5.	BBGTPP	42.	KUNDAH 6	79.	PERIYAR	116.	TIRUPPUR
6.	KORATUR	43.	KUNDAH 5	80.	SURULIYAR	117.	PALLADAM
7.	SRF	44.	KUNDAH 1	81.	KAYATHAR	118.	PEELAMEDU
8.	SEMBIUM	45.	INGUR	82.	SIVAGANGAI	119.	S.NALLUR
9.	GRMV	46.	ERODE	83.	TTPS	120.	E.NAGAR
10.	PARRYS	47.	KUNDAH 2	84.	TTN	121.	NALLUR
11.	VELACHERI	48.	ARASUR	85.	A.MUGANERI	122.	P.PALAYAM
12.	TARAMANI	49.	TUDIALUR	86.	PLYMKOTTAI	123.	KBLMALAI
13.	KADAPERI	50.	SANKARI	87.	S.R.PUDUR	124.	ACPALAYAM
14.	CPT	51.	SALEM 1	88.	KODAYARI	125.	TNPL
15.	MYLAPORE	52.	SALEM 2	89.	KODAYAR 2	126.	DINDUGAL
16.	S.P.KOIL	53.	DVKRCY	90.	EDAPADI	127.	NATHAN
17.	CHENGALPT	54.	UNJANAI	91.	PUGALUR	128.	POOVALUR
18.	S.P.BUDUR	55.	CBE	92.	K.MANGLM	129.	MRL
19.	MOSUR	56.	K.KADAVU	93.	HOSUR	130.	NGPATTINAM
20.	SOLINGUR	57.	POLLACHI	94.	Z.VADI	131.	TRPATTINAM
21.	SALAI	58.	ALIYAR	95.	BAGALUR	132.	KARAIKAL
22.	T.VALAM	59.	UDMLPT 2	96.	K.GIRI	133.	KOILVENI
23.	KANCHI	60.	NLC 1	97.	KEMBATTY	134.	MNRGUDI
24.	ARNI	61.	SHOLAYAR 1	98.	AVADI	135.	ALANGUDI
25.	ARNI 1	62.	SHOLAYAR 2	99.	T.VALLUR	136.	T.NALLUR
26.	METTUR	63.	UDMLPT 22	100.	M.M.NAGAR	137.	T.PALLAM
27.	MALCO	64.	SEMBATTY	101.	T.PORUR	138.	T.MANGLM
28.	MTR DAM	65.	THENI	102.	GDYATHUM	139.	T.K.PATTI
29.	MTPS	66.	TRICHY	103.	VELLORE	140.	RJPALAYAM
30.	S.PET	67.	M.ADUTHURAI	104.	KVRIPAUK	141.	EP.VENDRAN
31.	T.V.MALAI	68.	ADUTHURAI	105.	HARUR	142.	SNKOIL
32.	V.PURAM	69.	THANJAVUR	106.	MADURAPKM	143.	MNKAYAL
33.	V.PURAM 1	70.	NRNMN	107.	T.KOILUR	144.	T.VARUR
34.	LOMPH 1	71.	T.VARUR	108.	NANGAVELI	145.	S.PATTI
35.	LOMPH 2	72.	P.KOTTAI	109.	KASIPURAM	146.	ARASARADI
36.	LOMPH 3	73.	K.KUDI	110.	T.VASAL		
37.	LOMPH 4	74.	ALGRKOIL	111.	K.KURUCHI		

Table C.4. Transmission Line Data

Line No.	From Bus	To Bus	Series Impedance (p.u)		Half Line Charging susceptance (p.u.)	MVA Rating	Tap Setting	Annual Cost 10 <sup>6</sup> (Rs/year) or Rs lakh/year
			R	X				
1.	1	3	0.00305	0.01260	0.03401	150	-	619.290
2.	1	2	0.00716	0.02670	0.02340	180	-	620.210
3.	1	7	0.00548	0.01810	0.00390	100	-	134.000
4.	2	4	0.01569	0.04060	0.04540	100	-	134.000
5.	2	10	0.00229	0.00170	0.02080	150	-	134.000
6.	3	6	0.00411	0.02110	0.00950	130	-	324.500
7.	4	8	0.00168	0.00860	0.00295	150	-	217.790
8.	4	5	0.00289	0.01480	0.01373	150	-	456.750
9.	6	7	0.00381	0.01950	0.01800	100	-	368.550
10.	6	13	0.00411	0.02110	0.01950	150	-	121.590
11.	6	8	0.00520	0.02660	0.02460	160	-	384.300
12.	8	9	0.00411	0.02110	0.01950	150	-	379.650
13.	9	14	0.01315	0.06750	0.06237	150	-	379.560
14.	10	15	0.01537	0.07890	0.07292	190	-	488.250
15.	11	16	0.01905	0.09780	0.09030	150	-	408.290
16.	12	11	0.00686	0.03520	0.03250	100	-	63.000
17.	12	16	0.00716	0.03670	0.03390	150	-	346.500
18.	13	16	0.00575	0.01470	0.00309	190	-	299.250
19.	14	15	0.00030	0.00150	0.00578	90	-	144.270
20.	16	17	0.00049	0.00160	0.08612	190	-	129.150
21.	16	23	0.00575	0.01470	0.00309	100	-	125.055
22.	16	33	0.01406	0.07220	0.06670	120	-	272.790
23.	16	100	0.00343	0.01760	0.06504	90	-	144.900
24.	16	101	0.01850	0.09540	0.08810	150	-	157.500
25.	18	23	0.01371	0.02040	0.06704	150	0.96330	1632.655
26.	18	19	0.00396	0.01030	0.02516	100	-	304.290
27.	18	98	0.00305	0.00560	0.01445	200	-	241.290
28.	18	99	0.00126	0.00450	0.00600	150	-	94.500
29.	19	20	0.01062	0.05550	0.01037	100	-	218.925
30.	20	21	0.00941	0.04820	0.04459	150	-	267.750
31.	21	22	0.01173	0.06020	0.05565	150	-	267.750
32.	22	102	0.00533	0.02730	0.02529	100	-	761.985
33.	22	103	0.02058	0.10570	0.06763	100	-	327.285
34.	23	24	0.02042	0.10480	0.09680	100	-	395.325
35.	24	104	0.01981	0.10170	0.03395	150	-	29.925
36.	24	25	0.01563	0.08030	0.04415	100	-	166.005
37.	24	30	0.00707	0.03631	0.01353	180	-	141.750
38.	25	26	0.00135	0.00690	0.02550	150	-	141.750
39.	26	28	0.00396	0.02030	0.01870	90	-	393.750
40.	26	30	0.01219	0.06260	0.05781	90	-	176.715
41.	28	27	0.01554	0.07990	0.07370	100	-	100.800
42.	28	34	0.00335	0.01710	0.01590	90	-	575.505
43.	29	27	0.00609	0.03130	0.02890	100	-	503.370
44.	30	31	0.00076	0.00390	0.01440	100	-	355.950
45.	30	33	0.00914	0.04690	0.04330	100	-	22.050



Table C.4. Contd...

Line No.	From Bus	To Bus	Series Impedance (p.u.)		Half Line Charging susceptance (p.u.)	MVA Rating	Tap Setting	Annual Cost $10^5$ (Rs/year) or Rs lakh/year
			R	X				
46.	30	92	0.02110	0.07278	0.03250	90	-	31.500
47.	30	105	0.00321	0.03522	0.03252	90	-	203.250
48.	32	24	0.00229	0.01174	0.02083	100	-	157.500
49.	32	31	0.00044	0.05361	0.05495	130	-	126.000
50.	32	106	0.00096	0.05525	0.00103	90	-	340.200
51.	32	107	0.01220	0.01022	0.03432	150	-	378.000
52.	34	35	0.01233	0.08922	0.03257	100	-	384.300
53.	35	36	0.00500	0.03600	0.05633	50	-	346.500
54.	36	37	0.00130	0.00184	0.00679	150	-	261.450
55.	36	90	0.00670	0.08609	0.07949	50	-	378.000
56.	37	46	0.00780	0.09180	0.08477	90	-	283.500
57.	37	50	0.00590	0.05095	0.04705	100	-	283.500
58.	38	40	0.00010	0.03678	0.03397	90	-	567.000
59.	39	38	0.00300	0.01565	0.01445	100	-	590.625
60.	39	41	0.02200	0.11301	0.10435	50	-	234.200
61.	39	49	0.00390	0.02035	0.07516	90	-	120.677
62.	41	42	0.02090	0.10761	0.09937	150	-	120.677
63.	41	49	0.01820	0.09391	0.08672	50	-	187.500
64.	41	42	0.00100	0.00536	0.01980	150	-	487.500
65.	41	49	0.01670	0.08609	0.07949	50	-	31.500
66.	42	43	0.00880	0.04539	0.04191	150	-	218.925
67.	43	44	0.00920	0.04735	0.04372	150	-	218.925
68.	44	47	0.00240	0.01252	0.04625	100	-	300.036
69.	44	49	0.01490	0.07701	0.07111	100	-	307.755
70.	44	92	0.01380	0.07106	0.06562	100	-	29.925
71.	45	96	0.00330	0.01722	0.06359	150	-	136.395
72.	45	98	0.00410	0.02113	0.01951	150	-	213.255
73.	45	63	0.00670	0.03443	0.03180	50	-	295.470
74.	47	45	0.00180	0.00939	0.00800	150	-	346.500
75.	47	49	0.00150	0.00783	0.00700	100	-	165.060
76.	48	113	0.00250	0.01330	0.01220	90	-	243.495
77.	48	114	0.01120	0.05791	0.05340	50	-	47.250
78.	48	115	0.01130	0.05815	0.05360	100	-	300.100
79.	48	116	0.01410	0.07278	0.06721	100	-	244.880
80.	48	117	0.01190	0.06112	0.06644	150	-	156.000
81.	48	118	0.00400	0.02090	0.01930	50	-	237.825
82.	48	119	0.01250	0.06441	0.05948	50	-	303.030
83.	49	55	0.00060	0.00337	0.01242	150	-	31.500
84.	49	63	0.00670	0.03443	0.03180	90	-	181.500
85.	49	65	0.00360	0.01878	0.06938	150	-	187.500
86.	50	52	0.01270	0.07043	0.04504	90	-	187.500
87.	50	54	0.00690	0.04070	0.03758	150	-	120.677
88.	51	108	0.01160	0.07012	0.02475	150	-	120.677
89.	52	51	0.02210	0.06222	0.05345	150	-	334.200
90.	52	53	0.01154	0.03113	0.01479	150	-	390.625

Table C.4. Contd...

Line No.	From Bus	To Bus	Series Impedance (p.u)		Half Line Charging susceptance (p.u.)	MVA Rating	Tap Setting	Annual Cost 10 <sup>6</sup> (Rs/year) or Rs lakh/year
			R	X				
91.	52	40	0.01410	0.02148	0.06223	100	-	346.500
92.	52	30	0.00680	0.01520	0.03252	100	-	384.300
93.	52	109	0.00220	0.00170	0.02085	100	-	340.200
94.	53	111	0.01040	0.05360	0.04650	150	-	378.000
95.	53	110	0.01070	0.03520	0.05102	150	-	126.000
96.	53	112	0.01990	0.00020	0.06438	150	-	157.500
97.	54	120	0.01730	0.01920	0.02258	100	-	303.250
98.	54	121	0.00700	0.03600	0.02320	100	-	31.500
99.	54	122	0.00030	0.00180	0.00670	150	-	355.950
100.	55	56	0.01670	0.02600	0.07940	50	-	22.050
101.	58	57	0.01780	0.01180	0.02470	90	-	100.800
102.	58	59	0.00990	0.05090	0.04700	50	-	50.514
103.	58	61	0.00710	0.03670	0.03390	150	-	393.750
104.	58	145	0.00300	0.01560	0.01440	100	-	141.750
105.	59	56	0.02200	0.21300	0.10430	100	-	141.750
106.	60	53	0.00390	0.00030	0.07510	90	-	161.005
107.	60	68	0.02090	0.11760	0.05690	100	-	129.925
108.	61	62	0.01820	0.09390	0.03670	200	-	395.325
109.	63	119	0.00100	0.00530	0.01980	150	0.98321	1327.285
110.	63	64	0.01670	0.02600	0.07949	50	-	461.985
111.	63	75	0.00880	0.04530	0.04191	150	1.01450	1267.750
112.	64	66	0.00920	0.04230	0.04372	150	-	267.750
113.	64	77	0.00240	0.01350	0.04625	100	-	218.925
114.	64	91	0.01490	0.07300	0.05111	100	-	94.500
115.	64	126	0.01380	0.07000	0.06562	100	-	241.290
116.	64	127	0.00330	0.01720	0.03359	100	-	304.290
117.	65	75	0.00410	0.02110	0.01951	100	-	200.323
118.	65	77	0.00670	0.03440	0.03180	100	-	157.500
119.	65	79	0.00180	0.00930	0.00867	150	1.03242	1144.900
120.	66	69	0.00150	0.00780	0.00723	100	-	272.790
121.	66	128	0.00250	0.01330	0.01220	90	-	125.055
122.	68	67	0.01120	0.05790	0.04530	50	-	129.150
123.	69	71	0.01130	0.05810	0.05360	100	-	144.270
124.	70	71	0.01410	0.07270	0.03720	100	-	299.250
125.	70	129	0.01190	0.06110	0.05640	150	-	346.500
126.	70	130	0.00400	0.02090	0.01930	50	-	63.000
127.	71	67	0.01250	0.06440	0.02940	50	0.97321	1170.124
128.	71	131	0.00060	0.00330	0.01242	150	-	288.250
129.	71	132	0.00670	0.03440	0.03180	90	-	384.300
130.	71	133	0.00360	0.01870	0.03938	150	-	121.590
131.	71	134	0.01370	0.07040	0.05504	90	-	368.550
132.	71	144	0.00790	0.04070	0.03758	150	-	456.750
133.	72	73	0.01360	0.07012	0.07475	150	-	217.790
134.	72	135	0.01210	0.06222	0.03745	150	-	224.500
135.	72	136	0.01785	0.01342	0.04672	150	-	133.000

Table C.4. Contd...

Line No.	From Bus	To Bus	Series Impedance (p.u)		Half Line Charging susceptance (p.u.)	MVA Rating	Tap Setting	Annual Cost 10 <sup>6</sup> (Rs/year) or Rs lakh/year
			R	X				
136.	73	76	0.00317	0.01271	0.01320	150	-	346.500
137.	73	82	0.00486	0.03523	0.05250	150	-	261.450
138.	74	137	0.00129	0.01171	0.01080	100	-	378.000
139.	75	64	0.00044	0.05367	0.04450	100	-	283.500
140.	75	77	0.00076	0.05523	0.04100	100	-	283.500
141.	76	74	0.00990	0.01027	0.03430	150	-	467.000
142.	77	74	0.00737	0.03923	0.05625	100	-	490.625
143.	77	78	0.01701	0.03600	0.02332	50	-	234.200
144.	81	83	0.01036	0.00180	0.00670	150	0.98223	1120.677
145.	91	123	0.00676	0.04600	0.07940	50	-	120.677
146.	91	124	0.00787	0.01820	0.08470	90	-	387.500
147.	91	125	0.01992	0.04090	0.02700	100	-	287.500
148.	93	92	0.00716	0.02670	0.07397	150	-	31.500
149.	93	94	0.00305	0.01560	0.00445	100	-	218.925
150.	93	95	0.02200	0.01300	0.10435	100	-	218.925
151.	95	96	0.00396	0.02030	0.09510	90	-	256.250
152.	96	97	0.02095	0.00760	0.09930	100	-	307.755
153.	101	94	0.01828	0.09390	0.04560	100	-	29.925
154.	97	84	0.00104	0.00530	0.01980	150	-	136.925
155.	98	92	0.01676	0.08600	0.07949	50	-	213.255
156.	99	94	0.00884	0.04530	0.04191	150	-	295.470
157.	95	91	0.00922	0.04730	0.04372	150	-	346.500
158.	104	101	0.00244	0.01250	0.04625	100	-	165.060
159.	104	108	0.01499	0.07700	0.07111	100	-	243.495
160.	101	103	0.01383	0.07100	0.06560	100	-	124.250
161.	100	96	0.01335	0.01720	0.06350	150	-	256.100
162.	98	94	0.00411	0.02110	0.01951	150	-	244.480
163.	97	91	0.01670	0.03440	0.03180	100	-	256.230
164.	95	97	0.01183	0.00930	0.00867	150	-	237.030
165.	94	92	0.00052	0.00780	0.00723	100	-	303.030
166.	92	90	0.00259	0.01330	0.01220	100	-	307.755
167.	96	93	0.00127	0.05791	0.07340	150	-	329.925
167.	105	101	0.02132	0.05815	0.05369	100	-	136.395
168.	107	106	0.00417	0.07276	0.03721	100	-	213.255
169.	121	115	0.00190	0.06113	0.05644	150	-	295.470
170.	112	110	0.00407	0.02092	0.01930	150	-	346.500
171.	117	108	0.00254	0.06446	0.00949	150	-	165.369

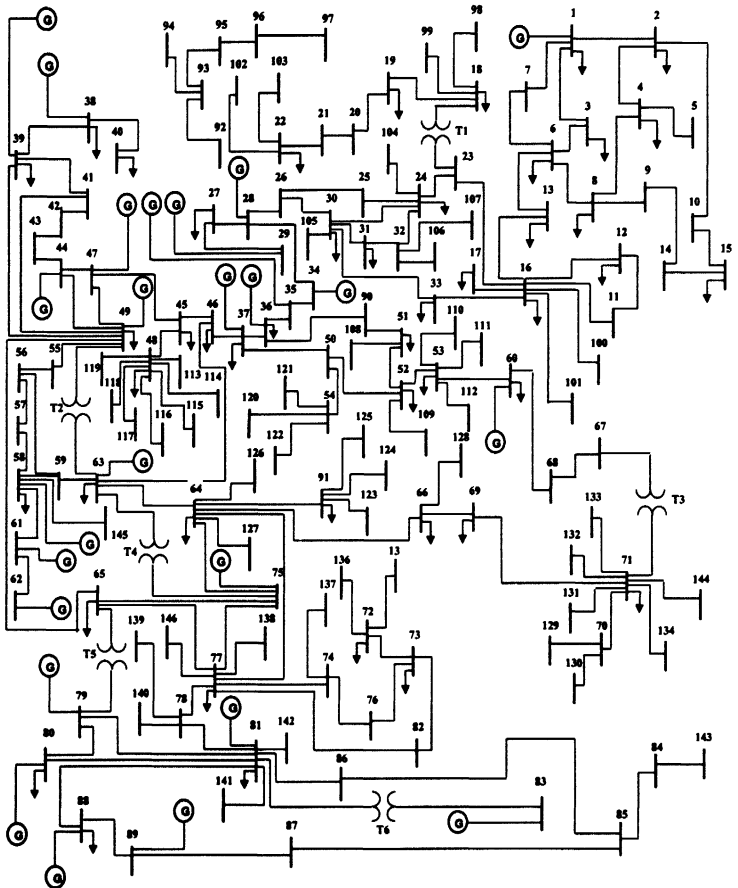


Fig. C.1. One line diagram – Indian Utility – 146 bus System

