Power Flow Analysis on IEEE 57 bus System using MATLAB

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Abstract- **For proper planning and operation of power system, economic scheduling of generating units and to achieve power through tie line as per agreement, power flow analysis is a must. It is performed to have clear knowledge regarding bus voltage magnitude and angle and line flows. A number of methods are being used all over the world for power flow analysis. Newton Raphson method, Gauss Seidal method, fast decoupled load flow methods are a few to name. Now days, various soft computing techniques are adopted by researchers as well as practising engineers for load flow analysis to cater various needs of the research institutes and the utilities. Every method has got advantages as well as disadvantages. The objective of this paper is to develop an user friendly software to perform load flow analysis for IEEE 57 bus system. The software will be helpful for researchers, practising engineers, students of power system of various levels to carry out power flow quickly and efficiently as per their requirement. The software is developed using MATLAB programming.**

Keywords - Power flow, Newton Raphson method, line loss.

I. INTRODUCTION

An ideal power system is composed of three main networks. These are generating network, transmission network and distribution network. The power system is complete with various kinds of loads along with the above networks. Power flow analysis aims at better operation of the power system under normal as well as abnormal conditions. For augmentation of power system, contingency analysis, expansion of power system, power flow analysis is a must.
In this process, profiles of the bus voltages, flow of Active and Reactive power, effect of re-arranging circuit configurations and installation of regulating devices, etc. for different loading conditions are to be analysed efficiently. Modern power systems have become so large and complex that these investigations should be done with some sort of computer programs. This program and subsequent assessment of power flow is commonly known as load flow analysis. Load flow study thus aims at arriving at a steady state solution of complete power networks.

Load flow analysis of a real time power system comprising a large number of buses is complex because many data relating to power, voltage, condition of circuit breaker, position of tap of transformer, condition of reactive power source and sink being necessary. Hence it is necessary to proceed systematically by first formulating the network model of the system. A power system comprises of several buses, which are interconnected by means of transmission lines. With the help of power flow analysis, the voltage magnitude and angles for all buses in steady state condition can be obtained. For efficient power flow through the transmission line, it is required to keep voltage level of the buses within specified limit. Once the bus voltages and angles are calculated, the real and reactive power flow through the lines can be computed with the help of MATLAB. [1]

The steady state real and reactive power supplied by a bus in a power network is expressed in terms of nonlinear algebraic equations. Therefore it would require iterative methods for solving these equations.
In this paper Newton Raphson method for power flow analysis is used because it is preferred to Gauss Sidle method considering several computational aspects. [2]

II. NECESSITY OF POWER FLOW ANALYSIS

Load flow studies are undertaken to determine

i) The bus voltage magnitude and system voltage profile.

ii) The line flows.

iii) The effect of change in circuit configurations and inclusion of new circuit elements on system loading.

iv) The effect of temporary loss of transmission capacity and generations on supplied load and accompanied effects.

v) The effect of in-phase and quadrature boost voltages on system loading data obtained from load flow can be further useful for economic system operation and system transmission loss minimization.

III. POWER FLOW ANALYSIS

A bus is a node at which one or many lines, one or many loads and generators are connected. In a power system each node or bus is associated with 4 quantities, such as magnitude of voltage, phage angle of voltage, active or true power and reactive power in load flow problem two out of these 4 quantities are specified and remaining 2 are required to be determined through the solution of equation. Depending on the quantities that have been specified, the buses are classified into 3 categories. Buses are classified according to which two out of the four variables are specified

1. **Load bus**: No generator is connected to the bus. At this bus the real and reactive power are specified. it is desired to find out the voltage magnitude and phase angle through load flow solutions. It is required to specify only Pd and Qd at such bus as at a load bus voltage can be allowed to vary within the permissible values.

2. **Generator bus or voltage controlled bus**: Here the voltage magnitude corresponding to the generator voltage and real power Pg corresponds to its rating are specified. It is required to find out the reactive power generation Qg and phase angle of the bus voltage.

3. **Slack (swing) bus**: For the Slack Bus, it is assumed that the voltage magnitude $|V|$ and voltage phase angle ѳ are known, whereas real and reactive powers Pg and Qg are obtained through the load flow solution. [2, 8]

Newton - Raphson Technique:

The Newton-Raphson method is widely used for solving non-linear equations. It transforms the original non-linear problem into a sequence of linear problems whose solutions approach the solutions of the original problem. The Newton-Raphson method is powerful method of solving non-linear algebraic equations. The fundamental Newton-Raphson expression allows for convergence to be assessed by comparing power mismatches (ΔS) against a prespecified tolerance rather than voltage comparisons.

$$S_k^* = V_k^* \sum_{j=1}^{n} Y_{kj} V_j$$

$$V_k = |V_k| e^{j\delta_k}$$

$$V_j = |V_j| e^{j\delta_j}$$

$$\mathbf{Y}_{kj} = |\mathbf{Y}_{kj}| e^{j\theta_{kj}}$$

Then

$$S_k^* = |V_k| \sum_{j=1}^{n} |Y_{kj}| |V_j| e^{j(\theta_{kj}+\delta_j-\delta_k)}$$

From which

$$\left.\begin{aligned} P_k &= |V_k| \sum_{j=1}^{n} |Y_{kj}| |V_j| \cos(\delta_k - \delta_j - \theta_{kj}) \\ Q_k &= |V_k| \sum_{j=1}^{n} |Y_{kj}| |V_j| \sin(\delta_k - \delta_j - \theta_{kj}) \end{aligned}\right\}$$

This Equation is in a suitable form for partial differentiation to derive the elements of the Jacobian, J given by the following matrix.

$$\begin{bmatrix} J_1 & J_2 \\ J_3 & J_4 \end{bmatrix}$$

Real and reactive power mismatch can be expressed by the following matrix equation

$$\begin{bmatrix} \Delta P \\ \Delta Q \end{bmatrix} = \begin{bmatrix} J_1 & J_2 \\ J_3 & J_4 \end{bmatrix} \begin{bmatrix} \Delta\delta \\ \Delta|V|/|V| \end{bmatrix}$$

A simplified flowchart of Newton Raphson method is shown in Fig 1.

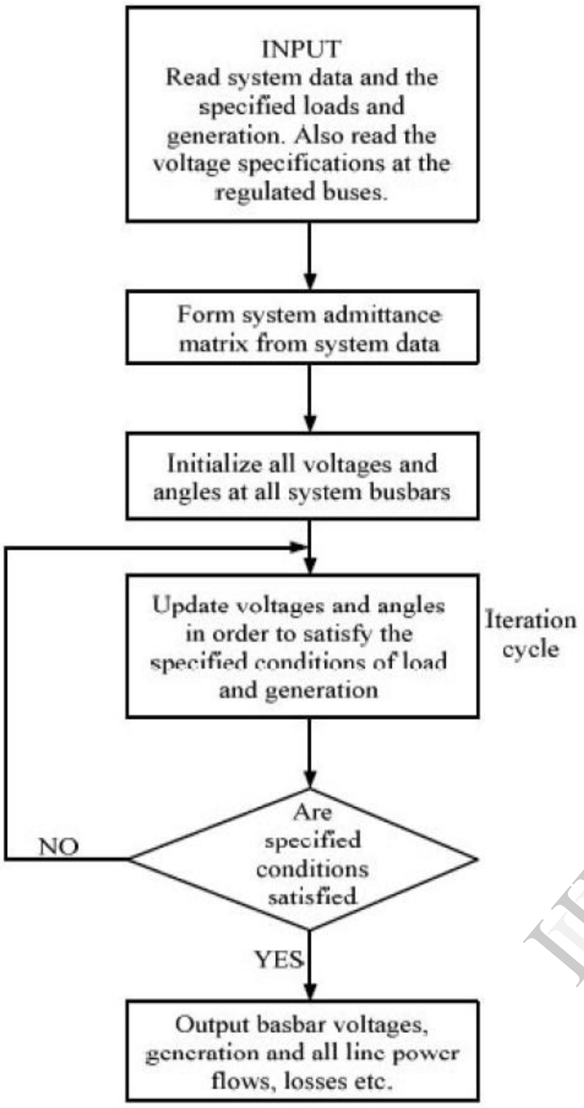

Fig1: Flowchart of Newton Raphson method

The Newton Raphson method is the most robust power flow algorithm used in practice. However, drawback of this method lies in the fact that the terms of the Jacobian matrix must be recalculated and then the entire set of linear equations must also be solved in each iteration. [3,7]

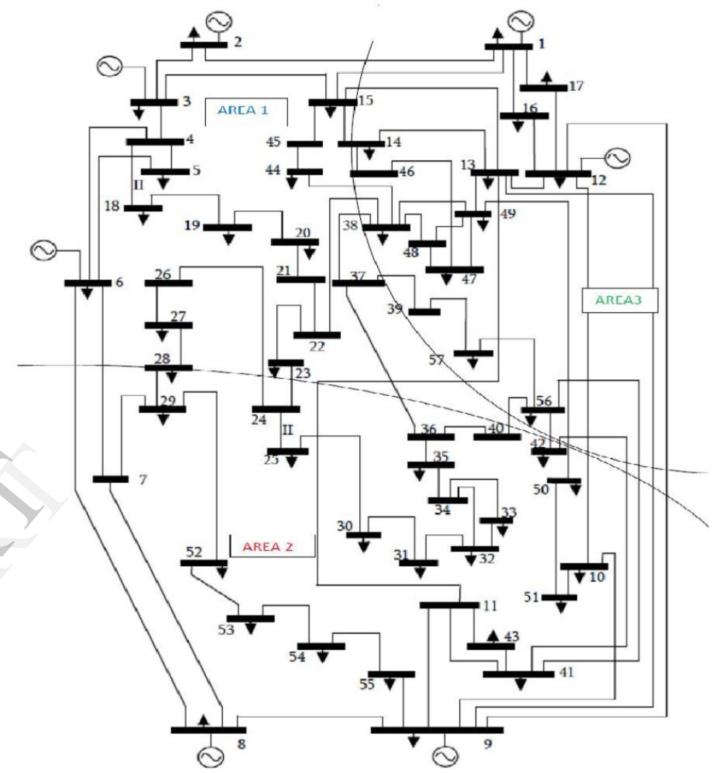

Fig 2: Single line diagram of IEEE 57 bus system with area devided [4,6]

IV. RESULTS AND DISCUSSIONS

Load flow analysis is carried out in IEEE 57 bus test system. Output Voltage magnitude and Voltage Angle values from Newton Raphson method for IEEE 57 bus system is presented below. All values are in per unit and angle is given in radian.

Table 1: Voltage magnitude and angles of IEEE57 bus system

Newton Raphson Loadflow Analysis

Bus No	V pu	Angle Degree	Injection MW	Injection MVar	Generation MW	Generation Mvar	Load MW	Load MVar
1	1.0400	0.0000	-373.097	37.517	-373.097	37.517	0.000	0.000
2	1.0400	1.4067	3.000	3.394	3.000	2.594	0.000	-0.800
3	1.0350	5.8615	1.000	-67.872	41.000	-68.872	40.000	-1.000
4	1.0400	6.9149	-0.000	-0.000	-0.000	-0.000	0.000	0.000
5	1.0383	7.9008	13.000	4.000	13.000	4.000	0.000	0.000
6	1.0300	8.0353	75.000	-56.841	75.000	-56.041	0.000	0.800
7	1.0440	6.7305	0.000	-0.000	0.000	0.000	0.000	0.000
8	1.0350	3.6456	-300.000	64.544	150.000	126.644	450.000	62.100
9	1.0300	8.6756	121.000	-136.453	121.000	-134.253	0.000	2.200
10	1.0703	9.8352	5.000	2.000	5.000	2.000	0.000	0.000
11	1.0564	9.0009	-0.000	-0.000	-0.000	-0.000	0.000	0.000
12	1.0650	8.7864	67.000	-9.453	377.000	119.047	310.000	128.500
13	1.0620	8.5663	18.000	2.300	18.000	2.300	0.000	0.000
14	1.0640	8.2373	10.500	5.300	10.500	5.300	0.000	0.000
15	1.0548	6.5271	22.000	5.000	22.000	5.000	0.000	0.000
16	1.0644	7.5757	43.000	3.000	43.000	3.000	0.000	0.000
17	1.0598	4.7206	42.000	8.000	42.000	8.000	0.000	0.000
18	1.0922	10.6655	27.200	9.800	27.200	9.800	0.000	0.000
19	1.1259	11.4934	3.300	0.600	3.300	0.600	0.000	0.000
20	1.1364	11.4429	2.300	1.000	2.300	1.000	0.000	0.000
21	1.1928	11.0236	-0.000	-0.000	-0.000	-0.000	0.000	0.000
22	1.1931	10.9344	0.000	0.000	0.000	0.000	0.000	0.000
23	1.1943	10.9695	6.300	2.100	6.300	2.100	0.000	0.000
24	1.2007	11.0921	-0.000	-0.000	-0.000	0.000	0.000	0.000
25	1.2363	14.3136	6.300	3.200	6.300	3.200	0.000	0.000
26	1.1488	10.8536	0.000	-0.000	0.000	-0.000	0.000	0.000
27	1.1196	9.9570	9.300	0.500	9.300	0.500	0.000	0.000

28	1.1032	9.2087	4.600	2.300	4.600	2.300	0.000	0.000
29	1.0896	8.6627	17.000	2.600	17.000	2.600	0.000	0.000
30	1.2520	14.6520	3.600	1.800	3.600	1.800	0.000	0.000
31	1.2736	15.0383	5.800	2.900	5.800	2.900	0.000	0.000
32	1.2666	14.5732	1.600	0.800	1.600	0.800	0.000	0.000
33	1.2683	14.5954	3.800	1.900	3.800	1.900	0.000	0.000
34	1.2163	12.1091	0.000	-0.000	0.000	0.000	0.000	0.000
35	1.2116	11.9452	6.000	3.000	6.000	3.000	0.000	0.000
36	1.2044	11.7686	-0.000	-0.000	-0.000	-0.000	0.000	0.000
37	1.2005	11.5585	-0.000	0.000	-0.000	0.000	0.000	0.000
38	1.1907	10.8433	14.000	7.000	14.000	7.000	0.000	0.000
39	1.2008	11.6063	-0.000	-0.000	-0.000	-0.000	0.000	0.000
40	1.2029	11.8678	-0.000	-0.000	-0.000	-0.000	0.000	0.000
41	1.1489	12.3211	6.300	3.000	6.300	3.000	0.000	0.000
42	1.1905	12.8993	7.100	4.400	7.100	4.400	0.000	0.000
42	1.1905	12.8993	7.100	4.400	7.100	4.400	0.000	0.000
43	1.1159	10.0297	2.000	1.000	2.000	1.000	0.000	0.000
44	1.1720	10.3286	12.000	1.800	12.000	1.800	0.000	0.000
45	1.1239	8.5923	-0.000	-0.000	-0.000	0.000	0.000	0.000
46	1.1837	9.3932	0.000	0.000	0.000	0.000	0.000	0.000
47	1.1927	10.4307	29.700	11.600	29.700	11.600	0.000	0.000
48	1.1924	10.5784	0.000	-0.000	0.000	-0.000	0.000	0.000
49	1.1933	10.6397	18.000	8.500	18.000	8.500	0.000	0.000
50	1.1974	11.1493	21.000	10.500	21.000	10.500	0.000	0.000
51	1.1611	10.7458	18.000	5.300	18.000	5.300	0.000	0.000
52	1.1284	9.8370	4.900	2.200	4.900	2.200	0.000	0.000
53	1.1439	10.2848	20.000	10.000	20.000	10.000	0.000	0.000
54	1.1284	10.0918	4.100	1.400	4.100	1.400	0.000	0.000
55	1.1046	9.5643	6.800	3.400	6.800	3.400	0.000	0.000
56	1.2070	12.8084	7.600	2.200	7.600	2.200	0.000	0.000
57	1.2182	13.0325	6.700	2.000	6.700	2.000	0.000	0.000
Total			22.703	-28.764	822.703	163.036	800.000	191.800

Line FLow and Losses

From Bus	To Bus	P MW	Q MVar	From Bus	To Bus	P MW	Q MVar	Line Loss MW	Line Loss MVar
1	2	-86.855	26.910	2	1	87.489	-24.770	0.634	2.140
2	3	-84.489	39.564	3	2	86.887	-32.724	2.398	6.840
3	4	-53.241	2.699	4	3	53.538	-1.729	0.297	0.971
4	5	-10.934	6.636	5	4	11.029	-6.436	0.095	0.200
4	6	-11.134	10.388	6	4	11.227	-10.071	0.092	0.317
6	7	20.500	-17.883	7	6	-20.361	18.594	0.140	0.712
6	8	45.200	-10.026	8	6	-44.515	13.522	0.685	3.495
8	9	-174.767	52.638	9	8	177.846	-36.933	3.079	15.705
9	10	-17.826	-20.655	10	9	18.085	21.833	0.259	1.178
9	11	-15.600	-27.333	11	9	15.841	28.124	0.241	0.792
9	12	-3.246	-11.507	12	9	3.334	11.904	0.087	0.397
9	13	-4.594	-19.432	13	9	4.775	20.026	0.181	0.594
13	14	12.282	-8.762	14	13	-12.256	8.849	0.027	0.088
13	15	44.561	-4.213	15	13	-44.083	5.757	0.478	1.544
1	15	-133.691	17.068	15	1	136.681	-1.785	2.989	15.283
1	16	-69.160	7.630	16	1	71.193	1.591	2.032	9.221
1	17	-83.391	2.727	17	1	84.923	4.224	1.532	6.951
3	15	-32.647	-28.517	15	3	32.931	29.447	0.284	0.930
4	18	-31.469	-21.962	18	4	31.469	25.177	0.000	3.215
4	18	-31.469	-21.962	18	4	31.469	25.177	0.000	3.215
5	6	1.971	12.495	6	5	-1.927	-12.400	0.045	0.095
7	8	81.566	-0.529	8	7	-80.718	4.876	0.849	4.346
10	12	16.741	0.950	12	10	-16.673	-0.640	0.068	0.310
11	13	8.427	-10.502	13	11	-8.391	10.621	0.036	0.119
12	13	8.418	3.019	13	12	-8.406	-2.978	0.013	0.041
12	16	28.324	-5.132	16	12	-28.193	5.726	0.131	0.594

12	17	43.597	-5.016	17	12	-42.923	8.056	0.674	3.039
14	15	61.163	-0.225	15	14	-60.598	2.032	0.565	1.807
18	19	-4.269	-2.489	19	18	4.364	2.629	0.094	0.140
19	20	-1.064	-2.029	20	19	1.075	2.047	0.012	0.018
21	20	-1.225	8.304	20	21	1.225	-7.902	0.000	0.401
21	22	1.225	-1.063	22	21	-1.223	1.065	0.001	0.002
22	23	-8.486	-4.221	23	22	8.492	4.231	0.006	0.010
23	24	-2.192	-1.532	24	23	2.200	1.544	0.008	0.013
24	25	-13.840	-6.720	25	24	13.840	7.710	0.000	0.990
24	25	-13.840	-6.720	25	24	13.840	7.710	0.000	0.990
24	26	11.639	126.250	26	24	-11.639	-120.749	0.000	5.501
26	27	11.639	5.721	27	26	-11.429	-5.397	0.210	0.324
27	28	20.729	5.897	28	27	-20.500	-5.544	0.229	0.354
28	29	25.100	7.844	29	28	-24.862	-7.510	0.238	0.334
7	29	-61.206	-74.863	29	7	61.206	80.238	-0.000	5.376
25	30	-7.540	-4.510	30	25	7.608	4.612	0.068	0.102
30	31	-4.008	-2.812	31	30	4.058	2.888	0.050	0.076
31	32	1.742	0.012	32	31	-1.733	0.002	0.009	0.014
32	33	-3.796	-1.896	33	32	3.800	1.900	0.004	0.004
34	32	-7.129	-6.432	32	34	7.129	7.010	0.000	0.579
34	35	7.129	2.586	35	34	-7.108	-2.555	0.020	0.030
35	36	13.108	5.908	36	35	-13.048	-5.832	0.061	0.076
36	37	15.123	0.806	37	36	-15.077	-0.749	0.046	0.058
37	38	17.818	0.209	38	37	-17.674	0.013	0.143	0.222
37	39	-2.740	0.683	39	37	2.742	-0.681	0.001	0.002
36	40	-2.075	5.142	40	36	2.082	-5.132	0.006	0.010
22	38	9.709	3.156	38	22	-9.695	-3.134	0.014	0.022
11	41	-9.827	-13.376	41	11	9.827	15.142	0.000	1.766
41	42	-8.835	-8.356	42	41	9.067	8.750	0.232	0.394
41	43	12.441	9.467	43	41	-12.441	-8.704	0.000	0.763

38	44	32.383	22.172	44	38	-32.069	-21.537	0.314	0.635
15	45	-42.930	-72.508	45	15	42.930	78.859	0.000	6.351
14	46	-38.407	-192.030	46	14	38.407	214.438	-0.000	22.408
46	47	-38.407	-2.417	47	46	38.650	3.136	0.243	0.719
47	48	-8.950	8.691	48	47	8.970	-8.666	0.020	0.025
48	49	-1.230	-0.077	49	48	1.231	0.078	0.001	0.001
49	50	-8.844	1.732	50	49	8.890	-1.659	0.046	0.073
50	51	12.110	12.159	51	50	-11.826	-11.707	0.285	0.452
10	51	-29.826	-146.594	51	10	29.826	159.530	0.000	12.937
13	49	-26.822	-81.119	49	13	26.822	92.184	-0.000	11.065
29	52	-19.343	-7.610	52	29	19.868	8.290	0.525	0.681
52	53	-14.968	-6.090	53	52	15.125	6.292	0.156	0.202
53	54	4.875	3.708	54	53	-4.822	-3.641	0.054	0.067
54	55	8.922	5.041	55	54	-8.779	-4.855	0.143	0.187
11	43	-14.441	-42.714	43	11	14.441	45.384	0.000	2.670
11	43	-14.441	-42.714	43	11	14.441	45.384	0.000	2.670
44	45	44.069	23.749	45	44	-42.930	-21.483	1.138	2.266
40	56	-2.082	-0.409	56	40	2.082	0.445	0.000	0.036
56	41	7.449	5.262	41	56	-7.133	-4.949	0.316	0.313
56	42	2.001	4.407	42	56	-1.967	-4.350	0.034	0.057
39	57	-2.742	-1.535	57	39	2.742	1.626	-0.000	0.091
57	56	3.958	2.609	56	57	-3.932	-2.570	0.026	0.039
38	49	1.216	-2.519	49	38	-1.209	2.529	0.006	0.010
38	48	7.771	-9.035	48	38	-7.740	9.084	0.031	0.048
9	55	-15.579	-67.731	55	9	15.579	72.889	0.000	5.157
Total Loss								22.703	169.196

IV. CONCLUSION

In this paper Power Flow analysis is carried out for IEEE 57 bus system using MATLAB. The aim is to determine voltage magnitude and corresponding angles for all the buses of the network. Line flows are also calculated. It is therefore easy to calculate the system losses from these flows. It is seen that number of iterations for convergence is less for IEEE 57 bus system using the software even under load deviation in load buses and change in R/X ratios for various lines. Future scope may be load flow analysis of such system with inclusion of FACTs devices in some lines.

V. APPENDIX

Bus data and Line data for IEEE 57 Bus test system is tabulated below

Table 2: Bus data of 57 bus system

Bus	Type	Vsp	theta	PGi	QGi	PLi	QLi	Qmin	Qmax
1	1	1.040	0	0.0	0.0	0.0	0.0	0.0	0.0
2	2	1.010	0	3.0	88.0	0.0	-0.8	50.0	-17.0
3	2	0.985	0	41.0	21.0	40.0	-1.0	60.0	-10.0
4	3	1.000	0	0.0	0.0	0.0	0.0	0.0	0.0
5	3	1.000	0	13.0	4.0	0.0	0.0	0.0	0.0
6	2	0.980	0	75.0	2.0	0.0	0.8	25.0	-8.0
7	3	1.000	0	0.0	0.0	0.0	0.0	0.0	0.0
8	2	1.005	0	150.0	22.0	450.0	62.1	200.0	-140.0
9	2	0.980	0	121.0	26.0	0.0	2.2	9.0	-3.0
10	3	1.000	0	5.0	2.0	0.0	0.0	0.0	0.0
11	3	1.000	0	0.0	0.0	0.0	0.0	0.0	0.0
12	2	1.015	0	377.0	24.0	310.0	128.5	155.0	-150.0
13	3	1.000	0	18.0	2.3	0.0	0.0	0.0	0.0
14	3	1.000	0	10.5	5.3	0.0	0.0	0.0	0.0
15	3	1.000	0	22.0	5.0	0.0	0.0	0.0	0.0
16	3	1.000	0	43.0	3.0	0.0	0.0	0.0	0.0
17	3	1.000	0	42.0	8.0	0.0	0.0	0.0	0.0
18	3	1.000	0	27.2	9.8	0.0	0.0	0.0	0.0
19	3	1.000	0	3.3	0.6	0.0	0.0	0.0	0.0
20	3	1.000	0	2.3	1.0	0.0	0.0	0.0	0.0
21	3	1.000	0	0.0	0.0	0.0	0.0	0.0	0.0
22	3	1.000	0	0.0	0.0	0.0	0.0	0.0	0.0
23	3	1.000	0	6.3	2.1	0.0	0.0	0.0	0.0
24	3	1.000	0	0.0	0.0	0.0	0.0	0.0	0.0
25	3	1.000	0	6.3	3.2	0.0	0.0	0.0	0.0
26	3	1.000	0	0.0	0.0	0.0	0.0	0.0	0.0
27	3	1.000	0	9.3	0.5	0.0	0.0	0.0	0.0
28	3	1.000	0	4.6	2.3	0.0	0.0	0.0	0.0
29	3	1.000	0	17.0	2.6	0.0	0.0	0.0	0.0
30	3	1.000	0	3.6	1.8	0.0	0.0	0.0	0.0
31	3	1.000	0	5.8	2.9	0.0	0.0	0.0	0.0
32	3	1.000	0	1.6	0.8	0.0	0.0	0.0	0.0
33	3	1.000	0	3.8	1.9	0.0	0.0	0.0	0.0
34	3	1.000	0	0.0	0.0	0.0	0.0	0.0	0.0
35	3	1.000	0	6.0	3.0	0.0	0.0	0.0	0.0
36	3	1.000	0	0.0	0.0	0.0	0.0	0.0	0.0
37	3	1.000	0	0.0	0.0	0.0	0.0	0.0	0.0
38	3	1.000	0	14.0	7.0	0.0	0.0	0.0	0.0
39	3	1.000	0	0.0	0.0	0.0	0.0	0.0	0.0
40	3	1.000	0	0.0	0.0	0.0	0.0	0.0	0.0
41	3	1.000	0	6.3	3.0	0.0	0.0	0.0	0.0
42	3	1.000	0	7.1	4.4	0.0	0.0	0.0	0.0
43	3	1.000	0	2.0	1.0	0.0	0.0	0.0	0.0
44	3	1.000	0	12.0	1.8	0.0	0.0	0.0	0.0
45	3	1.000	0	0.0	0.0	0.0	0.0	0.0	0.0
46	3	1.000	0	0.0	0.0	0.0	0.0	0.0	0.0
47	3	1.000	0	29.7	11.6	0.0	0.0	0.0	0.0
48	3	1.000	0	0.0	0.0	0.0	0.0	0.0	0.0
49	3	1.000	0	18.0	8.5	0.0	0.0	0.0	0.0
50	3	1.000	0	21.0	10.5	0.0	0.0	0.0	0.0
51	3	1.000	0	18.0	5.3	0.0	0.0	0.0	0.0
52	3	1.000	0	4.9	2.2	0.0	0.0	0.0	0.0
53	3	1.000	0	20.0	10.0	0.0	0.0	0.0	0.0
54	3	1.000	0	4.1	1.4	0.0	0.0	0.0	0.0
55	3	1.000	0	6.8	3.4	0.0	0.0	0.0	0.0
56	3	1.000	0	7.6	2.2	0.0	0.0	0.0	0.0
57	3	1.000	0	6.7	2.0	0.0	0.0	0.0	0.0

Table 3 : Line Data of 57 bus system

From Bus	To Bus	R pu	X pu	B/2 pu	X'mer TAP (a)
1	2	0.0083	0.0280	0.0645	1
2	3	0.0298	0.0850	0.0409	1
3	4	0.0112	0.0366	0.0190	1
4	5	0.0625	0.1320	0.0129	1
4	6	0.0430	0.1480	0.0174	1
6	7	0.0200	0.1020	0.0138	1
6	8	0.0339	0.1730	0.0235	1
8	9	0.0099	0.0505	0.0274	1
9	10	0.0369	0.1679	0.0220	1
9	11	0.0258	0.0848	0.0109	1
9	12	0.0648	0.2950	0.0386	1
9	13	0.0481	0.1580	0.0203	1
13	14	0.0132	0.0434	0.0055	1
13	15	0.0269	0.0869	0.0115	1
1	15	0.0178	0.0910	0.0494	1
1	16	0.0454	0.2060	0.0273	1
1	17	0.0238	0.1080	0.0143	1
3	15	0.0162	0.0530	0.0272	1
4	18	0.0	0.5550	0.0	0.970
4	18	0.0	0.4300	0.0	0.978
5	6	0.0302	0.0641	0.0062	1
7	8	0.0139	0.0712	0.0097	1
10	12	0.0277	0.1262	0.0164	1
11	13	0.0223	0.0732	0.0094	1
12	13	0.0178	0.0580	0.0302	1
12	16	0.0180	0.0813	0.0108	1
12	17	0.0397	0.1790	0.0238	1
14	15	0.0171	0.0547	0.0074	1
18	19	0.4610	0.6850	0.0	1
19	20	0.2830	0.4340	0.0	1
21	20	0.0	0.7767	0.0	1.043
21	22	0.0736	0.1170	0.0	1
22	23	0.0099	0.0152	0.0	1
23	24	0.1660	0.2560	0.0042	1
24	25	0.0	1.1820	0.0	1
24	25	0.0	1.2300	0.0	1
24	26	0.0	0.0473	0.0	1.043
26	27	0.1650	0.2540	0.0	1
27	28	0.0618	0.0954	0.0	1
28	29	0.0418	0.0587	0.0	1
7	29	0.0	0.0648	0.0	0.967
25	30	0.1350	0.2020	0.0	1
30	31	0.3260	0.4970	0.0	1
31	32	0.5070	0.7550	0.0	1
32	33	0.0392	0.0360	0.0	1
34	32	0.0	0.9530	0.0	0.975
34	35	0.0520	0.0780	0.0016	1
35	36	0.0430	0.0537	0.0008	1
36	37	0.0290	0.0366	0.0	1
37	38	0.0651	0.1009	0.0010	1
37	39	0.0239	0.0379	0.0	1
36	40	0.0300	0.0466	0.0	1
22	38	0.0192	0.0295	0.0	1

VI. REFERENCES

[1] M.A.Pai, "Computer Techniques in Power System Analysis", second edition, ISBN: 0-07-059363-9, Tata McGraw Hill [2005].
[2] A.E. Guile and W.D. Paterson, „Electrical power systems, Vol. 2‟. (Pergamon Press, 2nd edition, 1977).
[3] Dharamjit and D.K.Tanti, Load Flow study on IEEE 30 Bussystem, International Journal of Scientific and Research Publications, Volume 2, Issue 11, November 2012, ISSN 2250-3153
[4] Muralikrishna Allem , J.O.Chandle, Prediction of Weakest Area and Line in IEEE 57 Bus System, IJIRSET, Vol. 3, Issue 6, June 2014, ISSN: 2319-8753
[5] Glenn W. Stagg and Ahmed H. El-Abiad, "Computer Methods in Power System Analysis", McGraw-Hill [1968].
[6] S. Jamali. M.R.Javdan. H. Shateri and M. Ghorbani , "Load Flow Method for Distribution Network Design by Considering Committed Loads,"Universities Power Engineering Conference , vol.41, no.3, pp. 856 – 860, sept.2006
[7] N. Usha, Simulation results of eight bus system using push-pull inverter base STATCOM, Journal of Theoretical and Applied Information Technology, 2005 - 2009 JATIT.
[8] C. R. Feurte – Esquivel and E. Acha 'A Newton-type algorithm for the control of power flow in electrical power networks," IEEE Transactions on Power Systems, Vol.12, Nov.1997.
[9] Rohit Kapahi, Load flow analysis of 132 KV substation using ETAP software, International Journal of Scientific & Engineering Research Volume 4, Issue 2, February-2013,ISSN 2229-5518

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