

PowerApps Validation Document – Load Flow

(Comparison with Standard Published Results)

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1 Introduction

The objective of this document is to compare the results from PowerApps software with those of published results.

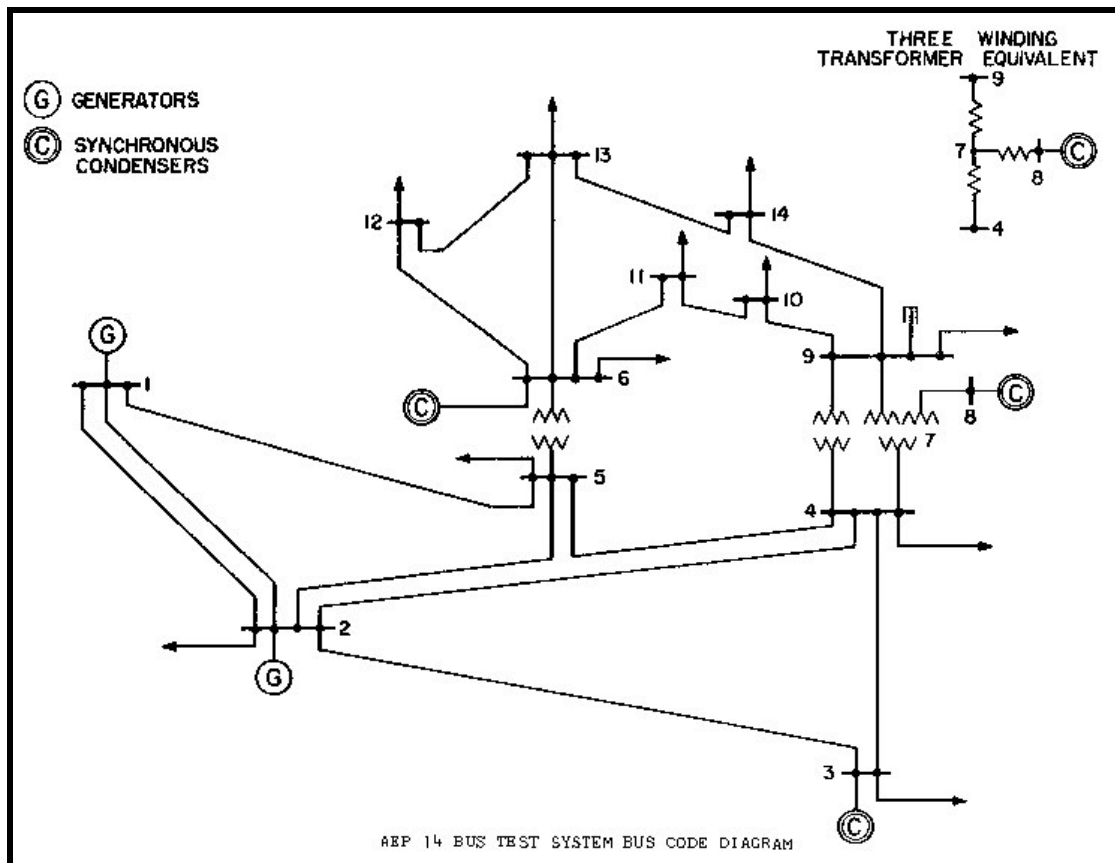
2 Load Flow Validation Examples

Comparison of the test systems with PowerApps results are made by comparing the bus voltages (magnitudes and their phase angles) and generations. Since, for power flow solution, bus voltages are the state variables providing complete flow information, this comparison is considered adequate. The comparison is made using per unit values of bus voltage magnitudes and bus powers as generally the tolerances are specified in per unit for power flow convergence testing. The phase angles are compared in electrical degrees.

2.1 IEEE 14 Bus System

This system data was obtained from the Power Systems Test Case Archive – UWEE, (University of Washington, EE department). For more information refer the web-link <http://www.ee.washington.edu/research/pstca/>

2.1.1 One Line Diagram



2.1.2 Notes

NOTES	
1	Input Data and results of IEEE test system is of limited precision
2	PowerApps input data precision is same as IEEE test system but output precision higher possibly resulting in some differences comparison
3	Tolerances for load flow convergence are unknown for IEEE test system. PowerApps has used 0.00001 per unit for P and Q bus powers for convergence criteria

2.1.3 Comparison of Bus Voltages

NODENAME	IEEE		PowerApps		Comparison	
	VMAG V	ANG(DEG)	VMAG V	ANG(DEG)	pu Diff VMAG V	Diff ANG(DEG)
BUS-1	1.0600	0.0000	1.06	0.000000	0.00000	0.00000
BUS-2	1.0450	-4.9800	1.045	-4.982590	0.00000	0.00259
BUS-3	1.0100	-12.7200	1.01	-12.725100	0.00000	0.00510
BUS-6	1.0700	-14.2200	1.07	-14.220950	0.00000	0.00095
BUS-8	1.0900	-13.3600	1.09	-13.359630	0.00000	-0.00037
BUS-9	1.0560	-14.9400	1.05593	-14.938520	0.00007	-0.00148
BUS-10	1.0510	-15.1000	1.05098	-15.097290	0.00002	-0.00271
BUS-11	1.0570	-14.7900	1.05691	-14.790620	0.00009	0.00062
BUS-12	1.0550	-15.0700	1.05519	-15.075580	-0.00019	0.00558
BUS-13	1.0500	-15.1600	1.05038	-15.156280	-0.00038	-0.00372
BUS-14	1.0360	-16.0400	1.03553	-16.033640	0.00047	-0.00636
BUS-4	1.0190	-10.3300	1.01767	-10.312900	0.00133	-0.01710
BUS-5	1.0200	-8.7800	1.01951	-8.773850	0.00049	-0.00615
BUS-7	1.0620	-13.3700	1.06152	-13.359630	0.00048	-0.01037

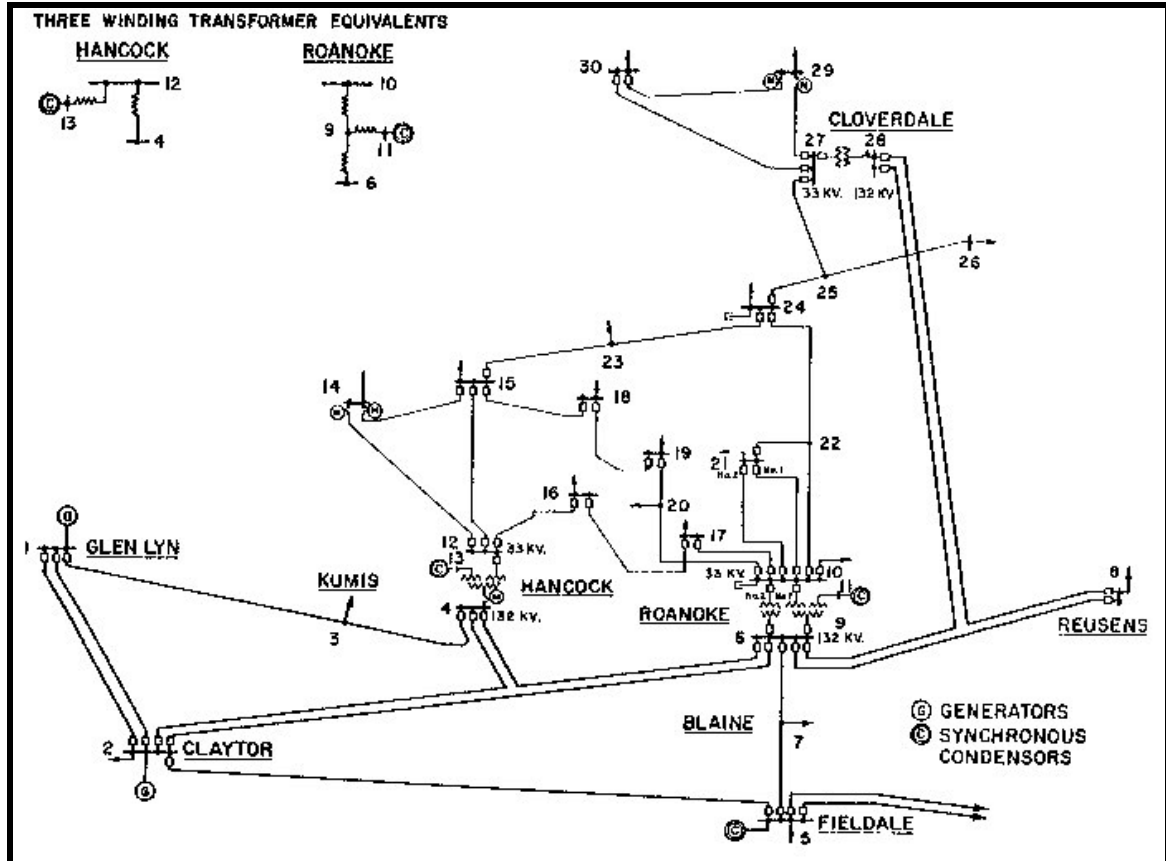
2.1.4 Comparison of Generation

NODENAME	IEEE		PowerApps		Comparison	
	PGEN(MW)	QGEN(MVAR)	PGEN(MW)	QGEN(MVAR)	PU diff MW	PU diff MVAR
BUS-1	232.4	-16.9	232.39327	-16.5493	0.000067	-0.003507
BUS-2	40	42.4	40	43.55709	0.000000	-0.0115709
BUS-3	0	23.4	0	25.07535	0.000000	-0.0167535
BUS-6	0	12.2	0	12.73094	0.000000	-0.0053094
BUS-8	0	17.4	-0	17.62345	0.000000	-0.0022345

2.2 IEEE 30 Bus System

This system data was obtained from the Power Systems Test Case Archive – UWEE, (University of Washington, EE department). For more information refer the web-link <http://www.ee.washington.edu/research/pstca/>

2.2.1 One Line Diagram



2.2.2 Notes

	NOTES
1	Input Data and results of IEEE test system is of limited precision
2	PowerApps input data precision is same as IEEE test system but output precision higher possibly resulting in some differences comparison
3	Tolerances for load flow convergence are unknown for IEEE test system. PowerApps has used 0.00001 per unit for P and Q bus powers for convergence criteria

2.2.3 Comparison of Bus Voltages

NODENAME	IEEE		PowerApps		Comparison	
	VMAG [V]	ANG(DEG)	VMAG [V]	ANG(DEG)	PU Diff VMAG [V]	Diff ANG(DEG)
1	1.0600	0.0000	1.06	0	0.00000	0.00000
2	1.0430	-5.4800	1.043	-5.34999	0.00000	-0.13001
5	1.0100	-14.3700	1.01	-14.16711	0.00000	-0.20289
8	1.0100	-12.1000	1.01	-11.81455	0.00000	-0.28545
11	1.0820	-14.3900	1.082	-14.1098	0.00000	-0.28020
13	1.0710	-15.2400	1.071	-14.94414	0.00000	-0.29586
3	1.0210	-7.9600	1.02071	-7.53229	0.00029	-0.42771
4	1.0120	-9.6200	1.01173	-9.28452	0.00027	-0.33548
6	1.0100	-11.3400	1.01023	-11.06539	-0.00023	-0.27461
7	1.0020	-13.1200	1.00236	-12.86614	-0.00036	-0.25386
9	1.0510	-14.3800	1.0509	-14.1098	0.00010	-0.27020
10	1.0450	-15.9700	1.04511	-15.70056	-0.00011	-0.26944
12	1.0570	-15.2400	1.0571	-14.94414	-0.00010	-0.29586
14	1.0420	-16.1300	1.04226	-15.83631	-0.00026	-0.29369
15	1.038	-16.22	1.03767	-15.92825	0.00033	-0.29175
16	1.045	-15.83	1.04437	-15.5272	0.00063	-0.30280
17	1.04	-16.14	1.03988	-15.86228	0.00012	-0.27772
18	1.028	-16.82	1.02814	-16.5426	-0.00014	-0.27740
19	1.026	-17	1.02563	-16.71635	0.00037	-0.28365
20	1.03	-16.8	1.02972	-16.51979	0.00028	-0.28021
21	1.033	-16.42	1.03271	-16.14329	0.00029	-0.27671
22	1.033	-16.41	1.03324	-16.12905	-0.00024	-0.28095
23	1.027	-16.61	1.02716	-16.31897	-0.00016	-0.29103
24	1.021	-16.78	1.02156	-16.49558	-0.00056	-0.28442
25	1.017	-16.35	1.01732	-16.06774	-0.00032	-0.28226
26	1	-16.77	0.99964	-16.48742	0.00036	-0.28258
27	1.023	-15.82	1.02323	-15.54336	-0.00023	-0.27664
28	1.007	-11.97	1.0068	-11.68929	0.00020	-0.28071
29	1.003	-17.06	1.00339	-16.77336	-0.00039	-0.28664
30	0.992	-17.94	0.99191	-17.65622	0.00009	-0.28378

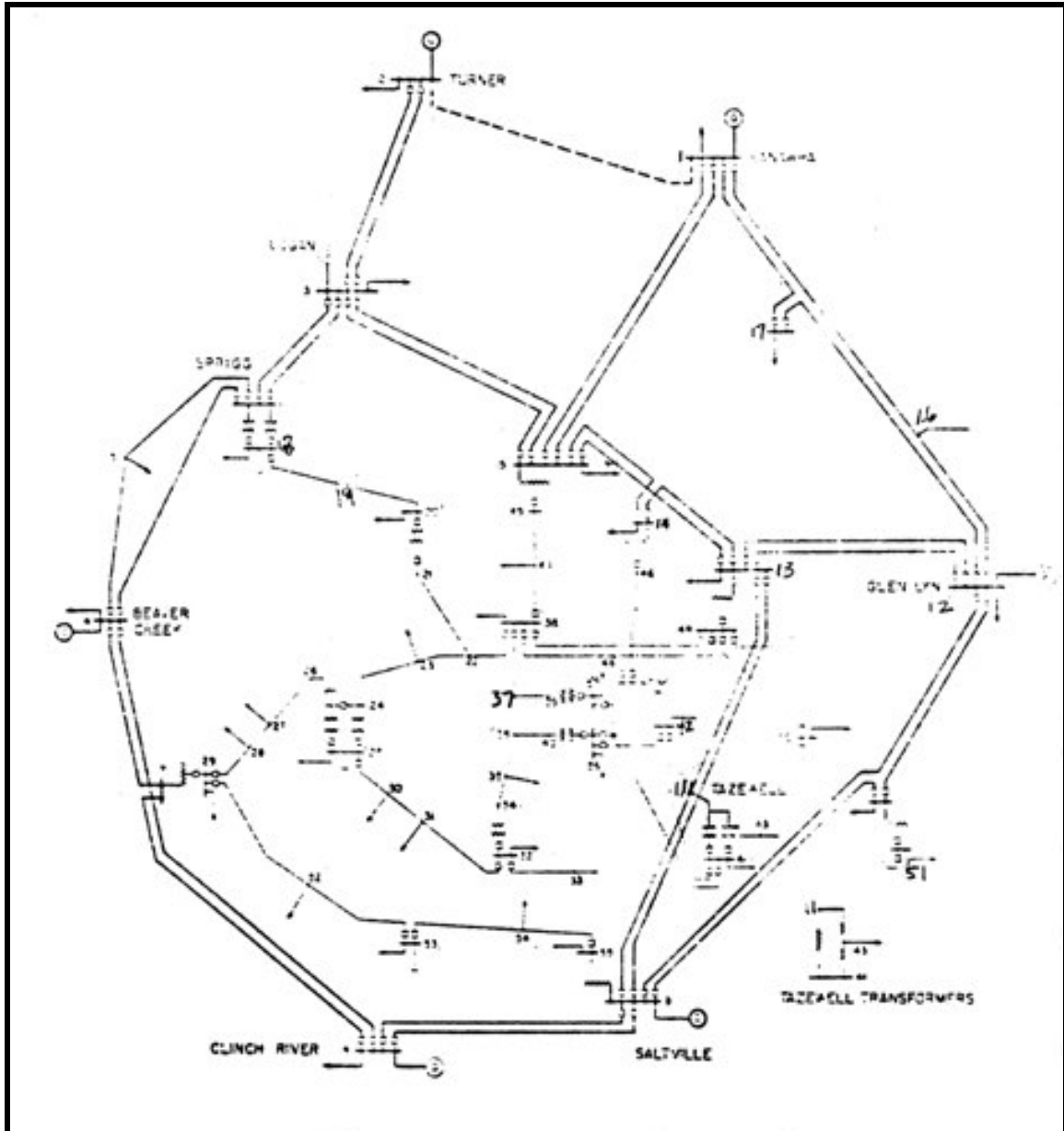
2.2.4 Comparison of Generation

NODENAME	IEEE		PowerApps		Comparison	
	PGEN(MW)	QGEN(MVAR)	PGEN(MW)	QGEN(MVAR)	PU diff MW	PU diff MVAR
1	260.2	-16.1	260.9518	-16.52652	-0.007518	0.0042652
2	40	50	40	49.56475	0.000000	0.0043525
5	0	37	0	36.93597	0.000000	0.0006403
8	0	37.3	0	37.21863	0.000000	0.0008137
11	0	16.2	0	16.17981	0.000000	0.0002019
13	0	10.6	0	10.63061	0.000000	-0.0003061

2.3 IEEE 57 Bus System

This system data was obtained from the Power Systems Test Case Archive – UWEE, (University of Washington, EE department). For more information refer the web-link <http://www.ee.washington.edu/research/pstca/>

2.3.1 One Line Diagram



2.3.2 Notes

NOTES	
1	Input Data and results of IEEE test system is of limited precision
2	PowerApps input data precision is same as IEEE test system but output precision higher possibly resulting in some differences comparison
3	Tolerances for load flow convergence are unknown for IEEE test system. PowerApps has used 0.00001 per unit for P and Q bus powers for convergence criteria
4	Slack Generation given in the sample example obtained from the web site of University of Washington is not consistent with the specified loads. The results of PowerApps is taken as correct with respect to the slack generation

2.3.3 Comparison of Bus Voltages

NODENAME	IEEE		PowerApps		Comparison	
	VMAG V	ANG(DEG)	VMAG V	ANG(DEG)	PU Diff VMAG V	Diff ANG(DEG)
1	1.0400	0.0000	1.04	0	0.00000	0.00000
2	1.0100	-1.1800	1.01	-1.18816	0.00000	0.00816
3	0.9850	-5.9700	0.985	-5.98812	0.00000	0.01812
6	0.9800	-8.6500	0.98	-8.67411	0.00000	0.02411
8	1.0050	-4.4500	1.005	-4.4779	0.00000	0.02790
9	0.9800	-9.5600	0.98	-9.58466	0.00000	0.02466
12	1.0150	-10.4600	1.015	-10.4712	0.00000	0.01120
4	0.9810	-7.3200	0.98078	-7.33736	0.00022	0.01736
5	0.9760	-8.5200	0.9765	-8.5464	-0.00050	0.02640
7	0.9840	-7.5800	0.9842	-7.60139	-0.00020	0.02139
10	0.9860	-11.4300	0.98624	-11.44965	-0.00024	0.01965
11	0.9740	-10.1700	0.97396	-10.19324	0.00004	0.02324
13	0.9790	-9.7900	0.97889	-9.80351	0.00011	0.01351
14	0.9700	-9.3300	0.97018	-9.3503	-0.00018	0.02030
15	0.988	-7.18	0.98803	-7.19017	-0.00003	0.01017
16	1.013	-8.85	1.01337	-8.85893	-0.00037	0.00893
17	1.017	-5.39	1.01745	-5.39589	-0.00045	0.00589
18	1.001	-11.71	1.00066	-11.72963	0.00034	0.01963
19	0.97	-13.2	0.97016	-13.2265	-0.00016	0.02650
20	0.964	-13.41	0.96379	-13.44431	0.00021	0.03431
21	1.008	-12.89	1.0085	-12.929	-0.00050	0.03900
22	1.01	-12.84	1.00974	-12.87431	0.00026	0.03431
23	1.008	-12.91	1.00833	-12.93955	-0.00033	0.02955
24	0.999	-13.25	0.99923	-13.29213	-0.00023	0.04213
25	0.982	-18.13	0.98252	-18.1732	-0.00052	0.04320
26	0.959	-12.95	0.95882	-12.98126	0.00018	0.03126
27	0.982	-11.48	0.98154	-11.51361	0.00046	0.03361
28	0.997	-10.45	0.99668	-10.4816	0.00032	0.03160
29	1.01	-9.75	1.01022	-9.77177	-0.00022	0.02177
30	0.962	-18.68	0.96266	-18.71961	-0.00066	0.03961
31	0.936	-19.34	0.93593	-19.38375	0.00007	0.04375
32	0.949	-18.46	0.94988	-18.51228	-0.00088	0.05228
33	0.947	-18.5	0.94758	-18.55195	-0.00058	0.05195
34	0.959	-14.1	0.9592	-14.14896	-0.00020	0.04896
35	0.966	-13.86	0.96621	-13.90619	-0.00021	0.04619

NODENAME	IEEE		PowerApps		Comparison	
	VMAG V	ANG(DEG)	VMAG V	ANG(DEG)	PU Diff VMAG V	Diff ANG(DEG)
36	0.976	-13.59	0.97583	-13.63481	0.00017	0.04481
37	0.985	-13.41	0.98489	-13.44592	0.00011	0.03592
38	1.013	-12.71	1.01281	-12.73462	0.00019	0.02462
39	0.983	-13.46	0.98282	-13.49103	0.00018	0.03103
40	0.973	-13.62	0.97281	-13.65823	0.00019	0.03823
41	0.996	-14.05	0.99622	-14.07667	-0.00022	0.02667
42	0.966	-15.5	0.96653	-15.53278	-0.00053	0.03278
43	1.01	-11.33	1.00956	-11.35438	0.00044	0.02438
44	1.017	-11.86	1.0168	-11.85646	0.00020	-0.00354
45	1.036	-9.25	1.03601	-9.27009	-0.00001	0.02009
46	1.05	-11.89	1.0598	-11.11606	-0.00980	-0.77394
47	1.033	-12.49	1.03325	-12.51159	-0.00025	0.02159
48	1.027	-12.59	1.02735	-12.61065	-0.00035	0.02065
49	1.036	-12.92	1.03625	-12.93607	-0.00025	0.01607
50	1.023	-13.39	1.02334	-13.4127	-0.00034	0.02270
51	1.052	-12.52	1.05226	-12.53339	-0.00026	0.01339
52	0.98	-11.47	0.98037	-11.49755	-0.00037	0.02755
53	0.971	-12.23	0.97095	-12.25258	0.00005	0.02258
54	0.996	-11.69	0.99632	-11.70965	-0.00032	0.01965
55	1.031	-10.78	1.03079	-10.80112	0.00021	0.02112
56	0.968	-16.04	0.96837	-16.06506	-0.00037	0.02506
57	0.965	-16.56	0.96483	-16.58369	0.00017	0.02369

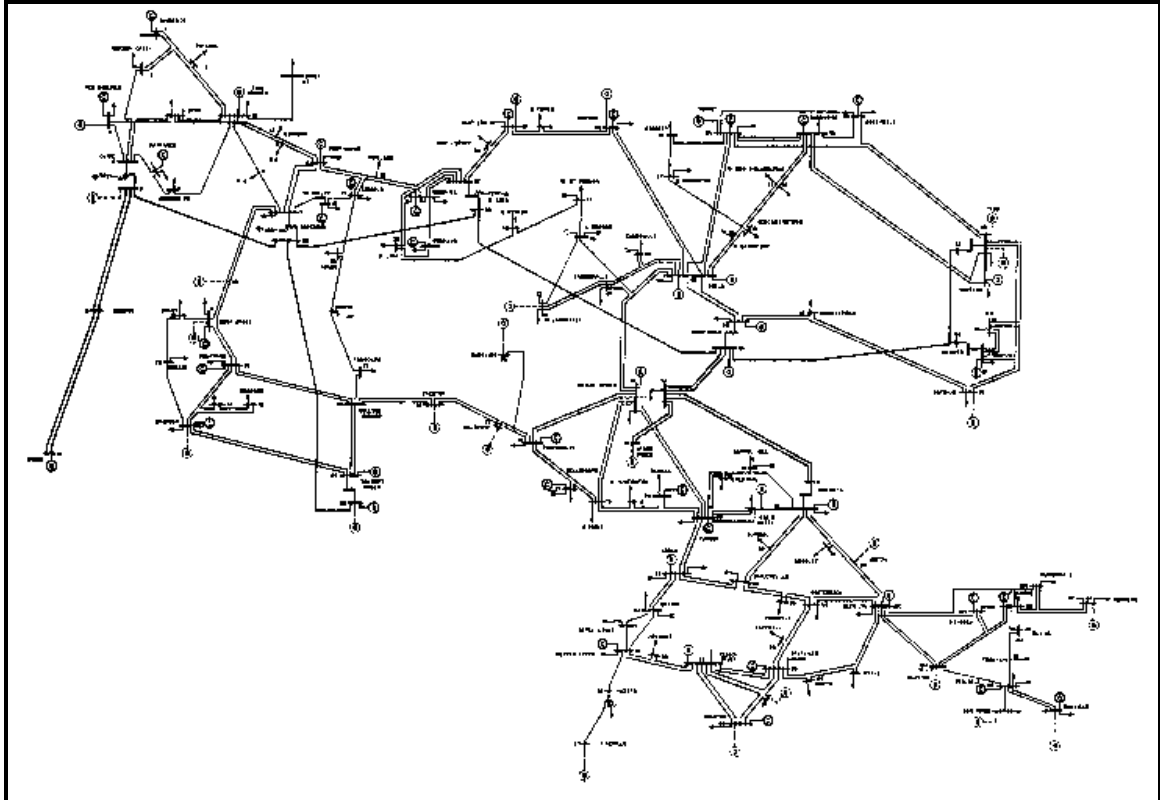
2.3.4 Comparison of Generation

NODENAME	IEEE		PowerApps		Comparison	
	PGEN(MW)	QGEN(MVAR)	PGEN(MW)	QGEN(MVAR)	PU diff MW	PU diff MVAR
1*	478.66351	128.84955	478.66351	128.84955	0.000000	0.0000000
2	0	-0.8	0	-0.75499	0.000000	-0.0004501
3	40	-1	40.00001	-0.90508	0.000000	-0.0009492
6	0	0.8	-0	0.87134	0.000000	-0.0007134
8	450	62.1	450	62.09954	0.000000	0.0000046
9	0	2.2	0.00002	2.2882	0.000000	-0.0008820
12	310	128.5	310.00001	128.63067	0.000000	-0.0013067

2.4 IEEE 118 Bus System

This system data was obtained from the Power Systems Test Case Archive – UWEE, (University of Washington, EE department). For more information refer the web-link <http://www.ee.washington.edu/research/pstca/>

2.4.1 One Line Diagram



2.4.2 Notes

NOTES	
1	Input Data and results of IEEE test system is of limited precision
2	PowerApps input data precision is same as IEEE test system but output precision higher possibly resulting in some differences comparison
3	Tolerances for load flow convergence is unknown for IEEE test system. PowerApps has used 0.00001 per unit for P and Q bus powers for convergence criteria
4	The source data obtained from the web-site of Washington University, does not specify the Q generations of any generators. The comparison is therefore made only with respect to Slack MW generation. The MW of generations of other generators are specified inputs.
5	For transformers the X/R value was assumed as 40 to obtain the results from PowerApps

2.4.3 Comparison of Bus Voltages

NODENAME	IEEE		PowerApps		Comparison	
	VMAG V	ANG(DEG)	VMAG V	ANG(DEG)	PU Diff VMAG V	Diff ANG(DEG)
69	1.035	30	1.035	30	0.00000	0.00000
1	0.955	10.67	0.955	10.83539	0.00000	-0.16539
4	0.998	15.28	0.998	15.43516	0.00000	-0.15516
6	0.99	13	0.99	13.15442	0.00000	-0.15442
8	1.015	20.77	1.015	20.87128	0.00000	-0.10128
10	1.05	35.61	1.05	35.7063	0.00000	-0.09630
12	0.99	12.2	0.99	12.35435	0.00000	-0.15435
15	0.97	11.23	0.97	11.3635	0.00000	-0.13350
18	0.973	11.53	0.973	11.66691	0.00000	-0.13691
19	0.963	11.05	0.96344	11.18437	-0.00044	-0.13437
24	0.992	20.89	0.992	21.01933	0.00000	-0.12933
25	1.05	27.93	1.05	28.04999	0.00000	-0.11999
26	1.015	29.71	1.015	29.81282	0.00000	-0.10282
27	0.968	15.35	0.968	15.48674	0.00000	-0.13674
31	0.967	12.75	0.967	12.88797	0.00000	-0.13797
32	0.964	14.8	0.964	14.92996	0.00000	-0.12996
34	0.986	11.3	0.986	11.40779	0.00000	-0.10779
36	0.98	10.87	0.98	10.98764	0.00000	-0.11764
40	0.97	7.35	0.97	7.4384	0.00000	-0.08840
42	0.985	8.53	0.985	8.59953	0.00000	-0.06953
46	1.005	18.49	1.005	18.52953	0.00000	-0.03953
49	1.025	20.94	1.025	20.97473	0.00000	-0.03473
54	0.955	15.26	0.955	15.2959	0.00000	-0.03590
55	0.952	14.97	0.952	15.00566	0.00000	-0.03566
56	0.954	15.16	0.954	15.19254	0.00000	-0.03254
59	0.985	19.37	0.985	19.39169	0.00000	-0.02169
61	0.995	24.04	0.995	24.05222	0.00000	-0.01222
62	0.998	23.43	0.998	23.43923	0.00000	-0.00923
65	1.005	27.65	1.005	27.63572	0.00000	0.01428
66	1.05	27.48	1.05	27.50734	0.00000	-0.02734
70	0.984	22.58	0.984	22.59136	0.00000	-0.01136
72	0.98	20.98	0.98	21.04623	0.00000	-0.06623
73	0.991	21.94	0.991	21.96295	0.00000	-0.02295
74	0.958	21.64	0.958	21.65016	0.00000	-0.01016
76	0.943	21.77	0.943	21.78343	0.00000	-0.01343
77	1.006	26.72	1.006	26.73598	0.00000	-0.01598
80	1.04	28.96	1.04	28.97171	0.00000	-0.01171
85	0.985	32.51	0.985	32.52707	0.00000	-0.01707
87	1.015	31.4	1.015	31.41683	0.00000	-0.01683
89	1.005	39.69	1.005	39.71065	0.00000	-0.02065
90	0.985	33.29	0.985	33.30735	0.00000	-0.01735
91	0.98	33.31	0.98	33.32834	0.00000	-0.01834
92	0.993	33.8	0.993	33.81729	0.00000	-0.01729
99	1.01	27.04	1.01	27.06028	0.00000	-0.02028
100	1.017	28.03	1.017	28.05713	0.00000	-0.02713
103	1.001	24.44	1.00071	24.46216	0.00029	-0.02216
104	0.971	21.69	0.971	21.71718	0.00000	-0.02718

NODENAME	IEEE		PowerApps		Comparison	
	VMAG V	ANG(DEG)	VMAG V	ANG(DEG)	PU Diff VMAG V	Diff ANG(DEG)
105	0.965	20.57	0.96599	20.59508	-0.00099	-0.02508
107	0.952	17.53	0.952	17.55714	0.00000	-0.02714
110	0.973	18.09	0.973	18.1161	0.00000	-0.02610
111	0.98	19.74	0.98	19.76118	0.00000	-0.02118
112	0.975	14.99	0.975	15.01689	0.00000	-0.02689
113	0.993	13.74	0.993	13.87677	0.00000	-0.13677
116	1.005	27.12	1.005	27.09133	0.00000	0.02867
2	0.971	11.22	0.97139	11.37695	-0.00039	-0.15695
3	0.968	11.56	0.96759	11.72001	0.00041	-0.16001
5	1.002	15.73	1.00157	15.88531	0.00043	-0.15531
7	0.989	12.56	0.98933	12.71098	-0.00033	-0.15098
9	1.043	28.02	1.04292	28.12539	0.00008	-0.10539
11	0.985	12.72	0.98502	12.87122	-0.00002	-0.15122
13	0.968	11.35	0.96825	11.50049	-0.00025	-0.15049
14	0.984	11.5	0.98359	11.64316	0.00041	-0.14316
16	0.984	11.91	0.98383	12.05957	0.00017	-0.14957
17	0.995	13.74	0.99487	13.8826	0.00013	-0.14260
20	0.958	11.93	0.95809	12.06597	-0.00009	-0.13597
21	0.959	13.52	0.95866	13.65511	0.00034	-0.13511
22	0.97	16.08	0.9697	16.21086	0.00030	-0.13086
23	1	21	0.99974	21.1333	0.00026	-0.13330
28	0.962	13.62	0.96157	13.76267	0.00043	-0.14267
29	0.963	12.63	0.96322	12.77089	-0.00022	-0.14089
30	0.968	18.79	0.98654	18.87314	-0.01854	-0.08314
33	0.972	10.63	0.97155	10.75278	0.00045	-0.12278
35	0.981	10.87	0.98067	10.98324	0.00033	-0.11324
37	0.992	11.77	0.99195	11.87442	0.00005	-0.10442
38	0.962	16.91	0.96338	16.95959	-0.00138	-0.04959
39	0.97	8.41	0.97045	8.50841	-0.00045	-0.09841
41	0.967	6.92	0.96683	6.99545	0.00017	-0.07545
43	0.978	11.28	0.97856	11.37486	-0.00056	-0.09486
44	0.985	13.82	0.98502	13.87953	-0.00002	-0.05953
45	0.987	15.67	0.98665	15.71726	0.00035	-0.04726
47	1.017	20.73	1.01704	20.75859	-0.00004	-0.02859
48	1.021	19.93	1.02063	19.97177	0.00037	-0.04177
50	1.001	18.9	1.00108	18.93471	-0.00008	-0.03471
51	0.967	16.28	0.96687	16.31443	0.00013	-0.03443
52	0.957	15.32	0.95681	15.36068	0.00019	-0.04068
53	0.946	14.35	0.94598	14.38483	0.00002	-0.03483
57	0.971	16.36	0.97058	16.3987	0.00042	-0.03870
58	0.959	15.51	0.95904	15.54164	-0.00004	-0.03164
60	0.993	23.15	0.99316	23.16237	-0.00016	-0.01237
63	0.969	22.75	0.96949	22.74028	-0.00049	0.00972
64	0.984	24.52	0.98411	24.51083	-0.00011	0.00917
67	1.02	24.84	1.01968	24.86117	0.00032	-0.02117
68	1.003	27.55	1.00314	27.5269	-0.00014	0.02310
71	0.987	22.15	0.98684	22.17445	0.00016	-0.02445
75	0.967	22.91	0.96732	22.9145	-0.00032	-0.00450
78	1.003	26.42	1.00342	26.43151	-0.00042	-0.01151

NODENAME	IEEE		PowerApps		Comparison	
	VMAG V	ANG(DEG)	VMAG V	ANG(DEG)	PU Diff VMAG V	Diff ANG(DEG)
79	1.009	26.72	1.00922	26.72947	-0.00022	-0.00947
81	0.997	28.1	0.9966	28.08043	0.00040	0.01957
82	0.989	27.24	0.98881	27.25276	0.00019	-0.01276
83	0.985	28.42	0.98457	28.44179	0.00043	-0.02179
84	0.98	30.95	0.97977	30.9737	0.00023	-0.02370
86	0.987	31.14	0.98669	31.15762	0.00031	-0.01762
88	0.987	35.64	0.98746	35.65638	-0.00046	-0.01638
93	0.987	30.79	0.98737	30.81281	-0.00037	-0.02281
94	0.991	28.64	0.99081	28.66292	0.00019	-0.02292
95	0.981	27.67	0.98111	27.69187	-0.00011	-0.02187
96	0.993	27.51	0.99279	27.52508	0.00021	-0.01508
97	1.011	27.88	1.01143	27.8979	-0.00043	-0.01790
98	1.024	27.4	1.02351	27.42117	0.00049	-0.02117
101	0.993	29.61	0.99276	29.62563	0.00024	-0.01563
102	0.991	32.3	0.99159	32.31759	-0.00059	-0.01759
106	0.962	20.32	0.96179	20.34726	0.00021	-0.02726
108	0.967	19.38	0.96681	19.40418	0.00019	-0.02418
109	0.967	18.93	0.96746	18.95495	-0.00046	-0.02495
114	0.96	14.46	0.96068	14.60168	-0.00068	-0.14168
115	0.96	14.46	0.96053	14.59433	-0.00053	-0.13433
117	0.974	10.67	0.97382	10.81335	0.00018	-0.14335
118	0.949	21.92	0.94943	21.92631	-0.00043	-0.00631

2.4.4 Comparison of Generation

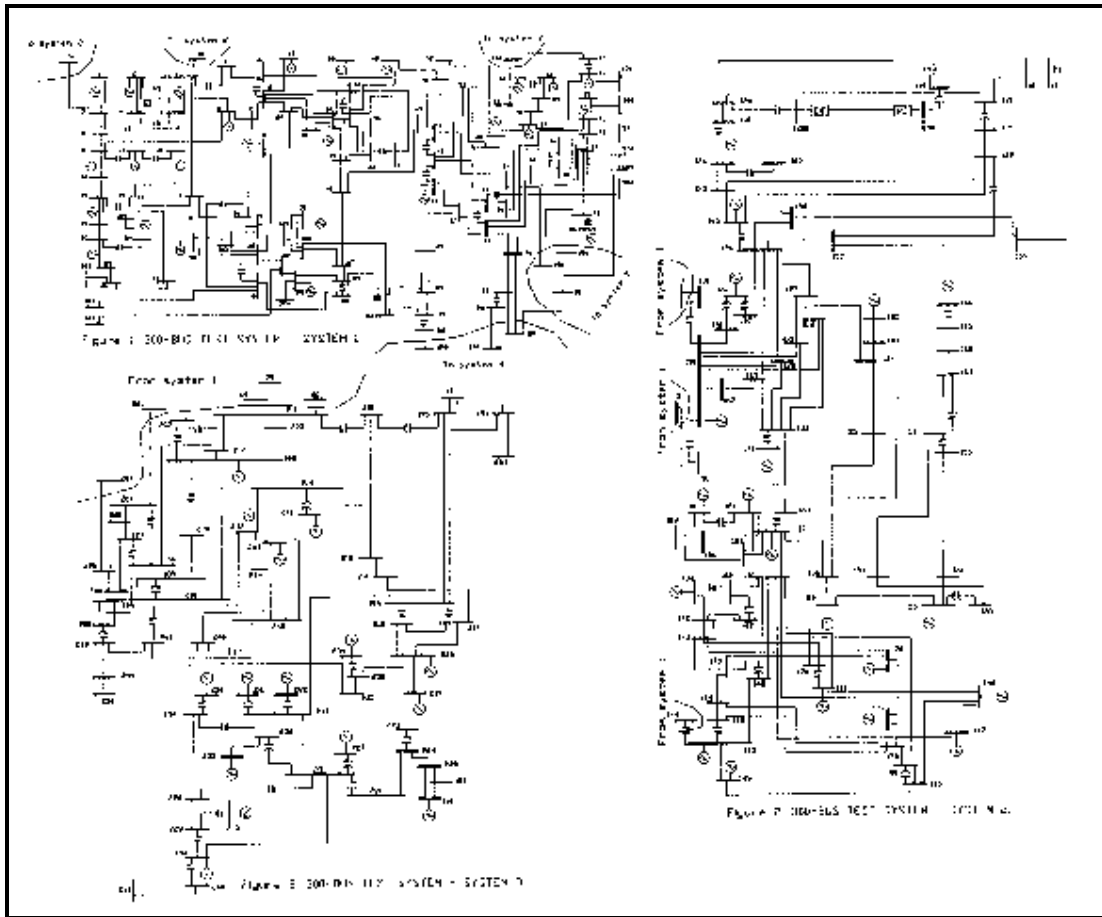
The original source data does not specify the reactive power generation. With all MW generation as specified variable comparison is possible only with respect to the slack MW generation.

NODENAME	IEEE		PowerApps		Comparison	
	PGEN(MW)	QGEN(MVAR)*	PGEN(MW)	QGEN(MVAR)*	PU diff MW	PU diff MVAR
69	516.4	0	516.22744	0	0.001726	0.000000

2.5 IEEE 300 Bus System

This system data was obtained from the Power Systems Test Case Archive – UWEE, (University of Washington, EE department). For more information refer the web-link <http://www.ee.washington.edu/research/pstca/>

2.5.1 One Line Diagram



2.5.2 Notes

NOTES	
1	Input Data and results of IEEE test system is of limited precision
2	PowerApps input data precision is same as IEEE test system but output precision higher possibly resulting in some differences comparison
3	Tolerances for load flow convergence is unknown for IEEE test system. PowerApps has used 0.00001 per unit for P and Q bus powers for convergence criteria
4	The source data obtained from the web-site of Washington University, does not specify the solution for slack MW generation and Q generations of any generators. No comparison is therefore possible.
5	There are very few significant difference between the results which could be due to TYPO error as mentioned on the web-site. Further, the actual representation of shunt elements could be different between PowerApps and IEEE bench mark result. This is due to the fact that no specific information is available in the source data as to the exact nature of shunt element representation. PowerApps results are therefore considered to be correct and acceptable.

2.5.3 Comparison of Bus Voltages

NODENAME	IEEE		PowerApps		Comparison	
	VMAG V	ANG(DEG)	VMAG V	ANG(DEG)	PU Diff VMAG V	Diff ANG(DEG)
7049	1.0507	0	1.0507	0	0.00000	0.00000
8	1.0153	2.4	1.0153	2.47071	0.00000	-0.07071
10	1.0205	1.35	1.02048	1.41895	0.00002	-0.06895
20	1.001	-2.46	1.00094	-2.39125	0.00006	-0.06875
63	0.9583	-17.62	0.9583	-17.53794	0.00000	-0.08206
76	0.9632	-26.54	0.9632	-26.44884	0.00000	-0.09116
84	1.025	-17.16	1.025	-17.09368	0.00000	-0.06632
91	1.052	-9.4	1.052	-9.38176	0.00000	-0.01824
92	1.052	-6.2	1.052	-6.18925	0.00000	-0.01075
98	1	-14.6	1	-14.6097	0.00000	0.00970
108	0.99	-20.26	0.99	-20.30821	0.00000	0.04821
119	1.0435	5.17	1.0435	5.24667	0.00000	-0.07667
124	1.0233	-13.49	1.0233	-13.40501	0.00000	-0.08499
125	1.0103	-18.43	1.0103	-18.347	0.00000	-0.08300
138	1.055	-6.35	1.055	-6.27107	0.00000	-0.07893
141	1.051	0.05	1.051	0.13693	0.00000	-0.08693
143	1.0435	4.03	1.0435	4.11292	0.00000	-0.08292
146	1.0528	4.32	1.0528	4.40573	0.00000	-0.08573
147	1.0528	8.36	1.05282	8.44745	-0.00002	-0.08745
149	1.0735	5.23	1.0735	5.31082	0.00000	-0.08082
152	1.0535	9.24	1.05354	9.31948	-0.00004	-0.07948
153	1.0435	10.46	1.0435	10.53714	0.00000	-0.07714
156	0.963	5.15	0.963	5.21799	0.00000	-0.06799
170	0.929	0.09	0.92894	0.16468	0.00006	-0.07468
171	0.9829	-9.94	0.9829	-9.85413	0.00000	-0.08587
176	1.0522	4.67	1.0522	4.76093	0.00000	-0.09093
177	1.0077	0.62	1.0077	0.7127	0.00000	-0.09270
185	1.0522	-4.33	1.0522	-4.25104	0.00000	-0.07896
186	1.065	2.17	1.065	2.25323	0.00000	-0.08323
187	1.065	1.4	1.065	1.47816	0.00000	-0.07816

NODENAME	IEEE		PowerApps		Comparison	
	VMAG V	ANG(DEG)	VMAG V	ANG(DEG)	PU Diff VMAG V	Diff ANG(DEG)
190	1.0551	-20.62	1.0551	-20.36222	0.00000	-0.25778
191	1.0435	12.25	1.0435	12.46629	0.00000	-0.21629
198	1.015	-20.58	1.015	-20.04049	0.00000	-0.53951
213	1.01	-11.67	1.01	-11.32359	0.00000	-0.34641
227	1	-27.22	1	-26.96109	0.00000	-0.25891
220	1.008	-21.73	1.008	-21.46244	0.00000	-0.26756
221	1	-22.49	1	-22.22609	0.00000	-0.26391
222	1.05	-23.17	1.05	-22.90747	0.00000	-0.26253
230	1.04	-13.82	1.04	-13.56354	0.00000	-0.25646
233	1	-25.9	1	-25.64109	0.00000	-0.25891
236	1.0165	-15.4	1.01631	-15.13597	0.00019	-0.26403
238	1.01	-20.94	1.01	-20.67804	0.00000	-0.26196
239	1	-15.86	1	-15.59923	0.00000	-0.26077
241	1.05	-16.5	1.05	-16.24521	0.00000	-0.25479
242	0.993	-17.53	0.993	-17.17085	0.00000	-0.35915
243	1.01	-19.27	1.01	-18.89378	0.00000	-0.37622
7001	1.0507	10.79	1.0507	10.86501	0.00000	-0.07501
7002	1.0507	12.48	1.0507	12.55761	0.00000	-0.07761
7003	1.0323	13.76	1.03229	13.83039	0.00001	-0.07039
7011	1.0145	4.99	1.0145	5.0648	0.00000	-0.07480
7012	1.0507	11.57	1.0507	11.64511	0.00000	-0.07511
7017	1.0507	-10.47	1.0507	-10.39599	0.00000	-0.07401
7023	1.0507	6.15	1.0507	6.21707	0.00000	-0.06707
7024	1.029	12.6	1.029	12.6639	0.00000	-0.06390
7039	1.05	2.11	1.05	2.19796	0.00000	-0.08796
7044	1.0145	-13.92	1.0145	-13.82839	0.00000	-0.09161
7055	0.9967	-7.5	0.9967	-7.43008	0.00000	-0.06992
7057	1.0212	-3.44	1.0212	-3.3623	0.00000	-0.07770
7061	1.0145	1.97	1.0145	2.05274	0.00000	-0.08274
7062	1.0017	5.8	1.0017	5.8817	0.00000	-0.08170
7071	0.9893	-25.35	0.9893	-25.26117	0.00000	-0.08883
7130	1.0507	19.02	1.0507	19.10076	0.00000	-0.08076
7139	1.0507	2.75	1.0507	2.82905	0.00000	-0.07905
7166	1.0145	35.05	1.0145	35.09113	0.00000	-0.04113
9002	0.9945	-18.86	0.9945	-18.69802	0.00000	-0.16198
9051	1	-19.4	1	-19.32623	0.00000	-0.07377
9053	1	-17.68	1	-17.58888	0.00000	-0.09112
9054	1	-6.83	1	-6.7593	0.00000	-0.07070
9055	1	-7.54	1	-7.47021	0.00000	-0.06979
1	1.0284	5.95	1.02842	6.02317	-0.00002	-0.07317
2	1.0354	7.74	1.03534	7.81066	0.00006	-0.07066
3	0.9971	6.64	0.99709	6.71291	0.00001	-0.07291
4	1.0308	4.71	1.03081	4.78368	-0.00001	-0.07368
5	1.0191	4.68	1.0191	4.7572	0.00000	-0.07720
6	1.0312	6.99	1.03119	7.06179	0.00001	-0.07179
7	0.9934	6.19	0.9934	6.26157	0.00000	-0.07157
9	1.0034	2.85	1.00338	2.92657	0.00002	-0.07657
11	1.0057	2.46	1.00565	2.53689	0.00005	-0.07689
12	0.9974	5.21	0.99736	5.28622	0.00004	-0.07622

NODENAME	IEEE		PowerApps		Comparison	
	VMAG V	ANG(DEG)	VMAG V	ANG(DEG)	PU Diff VMAG V	Diff ANG(DEG)
13	0.9977	-0.55	0.99764	-0.48137	0.00006	-0.06863
14	0.9991	-4.81	0.99918	-4.74091	-0.00008	-0.06909
15	1.0343	-8.59	1.03441	-8.51254	-0.00011	-0.07746
16	1.0315	-2.65	1.0316	-2.56846	-0.00010	-0.08154
17	1.0649	-13.1	1.06491	-13.02979	-0.00001	-0.07021
19	0.982	1.08	0.9819	1.14456	0.00010	-0.06456
21	0.9752	1.62	0.97514	1.68992	0.00006	-0.06992
22	0.9963	-1.97	0.99622	-1.90436	0.00008	-0.06564
23	1.0501	3.94	1.05009	4.0069	0.00001	-0.06690
24	1.0057	6.02	1.00564	6.08885	0.00006	-0.06885
25	1.0234	1.44	1.02334	1.5082	0.00006	-0.06820
26	0.9986	-1.73	0.99855	-1.66561	0.00005	-0.06439
27	0.975	-4.9	0.97499	-4.82725	0.00001	-0.07275
33	1.0244	-12.02	1.02466	-11.95068	-0.00026	-0.06932
34	1.0414	-7.94	1.04147	-7.84911	-0.00007	-0.09089
35	0.9757	-25.72	0.97568	-25.62745	0.00002	-0.09255
36	1.0011	-22.59	1.00113	-22.4645	-0.00003	-0.12550
37	1.0201	-11.23	1.02032	-11.16154	-0.00022	-0.06846
38	1.0202	-12.56	1.02042	-12.48741	-0.00022	-0.07259
39	1.0535	-5.81	1.05363	-5.72114	-0.00013	-0.08886
40	1.0216	-12.78	1.02176	-12.70873	-0.00016	-0.07127
41	1.0292	-10.45	1.02938	-10.37647	-0.00018	-0.07353
42	1.0448	-7.44	1.04497	-7.35454	-0.00017	-0.08546
43	1.0006	-16.79	1.00078	-16.7115	-0.00018	-0.07850
44	1.0086	-17.47	1.00875	-17.37844	-0.00015	-0.09156
45	1.0215	-14.74	1.02165	-14.63757	-0.00015	-0.10243
46	1.0344	-11.75	1.03451	-11.64408	-0.00011	-0.10592
47	0.9777	-23.17	0.97789	-23.10961	-0.00019	-0.06039
48	1.0019	-16.09	1.00201	-16.06744	-0.00011	-0.02256
49	1.0475	-2.95	1.04752	-2.93341	-0.00002	-0.01659
51	1.0253	-8.15	1.02546	-8.10148	-0.00016	-0.04852
52	0.9979	-11.86	0.99806	-11.79896	-0.00016	-0.06104
53	0.9959	-17.6	0.99608	-17.52739	-0.00018	-0.07261
54	1.005	-16.25	1.00517	-16.17214	-0.00017	-0.07786
55	1.015	-12.21	1.01518	-12.1418	-0.00018	-0.06820
57	1.0335	-8	1.0335	-7.9172	0.00000	-0.08280
58	0.9918	-5.99	0.99183	-5.90896	-0.00003	-0.08104
59	0.9789	-5.29	0.97886	-5.20215	0.00004	-0.08785
60	1.0246	-9.56	1.02472	-9.46266	-0.00012	-0.09734
61	0.9906	-3.47	0.99066	-3.38272	-0.00006	-0.08728
62	1.016	-1.1	1.01604	-1.01041	-0.00004	-0.08959
64	0.948	-12.97	0.94796	-12.88471	0.00004	-0.08529
69	0.963	-25.66	0.96292	-26.4187	0.00008	0.75870
70	0.9513	-35.16	0.95132	-35.06971	-0.00002	-0.09029
71	0.9793	-29.88	0.97939	-29.79049	-0.00009	-0.08951
72	0.9696	-27.48	0.96961	-27.38704	-0.00001	-0.09296
73	0.9775	-25.77	0.9776	-25.68318	-0.00010	-0.08682
74	0.9964	-22	0.99646	-21.88906	-0.00006	-0.11094
77	0.9837	-24.94	0.98379	-24.85684	-0.00009	-0.08316

NODENAME	IEEE		PowerApps		Comparison	
	VMAG V	ANG(DEG)	VMAG V	ANG(DEG)	PU Diff VMAG V	Diff ANG(DEG)
78	0.99	-24.05	0.99003	-23.98045	-0.00003	-0.06955
79	0.982	-24.97	0.98203	-24.95722	-0.00003	-0.01278
80	0.9872	-24.97	0.98725	-24.76294	-0.00005	-0.20706
81	1.034	-18.89	1.03402	-18.70163	-0.00002	-0.18837
85	0.9872	-17.68	0.98711	-17.70989	0.00009	0.02989
86	0.9909	-14.19	0.99081	-14.19273	0.00009	0.00273
87	0.9921	-7.77	0.99194	-7.73732	0.00016	-0.03268
88	1.0151	-20.96	1.01518	-20.8122	-0.00008	-0.14780
89	1.0317	-11.13	1.03177	-11.08835	-0.00007	-0.04165
90	1.0272	-11.23	1.02731	-11.18058	-0.00011	-0.04942
94	0.993	-9.42	0.99294	-9.39393	0.00006	-0.02607
97	1.0183	-13.24	1.01822	-13.23197	0.00008	-0.00803
99	0.9894	-20.27	0.98936	-20.32007	0.00004	0.05007
100	1.006	-14.45	1.00599	-14.44817	0.00001	-0.00183
102	1.0008	-15.23	1.00071	-15.23739	0.00009	0.00739
103	1.0288	-12.06	1.02877	-12.06338	0.00003	0.00338
104	0.9958	-17.33	0.99574	-17.34642	0.00006	0.01642
105	1.0223	-12.94	1.02228	-12.94721	0.00002	0.00721
107	1.0095	-16.03	1.00949	-16.0276	0.00001	-0.00240
109	0.9749	-26.06	0.97531	-26.23672	-0.00041	0.17672
110	0.973	-24.72	0.97327	-24.87651	-0.00027	0.15651
112	0.9725	-28.69	0.97465	-29.21851	-0.00215	0.52851
113	0.97	-25.38	0.97019	-25.39321	-0.00019	0.01321
114	0.9747	-28.59	0.977	-29.15393	-0.00230	0.56393
115	0.9603	-13.57	0.96029	-13.48905	0.00001	-0.08095
116	1.0249	-12.69	1.02486	-12.60748	0.00004	-0.08252
117	0.9348	-4.72	0.93483	-4.63984	-0.00003	-0.08016
118	0.9298	-4.12	0.92986	-4.04223	-0.00006	-0.07777
120	0.9584	-8.77	0.95844	-8.68985	-0.00004	-0.08015
121	0.9871	-12.64	0.98711	-12.55542	-0.00001	-0.08458
122	0.9728	-14.36	0.9728	-14.28363	0.00000	-0.07637
123	1.0006	-17.64	1.00059	-17.55396	0.00001	-0.08604
126	0.9978	-12.86	0.99781	-12.78329	-0.00001	-0.07671
127	1.0001	-10.52	1.00017	-10.44252	-0.00007	-0.07748
128	1.0024	-4.78	1.00246	-4.69696	-0.00006	-0.08304
129	1.0028	-4.4	1.00288	-4.31822	-0.00008	-0.08178
130	1.0191	5.56	1.01914	5.63483	-0.00004	-0.07483
131	0.9861	6.06	0.98614	6.12986	-0.00004	-0.06986
132	1.0045	3.04	1.00454	3.12106	-0.00004	-0.08106
133	1.002	-5.46	1.00207	-5.3796	-0.00007	-0.08040
134	1.022	-8.04	1.02211	-7.96328	-0.00011	-0.07672
135	1.0193	-6.76	1.01939	-6.67535	-0.00009	-0.08465
136	1.0476	1.54	1.04766	1.62004	-0.00006	-0.08004
137	1.0471	-1.45	1.04727	-1.37291	-0.00017	-0.07709
139	1.0117	-3.57	1.01185	-3.48373	-0.00015	-0.08627
140	1.043	-3.44	1.04329	-3.35253	-0.00029	-0.08747
142	1.0155	-2.77	1.01823	-2.69968	-0.00273	-0.07032
144	1.016	-0.7	1.01611	-0.60976	-0.00011	-0.09024
145	1.0081	-0.16	1.00822	-0.07291	-0.00012	-0.08709

NODENAME	IEEE		PowerApps		Comparison	
	VMAG V	ANG(DEG)	VMAG V	ANG(DEG)	PU Diff VMAG V	Diff ANG(DEG)
148	1.0577	0.28	1.05786	0.36057	-0.00016	-0.08057
150	0.9869	6.34	0.98693	6.41141	-0.00003	-0.07141
151	1.0048	4.13	1.00482	4.20749	-0.00002	-0.07749
154	0.9663	-1.8	0.96642	-1.72436	-0.00012	-0.07564
155	1.0177	6.75	1.01839	6.82118	-0.00069	-0.07118
157	0.9845	-11.93	0.98448	-11.84561	0.00002	-0.08439
158	0.9987	-11.4	0.99872	-11.3213	-0.00002	-0.07870
159	0.9867	-9.82	0.98665	-9.73892	0.00005	-0.08108
160	0.9998	-12.55	0.9998	-12.47073	0.00000	-0.07927
161	1.036	8.85	1.03631	8.91796	-0.00031	-0.06796
162	0.9918	18.5	0.99245	18.55198	-0.00065	-0.05198
163	1.041	2.91	1.04223	2.98112	-0.00123	-0.07112
164	0.9839	9.66	0.98486	9.72524	-0.00096	-0.06524
165	1.0002	26.31	1.00056	26.35361	-0.00036	-0.04361
166	0.9973	30.22	0.99745	30.26342	-0.00015	-0.04342
167	0.9715	-6.91	0.97154	-6.82632	-0.00004	-0.08368
168	1.0024	-4.8	1.00248	-4.71998	-0.00008	-0.08002
169	0.9879	-6.68	0.98792	-6.59732	-0.00002	-0.08268
172	1.0244	-6.22	1.02499	-6.13422	-0.00059	-0.08578
173	0.9837	-12.75	0.98536	-12.64325	-0.00166	-0.10675
174	1.0622	-2.69	1.06252	-2.60051	-0.00032	-0.08949
175	0.973	-7.21	0.97691	-7.12146	-0.00391	-0.08854
178	0.9397	-6.56	0.94006	-6.47476	-0.00036	-0.08524
179	0.9699	-9.37	0.97133	-9.27293	-0.00143	-0.09707
180	0.9793	-3.09	0.9795	-3.0059	-0.00020	-0.08410
181	1.0518	-1.33	1.05194	-1.24413	-0.00014	-0.08587
182	1.0447	-4.19	1.04487	-4.10446	-0.00017	-0.08554
183	0.9717	7.12	0.97165	7.1982	0.00005	-0.07820
184	1.0386	-6.85	1.0386	-6.76547	0.00000	-0.08453
188	1.0533	-0.72	1.05337	-0.64218	-0.00007	-0.07782
189	0.9975	-25.84	1.00301	-25.95994	-0.00551	0.11994
192	0.9374	-11.18	0.93812	-10.94592	-0.00072	-0.23408
193	0.9897	-26.09	0.99874	-27.41924	-0.00904	1.32924
194	1.0489	-19.21	1.04877	-18.98819	0.00013	-0.22181
195	1.0357	-20.79	1.03575	-20.52518	-0.00005	-0.26482
196	0.9695	-25.32	0.97435	-24.18128	-0.00485	-1.13872
197	0.9907	-23.72	0.99261	-23.00987	-0.00191	-0.71013
199	0.9528	-26.05	0.95447	-25.39343	-0.00167	-0.65657
200	0.955	-25.93	0.95632	-25.31351	-0.00132	-0.61649
201	0.9692	-27.49	0.97446	-29.17686	-0.00526	1.68686
202	0.9908	-25.33	0.99085	-24.91513	-0.00005	-0.41487
203	1.0033	-22.35	1.00337	-21.87149	-0.00007	-0.47851
204	0.9718	-25.7	0.96752	-29.5032	0.00428	3.80320
205	0.9838	-26.07	0.98618	-28.46711	-0.00238	2.39711
206	0.9992	-27.41	1.00411	-28.41878	-0.00491	1.00878
207	1.0137	-27.44	1.01884	-28.2391	-0.00514	0.79910
208	0.9929	-26.28	0.9998	-26.94526	-0.00690	0.66526
209	0.9999	-25.66	1.00496	-25.55922	-0.00506	-0.10078
210	0.9788	-24.22	0.98063	-23.55112	-0.00183	-0.66888

NODENAME	IEEE		PowerApps		Comparison	
	VMAG V	ANG(DEG)	VMAG V	ANG(DEG)	PU Diff VMAG V	Diff ANG(DEG)
211	1.0017	-23.31	1.00183	-22.91717	-0.00013	-0.39283
212	1.0132	-22.51	1.01323	-22.14797	-0.00003	-0.36203
214	0.9919	-17.53	0.99185	-17.18236	0.00005	-0.34764
215	0.9866	-20.23	0.98659	-19.89532	0.00001	-0.33468
216	0.9751	-22.53	0.97502	-22.21537	0.00008	-0.31463
217	1.0215	-22.2	1.02136	-21.92993	0.00014	-0.27007
218	1.0075	-22.63	1.00745	-22.36496	0.00005	-0.26504
219	1.0554	-21.15	1.05512	-20.89027	0.00028	-0.25973
223	0.9965	-22.7	0.9969	-22.44098	-0.00040	-0.25902
224	1.0002	-21.55	1.00231	-21.30315	-0.00211	-0.24685
225	0.9453	-11.34	0.94604	-11.11073	-0.00074	-0.22927
226	1.018	-21.61	1.01942	-21.35038	-0.00142	-0.25962
228	1.0423	-20.94	1.04224	-20.68052	0.00006	-0.25948
229	1.0496	-19.94	1.04946	-19.68535	0.00014	-0.25465
231	1.0535	-21.22	1.05327	-20.96339	0.00023	-0.25661
232	1.0414	-23.19	1.04122	-22.93838	0.00018	-0.25162
234	1.0387	-20.89	1.03853	-20.63341	0.00017	-0.25659
235	1.0095	-21.03	1.00951	-20.76576	-0.00001	-0.26424
237	1.0558	-21.1	1.05551	-20.83995	0.00029	-0.26005
240	1.0237	-20.14	1.02378	-19.87948	-0.00008	-0.26052
244	0.9921	-20.21	0.99218	-19.83243	-0.00008	-0.37757
245	0.9711	-20.9	0.97114	-20.52185	-0.00004	-0.37815
246	0.9651	-21.74	0.9652	-21.36076	-0.00010	-0.37924
247	0.9688	-21.67	0.96911	-21.27523	-0.00031	-0.39477
248	0.976	-25.23	0.97706	-24.75571	-0.00106	-0.47429
249	0.9752	-25.65	0.97629	-25.17922	-0.00109	-0.47078
250	1.0196	-23.8	1.0206	-23.32507	-0.00100	-0.47493
281	1.0251	-20.06	1.02513	-19.80667	-0.00003	-0.25333
319	1.0152	1.48	1.0152	1.54344	0.00000	-0.06344
320	1.0146	-2.23	1.01456	-2.16601	0.00004	-0.06399
322	1.0005	-17.61	1.00043	-17.63528	0.00007	0.02528
323	0.981	-13.69	0.98089	-13.69301	0.00011	0.00301
324	0.975	-23.42	0.97494	-23.46657	0.00006	0.04657
526	0.9429	-34.31	0.94287	-34.22634	0.00003	-0.08366
528	0.9723	-37.58	0.97238	-37.48851	-0.00008	-0.09149
531	0.9604	-29.1	0.96047	-29.01025	-0.00007	-0.08975
552	1.0009	-23.36	1.00093	-23.27621	-0.00003	-0.08379
562	0.9777	-28	0.9777	-27.89054	0.00000	-0.10946
609	0.9583	-28.79	0.95833	-28.70539	-0.00003	-0.08461
664	1.0309	-17	1.03081	-16.77519	0.00009	-0.22481
1190	1.0128	3.9	1.01288	3.98416	-0.00008	-0.08416
1200	1.0244	-7.52	1.02444	-7.4437	-0.00004	-0.07630
1201	1.0122	-15.18	1.01219	-15.09707	0.00001	-0.08293
2040*	0.9653	-14.94	0.96998	-24.65384	-0.00468	9.71384
9001	1.0117	-11.25	1.01194	-11.18143	-0.00024	-0.06857
9003	0.9833	-19.68	0.98588	-19.28759	-0.00258	-0.39241
9004	0.9768	-19.82	0.97949	-19.4199	-0.00269	-0.40010
9005	1.0117	-11.32	1.01187	-11.25452	-0.00017	-0.06548
9006	1.0029	-17.42	1.0048	-17.11908	-0.00190	-0.30092

NODENAME	IEEE		PowerApps		Comparison	
	VMAG V	ANG(DEG)	VMAG V	ANG(DEG)	PU Diff VMAG V	Diff ANG(DEG)
9007	0.9913	-18.69	0.99365	-18.3273	-0.00235	-0.36270
9012	1.0023	-17.27	1.00233	-17.13119	-0.00003	-0.13881
9021	0.9887	-19.09	0.98879	-18.91428	-0.00009	-0.17572
9022	0.9648	-21.67	0.9654	-21.35919	-0.00060	-0.31081
9023	0.9747	-19.41	0.97522	-19.20296	-0.00052	-0.20704
9024	0.9706	-21.43	0.97096	-21.13673	-0.00036	-0.29327
9025	0.9649	-20.48	0.96542	-20.21815	-0.00052	-0.26185
9026	0.9657	-20.39	0.96626	-20.1327	-0.00056	-0.25730
9031	0.9318	-25.03	0.93561	-24.34169	-0.00381	-0.68831
9032	0.9441	-23.84	0.94751	-23.22851	-0.00341	-0.61149
9033	0.9286	-25.33	0.93273	-24.64782	-0.00413	-0.68218
9034	0.9973	-21.1	1.00001	-20.63009	-0.00271	-0.46991
9035	0.9506	-23.19	0.95373	-22.59393	-0.00313	-0.59607
9036	0.9598	-22.67	0.96232	-22.25697	-0.00252	-0.41303
9037	0.957	-22.58	0.96015	-22.03426	-0.00315	-0.54574
9038	0.9391	-24.41	0.94279	-23.76848	-0.00369	-0.64152
9041	0.9636	-21.33	0.96647	-20.84385	-0.00287	-0.48615
9042	0.9501	-22.5	0.95352	-21.9487	-0.00342	-0.55130
9043	0.9646	-21.42	0.96739	-21.01498	-0.00279	-0.40502
9044	0.979	-19.78	0.98163	-19.38131	-0.00263	-0.39869
9052	0.9786	-17.25	0.97881	-17.17734	-0.00021	-0.07266
9071	0.9752	-20.48	0.978	-20.02068	-0.00280	-0.45932
9072	0.9803	-19.92	0.98293	-19.495	-0.00263	-0.42500
9121	0.9799	-19.3	0.97993	-19.15517	-0.00003	-0.14483
9533	1.0402	-18.24	1.04052	-18.05984	-0.00032	-0.18016

*	As mentioned on the web-site, the original source on the University Washington can have typo errors. This possibly explains one major difference
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2.5.4 Comparison of Generation

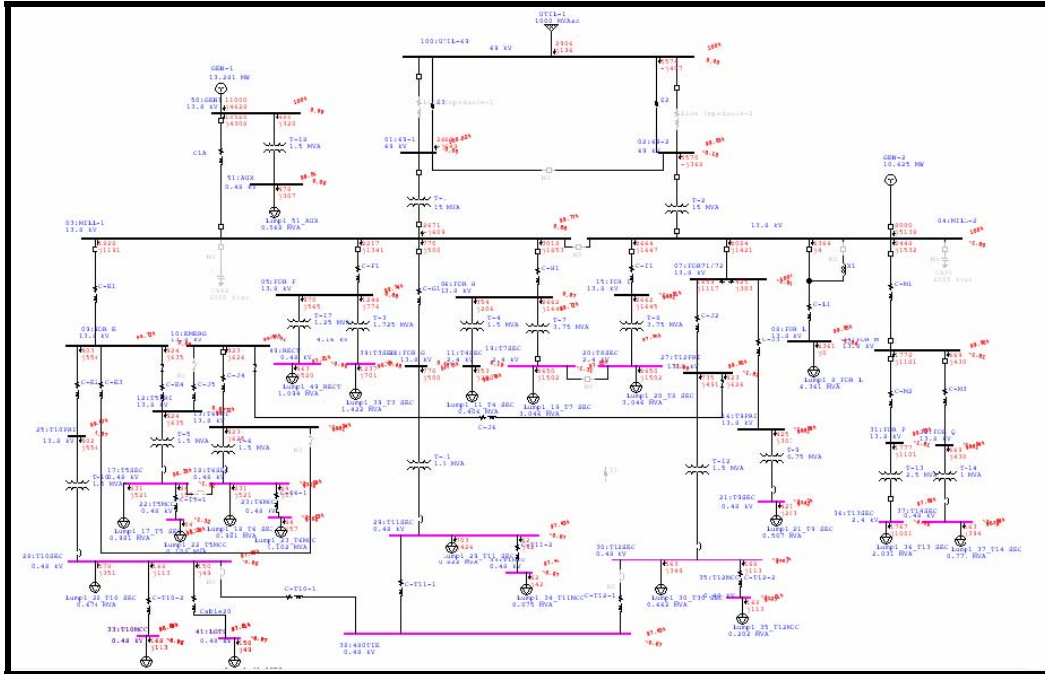
The original source data does not specify the reactive power generation or Slack MW generation. Thus, no comparison is possible.

2.6 Example from IEEE Std 399-1997

This example is taken from the IEEE Standard 399-1997, Page 157.

2.6.1 One Line Diagram

Please refer IEEE Standard 399-1997.



2.6.2 Notes

NOTES	
1	Input Data and results of IEEE Std 399-1997 test system is of limited precision (3 decimal places for voltage magnitude and 1 decimal for Angles). PowerApps results are used upto 5 decimal places. Consequently differences in the fourth decimal place for voltage magnitude and differences in the second decimal place for angles must be ignored.
2	PowerApps has used 0.00001 per unit for P and Q bus powers for convergence criteria

2.6.3 Comparison of Bus Voltages

NODENAME	IEEE-399-1997		PowerApps		Comparison	
	VMAG V	ANG(DEG)	VMAG V	ANG(DEG)	PU Diff VMAG V	Diff ANG(DEG)
69-1	1.00000	0.10000	1.00019	0.05023	-0.00019	0.04977
69-2	0.99900	-0.10000	0.99934	-0.09765	-0.00034	-0.00235
MILL-1	0.99800	0.90000	0.99767	0.87789	0.00033	0.02211
MILL-2	1.00000	-1.80000	1.00000	-1.80469	0.00000	0.00469
FDRF	0.99700	0.90000	0.99742	0.87564	-0.00042	0.02436
FDRH	0.99700	0.90000	0.99717	0.87371	-0.00017	0.02629
FDR71-72	1.00000	-1.80000	0.99999	-1.80589	0.00001	0.00589
FDRL	1.00000	-1.80000	0.99952	-1.83824	0.00048	0.03824
FDRE	0.99700	0.90000	0.99725	0.87503	-0.00025	0.02497
EMERG	0.99900	-1.80000	0.99946	-1.80891	-0.00046	0.00891
T4SEC	0.98800	0.20000	0.98777	0.19441	0.00023	0.00559
T5PRI	0.99700	0.90000	0.99719	0.87471	-0.00019	0.02529
T6PRI	0.99900	-1.80000	0.99939	-1.80933	-0.00039	0.00933
FDRI	0.99900	-1.80000	0.99908	-1.81213	-0.00008	0.01213
T9PRI	1.00000	-1.80000	0.99980	-1.80668	0.00020	0.00668
T5SEC	0.96300	-1.30000	0.96327	-1.31746	-0.00027	0.01746
T6SEC	0.97100	-3.70000	0.97082	-3.65803	0.00018	-0.04197
T7SEC	0.97100	-1.30000	0.97050	-1.31164	0.00050	0.01164
T8SEC	0.97200	-4.00000	0.97247	-3.98889	-0.00047	-0.01111
T9SEC	0.97100	-3.40000	0.97097	-3.42375	0.00003	0.02375
T5MCC	0.96300	-1.30000	0.96279	-1.31674	0.00021	0.01674
T6MCC	0.97000	-3.70000	0.97034	-3.65732	-0.00034	-0.04268
FDRM	1.00000	-1.80000	0.99956	-1.80808	0.00044	0.00808
T10PRI	0.99700	0.90000	0.99667	0.87025	0.00033	0.02975
FDRG	0.99700	0.90000	0.99748	0.87661	-0.00048	0.02339
T12PRI	1.00000	-1.80000	0.99962	-1.80804	0.00038	0.00804
T10SEC	0.97100	-1.00000	0.97075	-0.96388	0.00025	-0.03612
T11SEC	0.97400	-0.70000	0.97434	-0.67151	-0.00034	-0.02849
T12SEC	0.97700	-3.30000	0.97701	-3.27539	-0.00001	-0.02461
FDRP	0.99900	-1.80000	0.99935	-1.80972	-0.00035	0.00972
FDRQ	0.99900	-1.80000	0.99945	-1.80889	-0.00045	0.00889
T10MCC	0.97000	-1.00000	0.96980	-0.96271	0.00020	-0.03729
T11MCC	0.97400	-0.70000	0.97400	-0.67101	0.00000	-0.02899
T12MCC	0.97600	-3.30000	0.97607	-3.27423	-0.00007	-0.02577
T13SEC	0.97100	-4.10000	0.97081	-4.06322	0.00019	-0.03678
T14SEC	0.96900	-3.80000	0.96880	-3.78895	0.00020	-0.01105
480TIE	0.97400	-0.70000	0.97434	-0.67151	-0.00034	-0.02849
T3SEC	0.96600	-1.50000	0.96600	-1.48400	0.00000	-0.01600
LGTS	0.97000	-1.00000	0.97011	-0.97277	-0.00011	-0.02723
RECT	0.97200	-1.00000	0.97205	-0.96366	-0.00005	-0.03634
GEN1	1.00000	1.00000	1.00000	0.99451	0.00000	0.00549
AUX	0.98500	0.10000	0.98498	0.05766	0.00002	0.04234
UTIL-69	1.00000	0.00000	1.00000	0.00000	0.00000	0.00000

2.6.4 Comparison of Generation

NODENAME	IEEE-399-1997		PowerApps		Comparison	
	PGEN(MW)	QGEN(MVAR)	PGEN(MW)	QGEN(MVAR)	PU diff MW	PU diff MVAR
UTIL-69	2.91000	0.19600	2.90610	0.19621	0.000390	-0.000021
MILL-2	8.00000	5.13800	8.00000	5.13851	0.000000	-0.000051
GEN1	11.00000	4.62800	11.00000	4.62830	0.000000	-0.000030