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Power Flow Analysis of Simulink IEEE 57 Bus Test System Model using PSAT

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Abstract

In this paper, we have developed an IEEE 57 bus test system model for conducting the power flow analysis. Simulink library based editor in Power System Analysis Toolbox (PSAT) is used for designing the model. MATLAB is used as a platform for running the PSAT software package. Default Newton-Raphson method in PSAT is used for conducting the power flow analysis. The algorithm for designing the Simulink IEEE 57 bus test system model is developed and the power flow has conducted. All the results are tabulated and the necessary graphs were drawn for the voltage, angle, active, and the reactive power for all the 57 buses. All the results are analyzed and the conclusion has given for the validity of this computational power flow analysis.

Keywords: Load Flow, MATLAB, Power Flow, PSAT, Simulink IEEE 57 Bus Test System Model

1. Introduction

Conducting Power flow analysis/Load flow analysis will give a clear picture about the existing structure of a power system network[1,2]. The results are used for analyzing the present situation of a power system and to desire the future steps for the power system enhancement. Conducting the power flow analysis is a challenging issue for a large power system network is because; there is a huge mathematical burden with the data. There is a possible for manual errors when we go for those calculations. So there is a necessity for a computational tool[3] for reducing the mathematical burden as well as computational time. Nowadays, there are many tools available for conducting the power flow analysis for a power system network. Some of them are[5]:

- Educational Simulation Tool (EST)
- MatEMTP
- MatPower
- Power Analysis Toolbox (PAT)
- Power System Analysis Toolbox (PSAT)
- Power System Toolbox (PST)
- SimPowerSystems (SPS)
- Voltage Stability Toolbox (VST)

The tools MatPower, VST, and PSAT are the open source freely downloadable tools.

The main aim of this paper is conducting the power flow analysis for an IEEE 57 bus test system[4] to obtain fast and accurate results. Also the system network must be editable for different load conditions with different elements to add or remove for different analysis[2]. This will help for many researchers; those are interested on power system stability and enhancement.

In this work, for conducting power flow analysis, we have selected the PSAT mainly for two reasons.

- It is open source freely downloadable software and it will run in the MATLAB platform[5].
- We can develop/edit any test system using the simulink based library[5].

1.1 Power Flow Analysis

The steady state active and the reactive powers supplied by a bus in a power system network is always expressed in

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highly nonlinear algebraic equations, thus there is need for iterative methods for solving those types of equations. Traditionally power flow analysis is conducted by three methods:

- Gauss-Siedal method.
- Newton-Raphson method.
- Fast decoupled method.

Among the three methods, the Newton-Raphson method is very popular due to its fast convergence with a less iterations. PSAT's default power flow analysis is using this method for any test system network. In power flow analysis the four quantities are to be found out.

They are: 1. Voltage magnitude, 2. Phase angle, 3. Active power and 4. Reactive power.

Among the four quantities two are specified and two are to be found out for any buses in a system network[1].

Types of buses:

- *Slack bus:* At the time of start we have no idea about the transmission line losses so there is a need for a flat start. We assume the voltage and the angle initially and after getting the results, that results will be used to find the generations and the losses. Generally a high value generation bus is selected as a slack bus (Type 1)[1].
- *PV or Generator bus*: In this bus the active powers and the voltage magnitudes are specified values, the reactive powers, and the phase angles are to be found out (type 2)[1].
- *PQ or Load bus*: In this bus active and reactive powers are specified values, the voltage, and the phases angles are to be found out (Type 3)[1].

1.2 Power System Analysis Tool box

PSAT is an open source MATLAB and GNU/Octave-based software package for analysis and design of small to medium size power systems. The tool box is provided with a GUI (Graphical User Interface) and a simulink editor for editing or designing a single line diagram of any power system networks. It is available at http://faraday1.ucd.ie/psat.html, Federico Milano's website. There are many versions are available and they will run at different versions of MATLAB. PSAT can perform Power Flow (PF), Continuation Power Flow (CPF), Optimal Power Flow (OPF), Time Domain Simulation, and Small Signal Stability Analysis. The design and features of PSAT[5] is beyond the scope of this paper.

2. Newton-Raphson Solution Method

This method[1-3,6] begins with initial guesses of all voltage magnitude and angles at load buses and voltage angles at generator buses. Next, a Taylor Series is written, with the higher order terms ignored, for each of the power balance equations included in the system of equations. The result is a linear system of equations that can be expressed as:

$$\begin{bmatrix} \Delta\theta \\ \Delta|V| \end{bmatrix} = -J^{-1}\begin{bmatrix} \Delta P \\ \Delta Q \end{bmatrix}$$

Where ΔP and ΔQ are called the mismatch equations:

$$\Delta P_i = -P_i + \sum_{k=1}^{N} |V|_i |V|_k (G_{ik} cos\theta_{ik} + B_{ik} sin\theta_{ik})$$

$$\Delta Q_i = -Q_i + \sum_{k=1}^{N} |V|_i |V|_k (G_{ik} sin\theta_{ik} + B_{ik} cos\theta_{ik})$$

and J is a matrix of partial derivatives known as a Jacobian:

$$J = \begin{bmatrix} \dfrac{\partial \Delta P}{\partial \theta} & \dfrac{\partial \Delta P}{\partial |V|} \\ \dfrac{\partial \Delta Q}{\partial \theta} & \dfrac{\partial \Delta Q}{\partial |V|} \end{bmatrix}$$

The linearized system of equations is solved to determine the next guess (m+1) of voltage magnitude and angles based on:

$$\theta^{(m+1)} = \theta^{m} + \Delta\theta$$

$$|V|^{m+1} = |V|^{m} + \Delta|V|$$

This process continues until a stopping condition is met. A common stopping condition is to terminate if the norm of the mismatch equations is below a specified tolerance.

Newton- Raphson's algorithm for a power flow problem:

- Make an initial guess of all unknown voltage magnitudes and angles. It is common to use a "flat start" in which all voltage angles are set to zero and voltage magnitudes are set to 1.0 p.u.
- Solve the power balance equations using the most recent voltage angle and magnitude values.
- Linearize the system around the most recent voltage angle and magnitude values.
- Solve for the change in voltage angle and magnitude.
- Update the voltage magnitude and angles.
- Check the stopping conditions, if met then terminate, else go to step 2.

3. Methodology

The objective of this work is to build a Simulink 57 bus test system model for conducting the power flow analysis using PSAT because there is no inbuilt 57 bus test system model in PSAT versions. All the PSAT versions provided with 2, 3, 6, 9, 14, and 24 bus systems only[5]. There is a necessity to build a large system like 57 bus test system for many power system researches. The model we have developed will help for future researchers and academicians in the field of power system stability and enhancement[2].

The procedure to conduct the power flow analysis for an IEEE 57 bus test system model in PSAT:

- Take the single line diagram of an IEEE 57 bus test system with standard data[4].
- Use the simulink library to select the necessary components like slack bus, PV bus, PQ load bus, transformer, capacitor, and the transmission line etc.,
- Drag the components and draw the single line diagram.
- Feed the standard data to the corresponding components.
- Select the fixed MVA base value.
- Divide or sectionalize the test system into areas with different KVA ratings.
- Check the model connections with the standard test system.
- Save the model in PSAT.
- Conduct the power flow analysis.

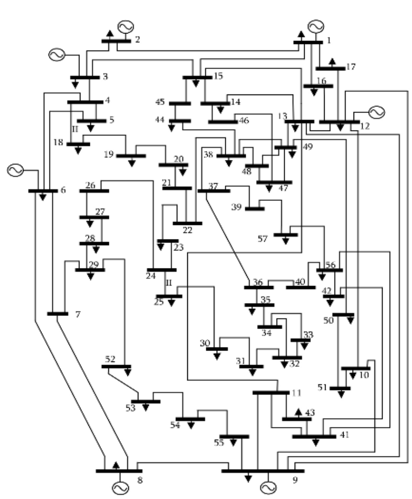

Figure 1. Single-line diagram of standard IEEE 57 bus test system.

3.1 The Proposed System Structure to be Converted as a Simulink Model

The single line diagram of the standard IEEE 57 bus test system is shown in the Figure 1.

The data to be used to form the test system model is given below:

Line data

Line No.	From Bus	To Bus	Line Impedance		Half Line Charging Susceptance (p.u)
			Resistance (p.u)	Reactance (p.u)	
1	1	2	0.0083	0.028	0.0645
2	2	3	0.0298	0.085	0.0409
3	3	4	0.0112	0.0366	0.0190
4	4	5	0.0625	0.132	0.0129
5	4	6	0.043	0.148	0.0174
6	6	7	0.02	0.102	0.0138
7	6	8	0.0339	0.173	0.0235
8	8	9	0.0099	0.0505	0.0274
9	9	10	0.0369	0.1679	0.0220
10	9	11	0.0258	0.0848	0.0109
11	9	12	0.0648	0.295	0.0386
12	9	13	0.0481	0.158	0.0203
13	13	14	0.0132	0.0434	0.0055
14	13	15	0.0269	0.0869	0.0115
15	1	15	0.0178	0.091	0.0494
16	1	16	0.0454	0.206	0.0273
17	1	17	0.0238	0.108	0.0143
18	3	15	0.0162	0.053	0.0272
19	4	18	0	0.555	0
20	4	18	0	0.43	0
21	5	6	0.0302	0.0641	0.0062
22	7	8	0.0139	0.0712	0.0097
23	10	12	0.0277	0.1262	0.0164
24	11	13	0.0223	0.0732	0.0094
25	12	13	0.0178	0.058	0.0302
26	12	16	0.018	0.0813	0.0108
27	12	17	0.0397	0.179	0.0238
28	14	15	0.0171	0.0547	0.0074
29	18	19	0.461	0.685	0
30	19	20	0.283	0.434	0
31	21	20	0	0.7767	0
32	21	22	0.0736	0.117	0
33	22	23	0.0099	0.0152	0
34	23	24	0.166	0.256	0.0042
35	24	25	0	1.182	0
36	24	25	0	1.23	0
37	24	26	0	0.0473	0
38	26	27	0.165	0.254	0
39	27	28	0.0618	0.0954	0
40	28	29	0.0418	0.0587	0
41	7	29	0	0.0648	0
42	25	30	0.135	0.202	0
43	30	31	0.326	0.497	0
44	31	32	0.507	0.755	0
45	32	33	0.0392	0.036	0
46	34	32	0	0.953	0
47	34	35	0.052	0.078	0.0016

48	35	36	0.043	0.0537	0.0008
49	36	37	0.029	0.0366	0
50	37	38	0.0651	0.1009	0.0010
51	37	39	0.0239	0.0379	0
52	36	40	0.03	0.0466	0
53	22	38	0.0192	0.0295	0
54	11	41	0	0.749	0
55	41	42	0.207	0.352	0
56	41	43	0	0.412	0
57	38	44	0.0289	0.0585	0.0010
58	15	45	0	0.1042	0
59	14	46	0	0.0735	0
60	46	47	0.023	0.068	0.0016
61	47	48	0.0182	0.0233	0
62	48	49	0.0834	0.129	0.0024
63	49	50	0.0801	0.128	0
64	50	51	0.1386	0.22	0
65	10	51	0	0.0712	0
66	13	49	0	0.191	0
67	29	52	0.1442	0.187	0
68	52	53	0.0762	0.0984	0
69	53	54	0.1878	0.232	0
70	54	55	0.1732	0.2265	0
71	11	43	0	0.153	0
72	44	45	0.0624	0.1242	0.0020
73	40	56	0	1.195	0
74	56	41	0.553	0.549	0
75	56	42	0.2125	0.354	0
76	39	57	0	1.355	0
77	57	56	0.174	0.26	0
78	38	49	0.115	0.177	0.0030
79	38	48	0.0312	0.0482	0
80	9	55	0	0.1205	0

Bus Data

Bus No.	Bus Voltage		Generation		Load		Reactive Power Limits	
	Magnitude (p.u)	Phase Angle (degrees)	Real Power (p.u)	Reactive Power (p.u)	Real Power (p.u)	Reactive Power (p.u)	Q_{min} (p.u)	Q_{max} (p.u)
1	1.040	0.000	4.78	1.289	0.55	0.17	–	–
2	1.010	0.000	0.000	–0.008	0.03	0.88	–0.17	0.50
3	0.985	0.000	0.4	–0.01	0.41	0.21	–0.10	0.60
4	1.000	0.000	0.000	0.000	0.000	0.000	–	–
5	1.000	0.000	0.000	0.000	0.13	0.04	–	–
6	0.98	0.000	0.000	0.008	0.75	0.02	–0.08	0.25
7	1.000	0.000	0.000	0.000	0.000	0.000	–	–
8	1.005	0.000	4.50	0.621	1.50	0.22	–1.40	2
9	0.98	0.000	0.000	0.022	1.21	0.26	–0.03	0.09
10	1.000	0.000	0.000	0.000	0.05	0.02	–	–
11	1.000	0.000	0.000	0.000	0.000	0.000	–	–
12	1.015	0.000	3.10	1.285	3.77	0.24	–0.5	1.55
13	1.000	0.000	0.000	0.000	0.18	0.023	–	–
14	1.000	0.000	0.000	0.000	0.105	0.053	–	–
15	1.000	0.000	0.000	0.000	0.22	0.05	–	–
16	1.000	0.000	0.000	0.000	0.43	0.03	–	–
17	1.000	0.000	0.000	0.000	0.42	0.08	–	–
18	1.000	0.000	0.000	0.000	0.272	0.098	–	–
19	1.000	0.000	0.000	0.000	0.033	0.06	–	–
20	1.000	0.000	0.000	0.000	0.023	0.01	–	–
21	1.000	0.000	0.000	0.000	0.000	0.000	–	–
22	1.000	0.000	0.000	0.000	0.000	0.000	–	–
23	1.000	0.000	0.000	0.000	0.063	0.021	–	–
24	1.000	0.000	0.000	0.000	0.000	0.000	–	–
25	1.000	0.000	0.000	0.000	0.063	0.032	–	–
26	1.000	0.000	0.000	0.000	0.000	0.000	–	–
27	1.000	0.000	0.000	0.000	0.093	0.005	–	–
28	1.000	0.000	0.000	0.000	0.046	0.023	–	–
29	1.000	0.000	0.000	0.000	0.17	0.026	–	–
30	1.000	0.000	0.000	0.000	0.036	0.018	–	–
31	1.000	0.000	0.000	0.000	0.058	0.029	–	–
32	1.000	0.000	0.000	0.000	0.016	0.008	–	–
33	1.000	0.000	0.000	0.000	0.038	0.019	–	–
34	1.000	0.000	0.000	0.000	0.000	0.000	–	–
35	1.000	0.000	0.000	0.000	0.06	0.03	–	–
36	1.000	0.000	0.000	0.000	0.000	0.000	–	–
37	1.000	0.000	0.000	0.000	0.000	0.000	–	–
38	1.000	0.000	0.000	0.000	0.14	0.07	–	–
39	1.000	0.000	0.000	0.000	0.000	0.000	–	–
40	1.000	0.000	0.000	0.000	0.000	0.000	–	–
41	1.000	0.000	0.000	0.000	0.063	0.03	–	–
42	1.000	0.000	0.000	0.000	0.071	0.044	–	–
43	1.000	0.000	0.000	0.000	0.02	0.01	–	–
44	1.000	0.000	0.000	0.000	0.12	0.018	–	–
45	1.000	0.000	0.000	0.000	0.000	0.000	–	–
46	1.000	0.000	0.000	0.000	0.000	0.000	–	–
47	1.000	0.000	0.000	0.000	0.297	0.116	–	–
48	1.000	0.000	0.000	0.000	0.000	0.000	–	–
49	1.000	0.000	0.000	0.000	0.18	0.085	–	–
50	1.000	0.000	0.000	0.000	0.21	0.105	–	–
51	1.000	0.000	0.000	0.000	0.18	0.053	–	–
52	1.000	0.000	0.000	0.000	0.049	0.022	–	–
53	1.000	0.000	0.000	0.000	0.20	0.10	–	–
54	1.000	0.000	0.000	0.000	0.041	0.014	–	–
55	1.000	0.000	0.000	0.000	0.068	0.034	–	–
56	1.000	0.000	0.000	0.000	0.076	0.022	–	–
57	1.000	0.000	0.000	0.000	0.067	0.02	–	–

Transformer tap setting data

From Bus	To Bus	Tap Setting Value (p.u.)
4	18	0.97
4	18	0.978
21	20	1.043
24	26	1.043
7	29	0.967
34	32	0.975
11	41	0.955
15	45	0.955
14	46	0.9
10	51	0.93
13	49	0.895
11	43	0.958
40	56	0.958
39	57	0.98
9	55	0.94
24	24	1.000
24	25	1.000

Shunt capacitor data

Bus No.	Susceptance (p.u.)
18	0.10
25	0.059
53	0.063

3.2 PSAT Simulink Library Editor

The simulink library is used to design the system model and also to edit the system by changing the components or by changing the data.

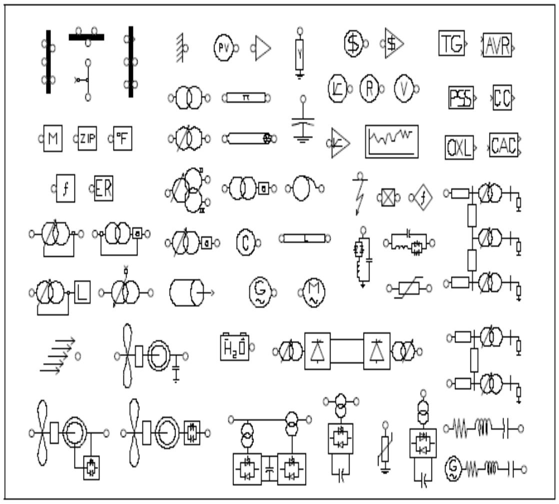

Figure 2. PSAT Simulink library components.

3.3 The Simulink IEEE 57 Bus Test System Model for Power Flow Analysis

The Simulink test system model is shown in the Figure 3. It has 7 generators, 57 buses, 17 transformers, and 63 lines (there is no line limits in 57 bus systems). It has divided into three areas (black-area 1, Green-area 2, and blue-area 3) and the corresponding voltage ratings are 69, 18, and 13.8KV. We have selected a 100 MVA base for this system structure. All the above standard data are used for designing the model. This model is loaded in PSAT and the power flow analysis has conducted for getting the results.

4. Results

The power flow results are given below:
POWER FLOW REPORT
P S A T 2.1.3
Author: Federico Milano, (c) 2002-2009
e-mail: Federico.Milano@uclm.es
website: http://www.uclm.es/area/gsee/Web/Federico

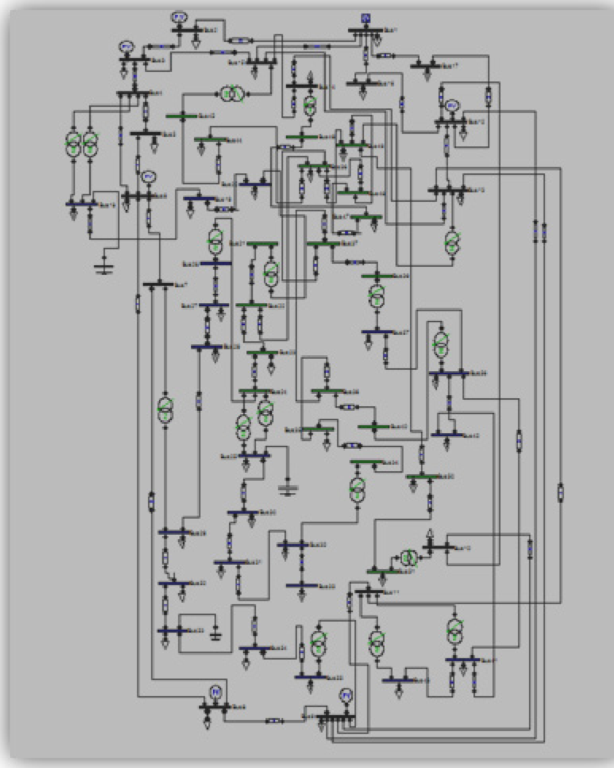

Figure 3. Simulink 57 bus test system model.

File: D:\bin\psat-2.1.3-mat\psat\tests\d_057.mdl
Date: 04-May-2015 13:29:18
NETWORK STATISTICS

Buses:	57
Lines:	63
Transformers:	17
Generators:	7
Loads:	42

SOLUTION STATISTICS

Number of Iterations:	5
Maximum P mismatch [p.u.]	0
Maximum Q mismatch [p.u.]	0
Power rate [MVA]	100

Bus	V [p.u.]	phase [rad]	P gen [p.u.]	Q gen [p.u.]	P load [p.u.]	Q load [p.u.]
Bus1	1.04	0	4.8393	1.3086	0.55	0.17
Bus10	0.98544	-0.20256	0	0	0.05	0.02
Bus11	0.97177	-0.18176	0	0	0	0
Bus12	1.015	-0.18506	3.1	1.3275	3.77	0.24
Bus13	0.977	-0.1736	0	0	0.18	0.023

Bus14	0.96696	-0.16584	0	0	0.105	0.053
Bus15	0.9858	-0.12755	0	0	0.22	0.05
Bus16	1.0133	-0.15627	0	0	0.43	0.03
Bus17	1.0174	-0.09503	0	0	0.42	0.08
Bus18	0.98871	-0.21246	0	0	0.272	0.00025
Bus19	0.92901	-0.2275	0	0	0.033	0.06
Bus2	1.01	-0.02108	0	-0.00684	0.03	0.88
Bus20	0.92993	-0.24119	0	0	0.023	0.01
Bus21	0.98913	-0.23726	0	0	0	0
Bus22	0.99239	-0.23851	0	0	0	0
Bus23	0.99037	-0.24031	0	0	0.063	0.021
Bus24	0.97146	-0.25749	0	0	0	0
Bus25	0.858	-0.33867	0	0	0.063	-0.01143
Bus26	0.98119	-0.19926	0	0	0	0
Bus27	0.99158	-0.1886	0	0	0.093	0.005
Bus28	1.0019	-0.17606	0	0	0.046	0.023
Bus29	1.0121	-0.16685	0	0	0.17	0.026
Bus3	0.985	-0.10594	0.4	0.06548	0.41	0.21
Bus30	0.84434	-0.35274	0	0	0.036	0.018
Bus31	0.83604	-0.37139	0	0	0.058	0.029
Bus32	0.88472	-0.35913	0	0	0.016	0.008
Bus33	0.88226	-0.35993	0	0	0.038	0.019
Bus34	0.93505	-0.254	0	0	0	0
Bus35	0.94619	-0.25054	0	0	0.06	0.03
Bus36	0.95887	-0.24659	0	0	0	0
Bus37	0.96868	-0.24416	0	0	0	0
Bus38	0.99715	-0.23537	0	0	0.14	0.07
Bus39	0.9672	-0.24429	0	0	0	0
Bus4	0.9796	-0.12872	0	0	0	0
Bus40	0.95737	-0.24643	0	0	0	0
Bus41	1.0033	-0.21468	0	0	0.063	0.03
Bus42	0.96497	-0.24468	0	0	0.071	0.044
Bus43	1.0099	-0.1935	0	0	0.02	0.01
Bus44	1.004	-0.21879	0	0	0.12	0.018
Bus45	1.0295	-0.17114	0	0	0	0
Bus46	1.0489	-0.20621	0	0	0	0
Bus47	1.0197	-0.23192	0	0	0.297	0.116
Bus48	1.0127	-0.2337	0	0	0	0
Bus49	1.0187	-0.24147	0	0	0.22068	0.10421
Bus5	0.97612	-0.14895	0	0	0.13	0.04
Bus50	1.0178	-0.24207	0	0	0.21	0.105
Bus51	1.0495	-0.22528	0	0	0.18	0.053
Bus52	0.98129	-0.19872	0	0	0.049	0.022
Bus53	0.97142	-0.21288	0	0	0.2	0.04055
Bus54	0.99565	-0.20574	0	0	0.041	0.014
Bus55	1.029	-0.19199	0	0	0.068	0.034
Bus56	0.95828	-0.259	0	0	0.076	0.022
Bus57	0.95061	-0.2734	0	0	0.067	0.02
Bus6	0.98	-0.15074	0	0.00728	0.75	0.02
Bus7	0.98545	-0.13009	0	0	0	0
Bus8	1.005	-0.07795	4.5	0.60486	1.5	0.22
Bus9	0.98	-0.16902	0	-0.16963	1.21	0.026

LINE FLOWS

From Bus	To Bus [p.u.]	Line [p.u.]	P Flow [p.u.]	Q Flow [p.u.]	P Loss [p.u]	Q Loss
Bus2	Bus1	1	-1.0194	-0.83744	0.0133	-0.09069
Bus3	Bus15	2	0.35913	-0.14673	0.0024	-0.04499
Bus1	Bus16	3	0.80073	-0.00877	0.02693	0.06464
Bus13	Bus14	4	-0.09164	0.24931	0.00101	-0.00706
Bus13	Bus15	5	-0.49025	0.05358	0.00689	0.00011
Bus14	Bus15	6	-0.69887	-0.10875	0.00912	0.01507
Bus18	Bus19	7	0.05386	0.05007	0.00255	0.00379
Bus4	Bus6	8	0.13144	-0.05595	0.00084	-0.03051
Bus5	Bus6	9	-0.0009	-0.06456	0.00011	-0.01163
Bus20	Bus19	10	-0.01814	0.01399	0.00017	0.00026
Bus21	Bus22	11	-0.00486	-0.02448	5e-005	7e-005
Bus12	Bus9	12	-0.02629	0.08687	0.00105	-0.07205
Bus15	Bus1	13	-1.4737	-0.25538	0.04057	0.10596
Bus22	Bus38	14	-0.14719	-0.06419	0.0005	0.00077
Bus22	Bus23	15	0.14228	0.03963	0.00022	0.00034
Bus23	Bus24	16	0.07906	0.0183	0.00114	-0.00632
Bus13	Bus9	17	-0.03059	-0.02857	5e-005	-0.0387
Bus10	Bus12	18	-0.18034	-0.20594	0.00196	-0.0239
Bus25	Bus30	19	0.06185	0.01702	0.00075	0.00113
Bus26	Bus27	20	-0.04693	-0.00944	0.00039	0.0006
Bus27	Bus28	21	-0.14032	-0.01504	0.00125	0.00193
Bus28	Bus29	22	-0.18757	-0.03998	0.00153	0.00215
Bus29	Bus52	23	0.18794	0.02429	0.00506	0.00656
Bus17	Bus1	24	-0.92211	0.01927	0.01958	0.05858
Bus30	Bus31	25	0.02509	-0.00211	0.00029	0.00044
Bus31	Bus32	26	-0.0332	-0.03155	0.00152	0.00227
Bus32	Bus33	27	0.03809	0.01908	9e-005	8e-005
Bus34	Bus35	28	-0.08881	-0.07575	0.0008	-0.00163
Bus35	Bus36	29	-0.14961	-0.10411	0.00159	0.00053
Bus36	Bus37	30	-0.16301	-0.1279	0.00135	0.00171
Bus4	Bus5	31	0.13028	-0.04673	0.00118	-0.02217
Bus40	Bus36	32	-0.0118	-0.02322	2e-005	3e-005
Bus39	Bus37	33	-0.01936	-0.02569	3e-005	4e-005
Bus37	Bus38	34	-0.18375	-0.15534	0.004	0.00426

Bus3	Bus2	35	-0.96076	0.04956	0.0286	0.00016
Bus38	Bus49	36	-0.03071	-0.10416	0.00129	-0.00411
Bus38	Bus48	37	-0.1713	-0.2104	0.00231	0.00357
Bus38	Bus44	38	-0.27342	0.02	0.00219	0.00242
Bus41	Bus42	39	0.10956	0.04603	0.0029	0.00494
Bus41	Bus43	40	-0.0521	-0.01552	0	0.00121
Bus6	Bus8	41	-0.42262	-0.0663	0.00637	-0.01379
Bus6	Bus7	42	-0.19779	-0.0248	0.00082	-0.02249
Bus56	Bus41	43	-0.07693	0.00065	0.00356	0.00354
Bus56	Bus42	44	-0.03536	0.0034	0.00029	0.00049
Bus44	Bus45	45	-0.39561	-0.00042	0.00969	0.01515
Bus16	Bus12	46	0.3438	-0.10341	0.00222	-0.01218
Bus47	Bus48	47	0.19724	0.15154	0.00108	0.00139
Bus46	Bus47	48	0.50121	0.28471	0.00697	0.01718
Bus48	Bus49	49	0.02255	-0.06381	0.00035	-0.00441
Bus49	Bus50	50	0.08579	0.03723	5e-005	8e-005
Bus50	Bus51	51	-0.12427	-0.06785	0.00268	0.00426
Bus52	Bus53	52	0.13389	-0.00427	0.00142	0.00183
Bus53	Bus54	53	-0.06753	-0.04665	0.00134	0.00166
Bus54	Bus55	54	-0.10987	-0.06231	0.00279	0.00365
Bus57	Bus56	55	-0.04764	0.00419	0.00044	0.00066
Bus3	Bus4	56	0.59163	-0.04736	0.00405	-0.02343
Bus10	Bus9	57	-0.17661	0.05262	0.00139	-0.03615
Bus12	Bus13	58	0.00779	0.63267	0.00761	-0.03513
Bus7	Bus8	59	-0.74566	-0.11555	0.00812	0.02237
Bus9	Bus8	60	-1.7844	-0.08083	0.03285	0.11359
Bus11	Bus9	61	-0.157	-0.05594	0.00073	-0.01836
Bus13	Bus11	62	0.11639	0.02579	0.00034	-0.01672
Bus17	Bus12	63	0.50211	-0.09927	0.00988	-0.00459
Bus7	Bus29	64	0.54705	0.11324	0	0.02082
Bus24	Bus25	65	0.05495	0.09185	0	0.01493
Bus39	Bus57	66	0.01936	0.02569	0	0.0015
Bus24	Bus25	67	0.06989	-0.06061	0	0.01072
Bus34	Bus32	68	0.08881	0.07575	0	0.01485
Bus24	Bus26	69	-0.04693	-0.00663	0	0.00281
Bus10	Bus51	70	0.30695	0.13332	0	0.00821
Bus4	Bus18	71	0.1416	0.04222	0	0.01263
Bus13	Bus49	72	0.31627	0.34469	0	0.04379
Bus4	Bus18	73	0.18426	0.03653	0	0.01581
Bus9	Bus55	74	0.18066	0.10544	0	0.00549
Bus15	Bus45	75	0.4053	0.0333	0	0.01773
Bus14	Bus46	76	0.50121	0.31212	0	0.02741
Bus40	Bus56	77	0.0118	0.02322	0	0.00071
Bus21	Bus20	78	0.00486	0.02448	0	0.00049
Bus11	Bus43	79	0.0721	0.0277	0	0.00097
Bus11	Bus41	80	0.20094	0.07075	0	0.00735

LINE FLOWS

From Bus	To Bus [p.u.]	Line [p.u.]	P Flow [p.u.]	Q Flow[p.u.]	P Loss [p.u.]	Q Loss [p.u.]
Bus1	Bus2	1	1.0327	0.74675	0.0133	-0.09069
Bus15	Bus3	2	-0.35674	0.10174	0.0024	-0.04499
Bus16	Bus1	3	-0.7738	0.07341	0.02693	0.06464
Bus14	Bus13	4	0.09266	-0.256370.00101	-0.00706	
Bus15	Bus13	5	0.49714	-0.05347	0.00689	0.00011
Bus15	Bus14	6	0.70799	0.12382	0.00912	0.01507
Bus19	Bus18	7	-0.05131	-0.04628	0.00255	0.00379
Bus6	Bus4	8	-0.1306	0.02544	0.00084	-0.03051
Bus6	Bus5	9	0.00101	0.05293	0.00011	-0.01163
Bus19	Bus20	10	0.01831	-0.01372	0.00017	0.00026
Bus22	Bus21	11	0.00491	0.02455	5e-005	7e-005
Bus9	Bus12	12	0.02734	-0.15891	0.00105	-0.07205
Bus1	Bus15	13	1.5143	0.36134	0.04057	0.10596
Bus38	Bus22	14	0.14769	0.06496	0.0005	0.00077
Bus23	Bus22	15	-0.14206	-0.0393	0.00022	0.00034
Bus24	Bus23	16	-0.07792	-0.02462	0.00114	-0.00632
Bus9	Bus13	17	0.03064	-0.01014	5e-005	-0.0387
Bus12	Bus10	18	0.1823	0.18204	0.00196	-0.0239
Bus30	Bus25	19	-0.06109	-0.01589	0.00075	0.00113
Bus27	Bus26	20	0.04732	0.01004	0.00039	0.0006
Bus28	Bus27	21	0.14157	0.01698	0.00125	0.00193
Bus29	Bus28	22	0.18911	0.04213	0.00153	0.00215
Bus52	Bus29	23	-0.18289	-0.01773	0.00506	0.00656
Bus1	Bus17	24	0.94169	0.03931	0.01958	0.05858
Bus31	Bus30	25	-0.0248	0.00255	0.00029	0.00044
Bus32	Bus31	26	0.03472	0.03381	0.00152	0.00227
Bus33	Bus32	27	-0.038	-0.019	9e-005	8e-005
Bus35	Bus34	28	0.08961	0.07411	0.0008	-0.00163
Bus36	Bus35	29	0.15119	0.10465	0.00159	0.00053
Bus37	Bus36	30	0.16437	0.12961	0.00135	0.00171
Bus5	Bus4	31	-0.1291	0.02456	0.00118	-0.02217
Bus36	Bus40	32	0.01182	0.02325	2e-005	3e-005
Bus37	Bus39	33	0.01938	0.02573	3e-005	4e-005
Bus38	Bus37	34	0.18775	0.1596	0.004	0.00426
Bus2	Bus3	35	0.98936	-0.0494	0.0286	0.00016
Bus49	Bus38	36	0.032	0.10006	0.00129	-0.00411
Bus48	Bus38	37	0.17361	0.21397	0.00231	0.00357
Bus44	Bus38	38	0.27561	-0.01758	0.00219	0.00242
Bus42	Bus41	39	-0.10665	-0.04109	0.0029	0.00494
Bus43	Bus41	40	0.0521	0.01673	0	0.00121
Bus8	Bus6	41	0.42899	0.05251	0.00637	-0.01379

Bus7	Bus6	42	0.19861	0.00231	0.00082	-0.02249
Bus41	Bus56	43	0.08049	0.00289	0.00356	0.00354
Bus42	Bus56	44	0.03565	-0.00291	0.00029	0.00049
Bus45	Bus44	45	0.4053	0.01557	0.00969	0.01515
Bus12	Bus16	46	-0.34157	0.09122	0.00222	-0.01218
Bus48	Bus47	47	-0.19616	-0.15015	0.00108	0.00139
Bus47	Bus46	48	-0.49424	-0.26754	0.00697	0.01718
Bus49	Bus48	49	-0.0222	0.0594	0.00035	-0.00441
Bus50	Bus49	50	-0.08573	-0.03715	5e-005	8e-005
Bus51	Bus50	51	0.12695	0.07211	0.00268	0.00426
Bus53	Bus52	52	-0.13247	0.0061	0.00142	0.00183
Bus54	Bus53	53	0.06887	0.04831	0.00134	0.00166
Bus55	Bus54	54	0.11266	0.06595	0.00279	0.00365
Bus56	Bus57	55	0.04808	-0.00353	0.00044	0.00066
Bus4	Bus3	56	-0.58758	0.02393	0.00405	-0.02343
Bus9	Bus10	57	0.178	-0.08877	0.00139	-0.03615
Bus13	Bus12	58	-0.00018	-0.6678	0.00761	-0.03513
Bus8	Bus7	59	0.75378	0.13793	0.00812	0.02237
Bus8	Bus9	60	1.8172	0.19442	0.03285	0.11359
Bus9	Bus11	61	0.15773	0.03758	0.00073	-0.01836
Bus11	Bus13	62	-0.11605	-0.0425	0.00034	-0.01672
Bus12	Bus17	63	-0.49223	0.09468	0.00988	-0.00459
Bus29	Bus7	64	-0.54705	-0.09241	0	0.02082
Bus25	Bus24	65	-0.05495	-0.07692	0	0.01493
Bus57	Bus39	66	-0.01936	-0.02419	0	0.0015
Bus25	Bus24	67	-0.06989	0.07133	0	0.01072
Bus32	Bus34	68	-0.08881	-0.0609	0	0.01485
Bus26	Bus24	69	0.04693	0.00944	0	0.00281
Bus51	Bus10	70	-0.30695	-0.12511	0	0.00821
Bus18	Bus4	71	-0.1416	-0.02959	0	0.01263
Bus49	Bus13	72	-0.31627	-0.3009	0	0.04379
Bus18	Bus4	73	-0.18426	-0.02072	0	0.01581
Bus55	Bus9	74	-0.18066	-0.09995	0	0.00549
Bus45	Bus15	75	-0.4053	-0.01557	0	0.01773
Bus46	Bus14	76	-0.50121	-0.28471	0	0.02741
Bus56	Bus40	77	-0.0118	-0.02251	0	0.00071
Bus20	Bus21	78	-0.00486	-0.02399	0	0.00049
Bus43	Bus11	79	-0.0721	-0.02673	0	0.00097
Bus41	Bus11	80	-0.20094	-0.06339	0	0.00735

GLOBAL SUMMARY REPORT

TOTAL GENERATION

REAL POWER [p.u.] 12.8393
REACTIVE POWER [p.u.] 3.1372

TOTAL LOAD

REAL POWER [p.u.] 12.5487
REACTIVE POWER [p.u.] 3.0026

TOTAL LOSSES

REAL POWER [p.u.] 0.29065
REACTIVE POWER [p.u.] 0.13467

The voltage profile, Phase angles, Active power and the reactive power for all the 57 buses are given for a graphical view.

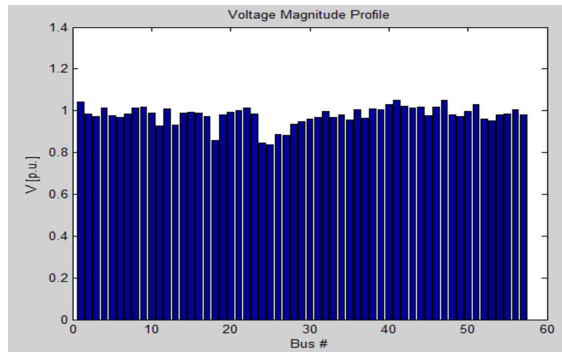

Figure 4. Voltage magnitudes for all the 57 buses.

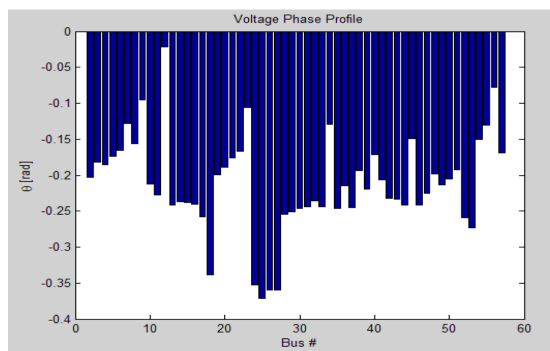

Figure 5. Phase angles for all the 57 buses.

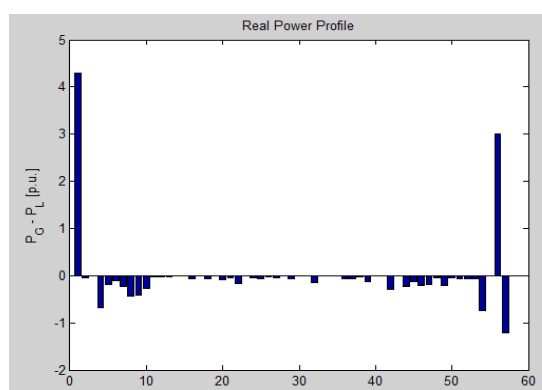

Figure 6. Active power in all the 57 buses.

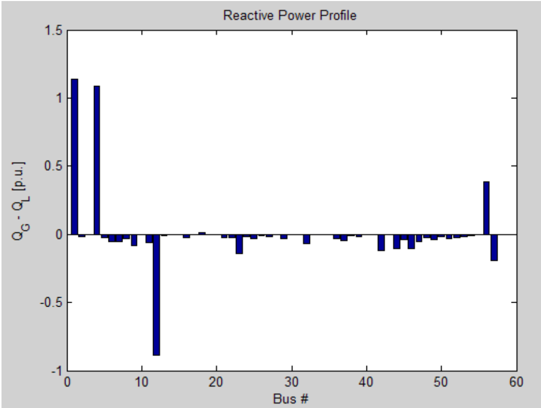

Figure 7. Reactive power in all the 57 buses.

5. Conclusion

In this work, we have conducted the power flow analysis in Power System Analysis Toolbox (PSAT). An IEEE 57 bus test system with its standard data has selected for this purpose. Then we have designed the single line diagram of IEEE 57 bus test system in to a PSAT modal. The power flow analysis has conducted using this model and all the results are tabulated. The corresponding graphs for the voltage, angle, active and reactive power profiles were also been drawn. All the active and the reactive power mismatches are zero and the number of iterations for the convergence is only 5. This gives the validity of this work and this method can be used for any power system analysis researches.

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