

# Load Flow Analysis of IEEE 30 Bus System

RiteshRaut<sup>1</sup>, Saquib Khan<sup>2</sup>, Kuldeep Lakhe<sup>3</sup>

<sup>1, 2, 3</sup>Dept of computer engineering

<sup>1, 2, 3</sup>pace, Pune, Maharashtra, India

**Abstract-** load flow analysis is an important tool used by engineers to determine the best operation for the power system and exchange the power between two utility companies, to have an efficient method of load flow power system, we have to determine the optimal method for it. The power flow analysis takes time and does not achieve optimal result solution because of power demands and generations. so this paper is to analyze the load flow problem in power system planning studies. There are a couple of methods to solve the power flow analysis solution like the Newton Raphson method, Gauss -Siedel method. The simulation is carried on MatLab for IEEE

**Keywords-** Power flow, Newton Raphson method, Voltage profile, active power, reactive power.

## I. INTRODUCTION

Load flow studies [1]-[2] are used to ensure that electrical power transfer from generators to consumers through the grid system is stable, reliable, and economic. Conventional techniques for solving the load flow problem are iterative, using the Newton-Raphson or the Gauss-Seidel methods [3]-[4]. Load flow analysis forms an essential prerequisite for power system studies. Considerable research has already been carried out in the development of computer programs for a load flow analysis of large power systems. However, these general-purpose programs may encounter convergence difficulties when a radial distribution system with a large number of buses is to be solved, and hence, the development of a special program for radial distribution studies becomes necessary [5]. There are many solution techniques for load flow analysis. The solution procedures and formulations can be precise or approximate, with values adjusted or unadjusted, intended for either online or offline applications, and designed for either single-case or multiple-case applications. Since an engineer is always concerned with the cost of products and services, the efficient optimum economic operation and planning of electric power generation system have always occupied an important position in the electric power industry. With the large interconnection of the electric networks, the energy crisis in the world, and the continuous rise in prices, it is very essential to reduce the running charges of electric energy [6]- [7]. Saving in the operation of the system of a small percent represents a significant reduction in operating cost as well as in the

quantities of fuel consumed. The classic problem is the economic load dispatch of generating systems to achieve minimum operating cost. This problem area has taken a subtle twist as the public has become increasingly concerned with environmental matters so that economic dispatch now includes the dispatch of systems to minimize pollutants and conserve various forms of fuel, as well as achieve minimum cost.

## II. POWER FLOW ANALYSIS

The power flow analysis (also known as a load-flow study) is an important tool involving numerical analysis applied to a power system. Unlike traditional circuit analysis, a power flow study usually uses simplified notation such as a one-line diagram and per-unit system and focuses on various forms of AC power (i.e: reactive, real, and apparent) rather than voltage and current. The advantage in studying power flow analysis is in planning the future expansion of power systems as well as in determining the best operation of existing systems. Power flow analysis is being used for solving power flow problems by the Newton-Raphson method and Gauss-Seidel method. This sub-chapter will discuss Newton Raphson's methods generally on formula or mathematical step to solving power flow problem.

### Bus classification

A bus is a point or node where the number of transmission lines is connected. In a power system, every bus is associated with 4 quantities Magnitude, phase, active power, and reactive power. Two quantities are provided and two have to find out the solution. hence bus play's an important role to find active and reactive power. Further Bus has been classified based on two given quantities.

### They are categorized into three:-

**Slack or Swing Bus:** The use of slack bus has an inherent disadvantage when dealing with uncertain input variables, the slack bus should absorb all uncertainties arising in the system and thus must have a widest possible nodal power distribution. even a moderate amount of uncertainty in a large system may allow the resulting beyond the slack bus margin. Usually, this bus is numbered 1 for the load flow studies. This bus sets the angular reference for all the other buses. Since it is the angle difference between two voltage sources that dictates

the real and reactive power flow between them, the particular angle of the slack bus is not important. However, it sets the reference against which angles of all the other bus voltages are measured. For this reason, the angle of this bus is usually chosen as 0°. Furthermore, it is assumed that the magnitude of the voltage of this bus is known.

**Load Buses:** It is often called a type of node which has both active power and reactive power incorporated in the network. In these buses, no generators are connected and hence the generated real power  $P_{Gi}$  and reactive power  $Q_{Gi}$  are taken as zero. The load drawn by these buses is defined by real power  $-P_{Li}$  and reactive power  $-Q_{Li}$  in which the negative sign accommodates for the power flowing out of the bus. This is why these buses are sometimes referred to as P-Q buses. The objective of the load flow is to find the bus voltage magnitude  $|V_i|$  and its angle  $\delta_i$ .

**Generator bus (PV)**

It is also known as voltage Bus. This bus is connected to the generators and the output power of this bus is controlled by a prime mover while terminal voltage is controlled by generator excitation Keeping the input power constant through turbine-governor control and keeping the bus voltage constant using an automatic voltage regulator, we can specify constant  $P_{Gi}$  and  $|V_i|$  for these buses.

**Bus Admittance Matrix:**

To obtain the node-voltage equations, consider the simple power system shown in Figure 3.3.1 where impedances are expressed per unit on a common MVA base and for simplicity, resistances are neglected. Since the nodal solution is based upon Kirchhoff's current law, impedance is converted to admittance,

i.e.,

$$Y_{pq} = 1/z_{pq} = 1/(r_{pq} + jx_{pq})$$

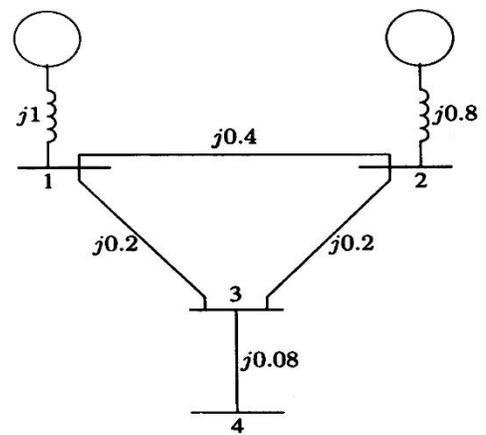


Fig: 3.3.1. The impedance diagram of a simple system.

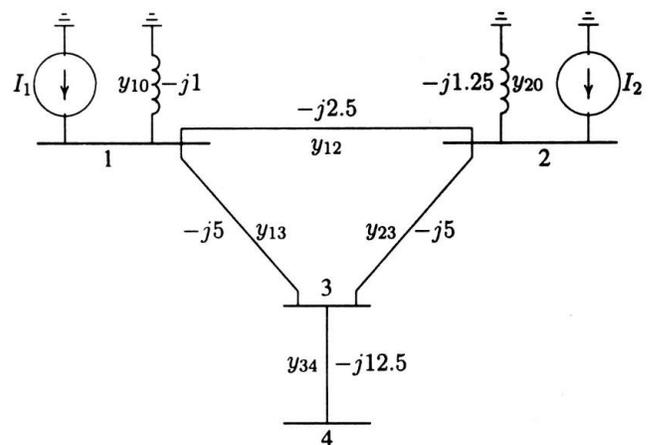
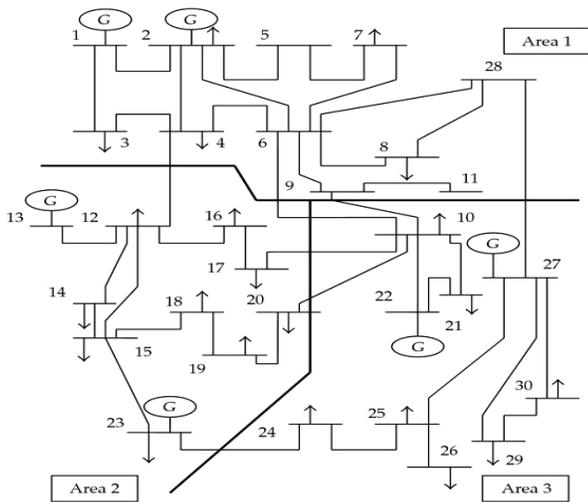


Fig: 3.3.2. The admittance diagram for the system of fig: 3.3.1.

**Newton Raphson method**

Newton Raphson's method is an iterative technique for solving nonlinear Equations with an equal number of unknowns. It is the most iterative method used for the load flow because its convergence characteristics are relatively more powerful compared to other alternative processes and the reliability of the Newton-Raphson approach is comparatively good since it can solve cases that lead to divergence with other popular processes. If the assumed value is near the solution, then the result is obtained very quickly, but if the assumed value is farther away from the solution then the method may take longer to converge. This is another iterative load flow method that is widely used for solving a nonlinear equation.

**Case study of IEEE 30 Bus system**



**(WITHOUT CAPACITOR)**

basemva = 100; accuracy = 0.001; accel = 1.8; maxiter = 100;

% IEEE 30-BUS TEST SYSTEM

% Bus Bus Voltage Angle ---Load----Generator--

--- Static Mvar

% No code Mag. Degree MW Mvar MW  
MvarQminQmaxQI

```
busdata=[1 1 1.037 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0
2 2 1.033 0.0 0.0 0.0 22.6 0.0 -10 10 0
3 2 1.024 0.0 0.0 0.0 12.2 0.0 -40 50 0
4 2 1.030 0.0 0.0 0.0 22.7 0.0 -20 20 0
5 2 1.030 0.0 0.0 0.0 11.5 0.0 -10 10 0
6 2 1.030 0.0 0.0 0.0 22.6 0.0 -40 50 0
7 0 1.000 0 0.0 0.0 0.0 0.0 0 0 0
8 0 1.000 0 2.4 1.2 0.0 0.0 0 0 0
9 0 1.000 0 0.0 0.0 0.0 0.0 0 0 0
10 0 1.000 0 5.8 2.0 0.0 0.0 0 0 0
11 0 1.000 0 7.6 1.6 0 0 0 0 0
12 0 1.000 0 16.2 7.5 0 0 0 0 0
13 0 1.000 0 0.0 0.0 0 0 0 0 0
14 0 1.000 0 6.2 1.6 0 0 0 0 0
15 0 1.000 0 8.2 2.5 0 0 0 0 0
16 0 1.000 0 3.5 1.8 0 0 0 0 0
17 0 1.000 0 9.0 5.8 0 0 0 0 0
18 0 1.000 0 3.2 0.9 0 0 0 0 0
19 0 1.000 0 9.5 3.4 0 0 0 0 0
20 0 1.000 0 2.2 0.7 0 0 0 0 0
21 0 1.000 0 17.5 11.2 0 0 0 0 0
22 0 1.000 0 0.0 0.0 0 0 0 0 0
23 0 1.000 0 3.2 1.6 0 0 0 0 0
24 0 1.000 0 8.7 6.7 0 0 0 0 0
25 0 1.000 0 22.8 10.9 0 0 0 0 0
26 0 1.000 0 3.5 2.3 0 0 0 0 0
27 0 1.000 0 0.0 0.0 0 0 0 0 0
28 0 1.000 0 0.0 0.0 0 0 0 0 0
```

```
29 0 1.000 0 2.4 0.9 0 0 0 0 0
30 0 1.000 0 5.6 1.9 0 0 0 0 0];
```

% Line code

% Bus bus R X 1/2 B = 1 for lines

% nl nr p.u. p.u. p.u. > 1 or < 1 tr. tap at bus nl

linedata=[1 2 0.0192 0.0575 0 1

```
1 8 0.0452 0.1852 0 1
2 11 0.0570 0.1737 0 1
8 11 0.0132 0.0379 0 1
2 5 0.0472 0.1983 0 1
2 13 0.0581 0.1783 0 1
11 13 0.0119 0.0414 0 1
5 25 0.0460 0.1160 0 1
13 25 0.0267 0.0820 0 1
3 13 0.0120 0.0420 0 1
13 9 0 0.2080 0 1
13 10 0 0.5560 0 1
9 4 0 0.2080 0 1
9 10 0 0.1100 0 1
11 12 0 0.2560 0 1
12 6 0 0.1400 0 1
12 14 0.1231 0.2559 0 1
12 15 0.0662 0.1304 0 1
12 16 0.0945 0.1987 0 1
14 15 0.0900 0.1997 0 1
16 17 0.0824 0.1932 0 1
15 18 0.1070 0.2185 0 1
18 19 0.0639 0.1292 0 1
19 20 0.0340 0.0680 0 1
10 20 0.0936 0.2090 0 1
10 17 0.0324 0.0845 0 1
10 21 0.0348 0.0749 0 1
28 22 0.0727 0.1499 0 1
21 22 0.0116 0.0236 0 1
15 23 0.1000 0.2020 0 1
22 24 0.1150 0.1790 0 1
23 24 0.1320 0.2700 0 1
24 7 0.1885 0.3292 0 1
7 26 0.2544 0.3800 0 1
7 27 0.1093 0.2087 0 1
28 27 0.0 0.3960 0 1
27 29 0.2198 0.4153 0 1
27 30 0.3202 0.6027 0 1
29 30 0.2399 0.4533 0 1
3 28 0.0636 0.2000 0 1
13 28 0.0169 0.0599 0 1];
```

(WITH CAPACITOR)

Clear

basemva = 100; accuracy = 0.001; accel = 1.8; maxiter = 100;

% IEEE 30-BUS TEST SYSTEM

% Bus Bus Voltage Angle ---Load----Generator--

--- Static Mvar

% No code Mag. Degree MW Mvar MW

MvarQminQmax 淳QI

```
busdata=[1 1 1.037 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0
2 2 1.033 0.0 0.0 0.0 22.6 0.0 -10 10 0
3 2 1.024 0.0 0.0 0.0 12.2 0.0 -40 50 0
4 2 1.030 0.0 0.0 0.0 22.7 0.0 -20 20 0
5 2 1.030 0.0 0.0 0.0 11.5 0.0 -10 10 0
6 2 1.030 0.0 0.0 0.0 22.6 0.0 -40 50 0
7 2 1.004 0 0.0 0.0 0.0 0.0 0 0 10
8 0 1.000 0 2.4 1.2 0.0 0.0 0 0 0
9 0 1.000 0 0.0 0.0 0.0 0.0 0 0 0
10 0 1.000 0 5.8 2.0 0.0 0.0 0 0 0
11 0 1.000 0 7.6 1.6 0 0 0 0 0
12 0 1.000 0 16.2 7.5 0 0 0 0 0
13 0 1.000 0 0.0 0.0 0 0 0 0 0
14 0 1.000 0 6.2 1.6 0 0 0 0 0
15 0 1.000 0 8.2 2.5 0 0 0 0 0
16 0 1.000 0 3.5 1.8 0 0 0 0 0
17 0 1.000 0 9.0 5.8 0 0 0 0 0
18 0 1.000 0 3.2 0.9 0 0 0 0 0
19 0 1.000 0 9.5 3.4 0 0 0 0 0
20 0 1.000 0 2.2 0.7 0 0 0 0 0
21 0 1.000 0 17.5 11.2 0 0 0 0 0
22 0 1.000 0 0.0 0.0 0 0 0 0 0
23 0 1.000 0 3.2 1.6 0 0 0 0 0
24 0 1.000 0 8.7 6.7 0 0 0 0 0
25 0 1.000 0 22.8 10.9 0 0 0 0 0
26 0 1.000 0 3.5 2.3 0 0 0 0 0
27 0 1.000 0 0.0 0.0 0 0 0 0 0
28 0 1.000 0 0.0 0.0 0 0 0 0 0
29 0 1.000 0 2.4 0.9 0 0 0 0 0
30 0 1.000 0 5.6 1.9 0 0 0 0 0];
```

linedata=[1 2 0.0192 0.0575 0.0264 1

1 8 0.0452 0.1852 0.0204 1

2 11 0.0570 0.1737 0.0184 1

8 11 0.0132 0.0379 0.0042 1

2 5 0.0472 0.1983 0.0209 1

2 13 0.0581 0.1783 0.0187 1

11 13 0.0119 0.0414 0.0045 1

5 25 0.0460 0.1160 0.0102 1

13 25 0.0267 0.0820 0.0085 1

3 13 0.0120 0.0420 0.0045 1

13 9 0 0.2080 0 1

```
13 10 0 0.5560 0 1
9 4 0 0.2080 0 1
9 10 0 0.1100 0 1
11 12 0 0.2560 0 1
12 6 0 0.1400 0 1
12 14 0.1231 0.2559 0 1
12 15 0.0662 0.1304 0 1
12 16 0.0945 0.1987 0 1
14 15 0.0900 0.1997 0 1
16 17 0.0824 0.1932 0 1
15 18 0.1070 0.2185 0 1
18 19 0.0639 0.1292 0 1
19 20 0.0340 0.0680 0 1
10 20 0.0936 0.2090 0 1
10 17 0.0324 0.0845 0 1
10 21 0.0348 0.0749 0 1
28 22 0.0727 0.1499 0 1
21 22 0.0116 0.0236 0 1
15 23 0.1000 0.2020 0 1
22 24 0.1150 0.1790 0 1
23 24 0.1320 0.2700 0 1
24 7 0.1885 0.3292 0 1
7 26 0.2544 0.3800 0 1
7 27 0.1093 0.2087 0 1
28 27 0.0 0.3960 0 1
27 29 0.2198 0.4153 0 1
27 30 0.3202 0.6027 0 1
29 30 0.2399 0.4533 0 1
3 28 0.0636 0.2000 0.0214 1
13 28 0.0169 0.0599 0.0065 1];
```

### III. CONCLUSION

Over the past ten years, deregulation in the power industry has been carried out in married countries. The operation of the power system calls for the support of ancillary services that involve grid open access. How to fairly allocate the costs of these ancillary services becomes an important issue. This paper focused on the reactive power part and developed a straightforward method based on the network theory. The proposed method can identify the source and can calculate the amount of the consumed reactive power on each load bus. The simulation results have also shown the conformity of reactive power supply and reception in a power system. The calculation results might bring about some differences from those based on other methods, but the allocation of reactive power costs is like the other topics stemming from deregulation, where different viewpoints and approaches may end up with different results. This project would like to try to offer the solution by an alternative methodology.

**REFERENCES**

- [1] Bialek. "Tracing the follow of electricity", Proc. Inst. Elect. Eng. Gen. Transm. Dist, vol. 143. no. 4. pp. 313-320. July 1996.
- [2] J. JanuszBialek. "J. Topological generation and load distribution factors for supplement charge allocation in transmission open access." IEEE Trans. Power Syst, vol. 12. pp. 1185-1193. Aug.1997.
- [3] "Allocation of transmission supplementary charge to real and reactive loads." IEEE Trans. Power Syst. Vol.13. 749-754. Aug. 1998.
- [4] D. Daniel Kirschen. R. Ron Allan, and G. GoranStrbac, "Contributions of individual generators to loads and flows" IEEE Trans. Power Syst. Vol. 12. pp. 52-60. Feb. 1997.
- [5] G. GoranStrbac. D. Daniel Kirschen, and S. Syed Ahmed, "Allocation transmission system usage based on traceable contributions of individuals generators to loads and flows." IEEE Trans. Power. Syst. Vol. 13. pp. 527-532. May 1998.
- [6] F. F. Felix F. Wu. Y. Yixin Ni. And P. Ping Wei "Power transfer allocation for open access using graph theory – fundamentals and applications in a system without loop flow." IEEE Trans. Power Syst. Vol. 15. pp. 923-929. Aug. 2000.
- [7] International Journal of Scientific and Research Publications, Volume 2, Issue 11, November 2012 Dhramjit, D.K Tanti.