Design of Electric Power System Studies Using Mipower

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***Abstract*—In the electric power system for the design, planning, control and operation at the current time and upcoming forecasting expansion of systems the power study or load flow analysis is essential. The effect of interconnections, add or remove generations, loads, transmission lines, etc. known before the installation gives the top, financial and effectual operation. This paper explains about the solution of load flow study considering of input voltage and indication power settings to power system and provides all the busses power flow and voltage magnitude. The calculation of load flow studies is easy for small system. But the system is too large that consists with hundreds or thousands busses it is problematical by hand. The MiPower (MiP) software is used to resolve power flow solution problem since large power system network. To solve the power flow problem in present many software program available for example MATLAB, Power World Simulator (PWS), PSCAD and MiPower but, Mipower is chosen. Because Mipower is best simulation software of power flow studies for bulky network and it is adoptable for like smart grid and smart city applications. And also it gives the detailed and accurate result with less time. The Mipower software is the forward-looking simulation equipment in an attempt to develop the load flow analysis. All the power system tools were designed to survive high effectiveness and to resist worst case situation. It is also has the inbuilt GPS interface due to this software is best for smart grid and smart city applications.**

***Index Terms*-IEEE bus, MATLAB, MiPower, Power Flow Studies.**

I. INTRODUCTION

In today's life electricity is compulsory each and every second of our life. The electric power demand is increased continuously hence this problem. According to increasing of power demand need to plan, design and implement the large generation, transmission and distribution [1]-[2].Therefore decipher is enormously significant to manage the speed and size. The researchers have study the load or power flow decipher enormously in last spans. The power system engineers are analyzing present and upcoming operating features of power system which are provided by the load flow studies. For the best operation of grid network the designing of the network is necessary. To survey the power system unconditional problems the load flow studies is crucial.

Load flow studies [3]heave light on some of the imperative features of the system operation, such as: generator overloading, line overloading, violation of voltage magnitudes mat the buses, reduction of phase margin, power angle changes among buses associated with line indication, result of incidents like line voltages, emergency blackout of generators, etc. To improve economic power system operation load flow is important. Based on the defined generation state, transmission network and load structure the load flow studies resolves steady state operation of power system with desired bus voltage, power flow results without considering transient process. Hence, the nonlinear algebraic equation system without differential equations is the arithmetic prototypical of power flow problematic. According to this the power flow study is the base for dynamic analysis and dynamic analysis is based on the algorithm of power flow studies. To understanding the approach of modern power system studies the knowledge of concept and algorithm of the power flow study is essential.

The load flow studies provide the voltage magnitude, phase angle, real power, reactive power and apparent power at various busses in the grid network. Together with line flow and losses of each and every line is provided. Associated to old circuit analysis, a load flow analysis generally used shortened representation for a single line diagram and per unit system, and concentrations on different methods of AC power.

In this study the use of nodes or buses transmission network designed by interconnection of transmission line. The Generator and load connected to nodes or busses to inject and eject the power from the network. For a radiated delivery system with a bulky quantity of nodes the general purpose program convergence must be have difficulties. Later, progress of a superior database is essential for radial distribution studies. The computer based power flow solution was great according to deliver accurate, quick and economic result.

The main advantage of load flow study is that gives the best and fast planning and explanation for different suppositious conditions. For example, if any one of the transmission line is disconnected for repairs, can other lines in the system maintain the demands within their limits. Nodal analysis is used to derive the basic equation of load flow analysis for the power system. The load flow analysis has several solution practices. The solution processes and preparation according to the formula is applicable for both single-case and multi-case and proposed for both online and off-line applications. This can be accurate or estimated, with adjusted or unadjusted

values. Therefore an engineer is always concerned with effective and cost-effective operation and planning in electric power generation system with interconnected transmission network in the power industry. Due to this large interconnection network the energy crisis problem will occur in the earth and also continuously increases the cost of the system, the power flow study reduces the this type of running charges. This statistics are important for nonstop observing and control of present and future expansion of the power system [4]-[5].

Different methods of power flow studies given in section II. Section III explains about the overview of power flow. Different software analysis and results in section IV. Lastly conclusion in section V.

II. LITERATURE REVIEW

In all power system analysis calculations the load flow studies are possibly most common. When the elements becomes burdened or overloaded that is found by the planning studies. Based on load-flow analysis major speculation choices start with strengthening approaches. In working examinations, to take care of the demand without over-burdening conditions; runs the generator at the ideal working point; and keep techniques can go before without harm the security of the framework the power stream considers are utilized.

Reasonable for the accompanying data is the target of the any heap stream program:

- Phase angle and voltage magnitude at each transport.
- Active and reactive power of every component.
- Reactive power loading on every generator.

The heap stream program giving the accompanying data to accomplish the above goals:

- ✓ Division rundown of the framework joins i.e., the impedance of every component, sending-end and getting end bus #. Lines and transformers are denoted by their π-equal models.
- ✓ Voltage magnitude and phase angle give in one transport, which is taken as the reference point for whatever remains of the framework.
- ✓ Voltage extent and Real power age for every generator transport.
- ✓ Active and reactive power required at each heap transport.

There are numerous techniques in power stream examination. These are

- Gauss-Seidal Iterative strategy
- Newton Raphson strategy
- Fast Decoupled strategy

A. Gauss-Seidal Iterative Method

To take care of power framework power flow Problems, the generally utilized technique was the gauss–seidel iterative strategy in view of a nodal admittance matrix. This technique is exceptionally straightforward and need of memory space is little. At the point when the system size is increases, likewise increments of iteration also suddenly and the cycle procedure not met every so often.

This issue prompted the utilization of the consecutive substitution technique in light of the nodal impedance network. The principle disadvantage of the impedance technique is its high memory need and calculating issue.

The Gauss-Siedel (GS) technique is an iterative calculation for resolving an arrangement of non-straight arithmetical conditions [6]-[7]. To begin with, the arrangement vector, created on the real experience, physical circumstance is considered. One of the conditions is the used to acquire the changed estimation of a specific variable by substituting in it the present estimations of the rest of the qualities. On account of the arrangement vector of these factors refreshed quickly. The procedure is then revised for every one of the factors in this manner finishing cycle. The iterative procedure is rehashed till the arrangement vector merges inside endorsed precision. The assumption of starting values cause the convergence fairly sensitive. Luckily, in power flow analysis is a beginning vector near the last answer can be effectively related to past understanding. To clarify how the GS strategy is connected to get the power flow solution, let it be expected that every one of the nodes other than the slack node are PQ nodes. Future this technique can be effortlessly actualized to contain PV buses as well.

B. Newton Raphson Method

The Newton technique is a typical strategy. The non-straight conditions in arithmetic, with advantageous convergence are being solved by the Newton technique. It changes the system of resolving nonlinear conditions into the methodology of over and again settling direct conditions. To greatly enhance the calculating productivity of the Newton technique the sparsity of Jacobean matrix is utilized in the iterative procedure [8]-[10].

C. Fast Decoupled Method

The power flow computing technique remains on creating in different ways. Among them the best is the quick decoupled technique, additionally called the P _ Q decoupled strategy. Comparing with the Newton technique, this strategy is significantly less difficult and more proficient algorithmic, and subsequently more mainstream in numerous applications. The fundamental thought of the quick decoupled strategy is communicating the nodal control as a component of voltages in polar frame; independently illuminating the real and reactive power conditions [11] by utilizing dynamic power confuse to adjust voltage angle and utilizing reactive power mismatch to alter voltage magnitude. Along these lines, the

processing weight of load flow computation is improved essentially.

III. OVERVIEW OF POWER FLOW STUDIES

In middle of the 1950s the calculation of load flow started by using of digital computers. Since, a variety of techniques has been used in power flow computation. Basic necessities of power flow calculation run the improvement of these approaches, which can be summed up as:

1. The convergence properties
2. The computing efficiency and memory requirements
3. The convenience and flexibility of the implementation

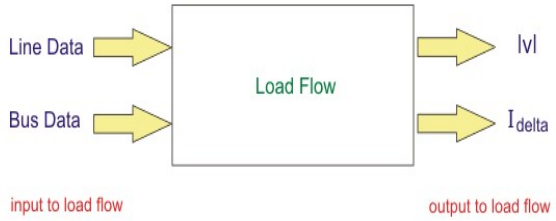

Fig 1.Basic Load Flow

Statistically, the power flow problem is a difficult of resolving a system of nonlinear algebraic equations. Some iteration process does not avoid generally in its solution. Thus dependable convergence develops the crucialstandard for a power flow calculation method.

The electric power network iscreated by the generator, transformer, transmission lines and loads. In the process of power system analysis, the static components, such as transformers, transmission lines, shunt capacitors and reactors, are denoted by their equivalent circuits.

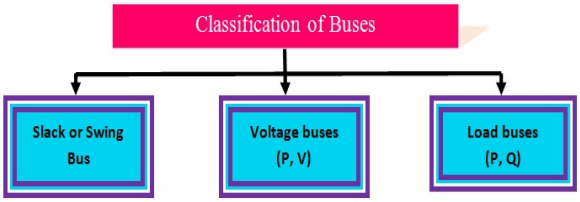

Fig 2.Bus Classification

The nodal admittance matrix based Gauss-Siedal Iterative method widely used in the openings usage of statistical computers to resolve the power flow problem. (It will be basically named as admittance technique below)[12].The principle of this method is rather simple and its memory requirement is relatively small. At the time, the computer and power system theory applies to these properties clarified. When the system size is increases, the number of iteration also rises suddenly, and the iteration process not converged occasionally. This difficulty directed to the use of the nodal impedance matrix based sequential substitution technique (also named the impedance technique)[13].

The impedance technique enhanced convergence and not being able to solve by the admittance method to solve some problems. Memory necessity and computer system burden are the main flaw of impedance method.

The Newton–Raphson method(also called the Newton method) is introduced to overcome the disadvantage of impedance method. The non-linear equations in mathematics, with advantageous convergence are being solved by the newton method. To greatly improve the computing efficiency of the Newton method the sparsity of Jacobean matrix is used in the iterative process. According to the consideration features of convergence, computing speed and memory demand the Newton-Raphson strategy has exceeded the impedance method.

The best is the quick decoupled technique, likewise called the P _ Q decoupled strategy. Comparing with the Newton strategy, this technique is significantly more straightforward and more proficient algorithmically, and in this way more prevalent in numerous applications.

Recently, the counterfeit insightful hypothesis, fuzzy calculation, the genetic calculation and artificial neural system calculation have been produced for power flow examination. Be that as it may, as of recently these new models and new calculations still can't supplant the Newton strategy and P _ Q decoupled technique. Since the sizes of power system proceed to extend and the necessities for online count turn out to be increasingly terrible, the parallel registering calculations are likewise contemplated seriously now and may turn into an imperative research field.

IV. METHODOLOGY

Main objective of this paper is to compare the results using MiPower with MATLAB. It gives simulation result from sample IEEE 30 bus system. In this paper Decoupled method is used for the simulation of power flow analysis.

A. Matlab

MATLAB is a special app. To generate and correct the practical work the Matlab is flexible. This is model for mathfans who are observing for an application that will support them to make equations, tables, graphs. MATLAB is a multi-paradigm arithmetical calculating atmosphere and exclusive coding language established by Mathworks. The term MATLAB opinions for matrix workroom.

B. MiPower

MiPower is a highly interactive, user friendly windows based Power System Analysis package. It includes a set of modules for the performance of power system design and analysis study for widespread area. MiPower characteristics include a highest scratch windows GUI with federal database. Steady

state, electro-magnetic and transient analysis can be achieved with greatest precision and tolerance.

Mipower is an Indian item created by Power Research and Development Consultants (PRDC). It is a bangalore based counseling and programming improvement organization. MiPower is the top product of PRDC containing of an extensive variety of programming applications for the outline, investigation and reproduction of electrical power framework (transmission, distribution and generation systems).

C. Power Flow Solution

With a specific end goal to produce the load flow solution of a power network, the input raw information of the system must be arranged. Creating a rough information document includes naming nodes and branches, allotting node categories, computing network parameters, allocating powers to loads, setting node voltages and framing dissimilar information segments in view of the network's setup and parameters[17-21].

Subsequent to contributing and preparing the information of the power network, the program builds the network admittance lattice, Y. The active and reactive power at i-th node in the power network is given by:

$$P_i = \sum_{j=1}^{n} |Y_{ij}||V_j||V_i| \cos(\theta_{ij} + \delta_j - \delta_i) \quad (1)$$

$$Q_i = -\sum_{j=1}^{n} |Y_{ij}||V_j||V_i| \sin(\theta_{ij} + \delta_j - \delta_i) \quad (2)$$

V_i and V_j are the voltages at ith node and jth node respectively. Y_{ij}admittance of the line between the ith node and jth node. n is the number of busses related to ith node.

Complex power is

$$S_i = P_i + jQ_i$$

D. Power Flow Procedure

1. Create a node admittance lattice Ybus for the power framework;
2. Make an first evaluation for the voltages (both magnitude of voltage and phase angle) at each node in the framework;
3. Substitute in the load flow equations and determine the deviations from the solution.
4. Update the predicted voltages in light of some ordinarily known numerical calculation.
5. Repeat the above procedure until the point when the deviations from the arrangement are negligible.

Fast Decoupled Method

i. we can reasonably eliminate J2and J3elements in Jacobean matrix

$$\begin{bmatrix} \Delta P \\ \Delta Q \end{bmatrix} = \begin{bmatrix} J_1 & 0 \\ 0 & J_4 \end{bmatrix} \begin{bmatrix} \Delta\delta \\ \Delta V \end{bmatrix} \quad (3)$$

- ✓ Diagonal elements of J1:

$$\frac{\partial P_i}{\partial \delta_i} = -|V_i|B_{ii} \quad (4)$$

- ✓ Off diagonal elements of J1:

$$\frac{\partial P_i}{\partial \delta_j} = -|V_i|B_{ij} \quad (5)$$

- ✓ Diagonal elements of J4:

$$\frac{\partial Q_i}{\partial V_i} = -|V_i|B_{ii} \quad (6)$$

- ✓ Off diagonal elements of J4:

$$\frac{\partial Q_i}{\partial V_j} = -|V_i|B_{ij} \quad (7)$$

ii. Δδand Δ|V| can be obtained from

$$\Delta\delta = -[B']^{-1} \frac{\Delta P}{|V|} \quad (8)$$

$$\Delta|V| = -[B'']^{-1} \frac{\Delta Q}{|V|} \quad (9)$$

E. IEEE 30 Bus

An examination were completed on the 30-transport IEEE test framework as appeared in Fig 3.This system was chosen since it speaking to the substantial number of power networks. It contains every one of the parts which typically required to be considered in making a power flow analysis, for example, generator, transmission line, transformer and load. A one-line chart of the framework examined is appeared in Fig 3.

The IEEE 30 bus system has

- ❖ 6 generators,
- ❖ 6 transformers,
- ❖ 35 transmission lines,
- ❖ 21 loads.

TABLE I LINE DATA

Line No.	From Bus	To Bus	Resistance (R)	Reactance (X)	Half Line Charging B/2
1	1	2	0.0192	0.0575	0.0264
2	1	3	0.0452	0.1852	0.0204
3	2	4	0.057	0.1737	0.0184
4	3	4	0.0132	0.0379	0.0042
5	2	5	0.0472	0.1983	0.0209
6	2	6	0.0581	0.1763	0.0187
7	4	6	0.0119	0.0414	0.0045
8	5	7	0.0460	0.1160	0.0102
9	6	7	0.0267	0.0820	0.0085
10	6	8	0.0120	0.0420	0.0045
11	6	9	0	0.2080	0
12	6	10	0	0.5560	0
13	9	11	0	0.2080	0

14	9	10	0	0.1100	0
15	4	12	0	0.2560	0
16	12	13	0	0.1400	0
17	12	14	0.1231	0.2559	0
18	12	15	0.0662	0.1304	0
19	12	16	0.0945	0.1987	0
20	14	15	0.2210	0.1997	0
21	16	17	0.0824	0.1923	0
22	15	18	0.1073	0.2185	0
23	18	19	0.0639	0.1292	0
24	19	20	0.0340	0.0680	0
25	10	20	0.0936	0.2090	0
26	10	17	0.0324	0.0845	0
27	10	21	0.0348	0.0749	0
28	10	22	0.0727	0.1499	0
29	21	22	0.0116	0.0236	0
30	15	23	0.1000	0.2020	0
31	22	24	0.1150	0.1790	0
32	23	24	0.1320	0.2700	0
33	24	25	0.1885	0.3292	0
34	25	26	0.2544	0.3800	0
35	25	27	0.1093	0.2087	0
36	28	27	0	0.3960	0
37	27	29	0.1298	0.4153	0
38	27	30	0.3202	0.6027	0
39	29	30	0.2399	0.4533	0
40	8	28	0.0636	0.2000	0.0214
41	6	28	0.0169	0.0599	0.0065

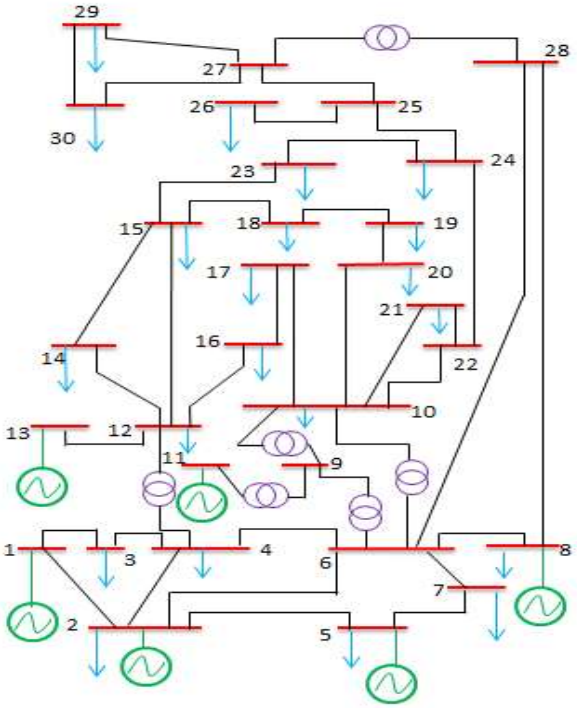

Fig 3.IEEE 30 Bus Systems

V. ANALYSIS AND RESULTS

The main objective of this paper is compared the load flow analysis in MiPower with normal MATLAB results. IEEE 30 bus system is taken as sample for this study.

Load flow solution is computed with the MiPower. Voltage at each bus, Real and Reactive power of the line flow and losses are calculated using both Matlab and MiPower.

TABLE II

COMPARITIVE POWER FLOW OF MATLAB, PWS AND MIP

Line		**Power at bus & line flow By using Matlab**		**Power at bus & line flow By using MiPower**	
From	To	MW	Mvar	MW	Mvar
1	2	58.5	5.952	58.68	5.898
1	3	40.407	9.454	42.496	12.021
2	4	31.619	5.846	34.485	8.852
3	4	37.294	9.768	39.532	12.122
2	5	45.337	7.119	44.884	7.188
2	6	39.246	5.853	43.353	10.485
4	6	33.922	0.055	39.126	6.854
5	7	0.21	4.928	4.444	5.181
6	7	22.744	2.645	18.531	-13.039
6	8	11.951	0.371	11.98	37.515
6	9	11.932	-2.967	9.898	-32.479
6	10	10.763	4.205	10.585	13.788
9	11	-20.0	-20.269	-19.027	-35.314
9	10	31.932	17.009	28.867	0.425
4	12	26.649	16.513	25.727	14.686
12	13	-20.0	-13.262	-19.806	-19.794
12	14	8.314	3.227	8.301	3.613
12	15	19.052	10.242	19.339	11.918
12	16	8.084	6.688	8.77	9.404
14	15	2.023	1.436	2.317	1.785
16	17	4.49	4.691	5.081	7.278
15	18	6.553	3.469	6.959	5.094
18	19	3.297	2.455	3.743	4.014
19	20	-6.214	-0.966	-5.505	0.573
10	20	8.494	1.843	7.735	0.305
10	17	4.549	1.203	3.799	-1.359
10	21	16.057	9.739	14.681	7.638
10	22	7.794	4.4418	6.969	3.073
21	22	-1.560	-1.713	-2.373	-3.667
15	23	6.032	5.155	5.999	5.403
22	24	6.178	2.589	4.541	-0.695
23	24	2.773	3.435	2.788	3.671
24	25	0.175	-0.806	-1.096	-3.743
25	26	3.546	2.369	3.429	2.340
25	27	-3.372	-3.177	-4.592	-6.147
28	27	16.684	7.808	17.683	11.411
27	29	6.193	1.674	5.926	1.709
27	30	7.096	1.670	6.788	1.719
29	30	3.705	0.608	3.536	0.636
8	28	1.935	-1.207	2.534	-6.103
6	28	14.792	3.486	17.471	12.496

TABLE III

COMPARISION RESULT OF MATLAB AND MIP

Software used	**No. of iterations**	**Total time in seconds**
MATLAB	28	6.152
MIPOWER	15	0.98

The table 2 and 3 gives the compared results of MATLAB and MiPower. Table 2 proved the line flow results

of Matlab and MiPower relatively same. By using MiPower the computation of power flow study gives accurate and fast compared with the Matlab was proved from table 3.

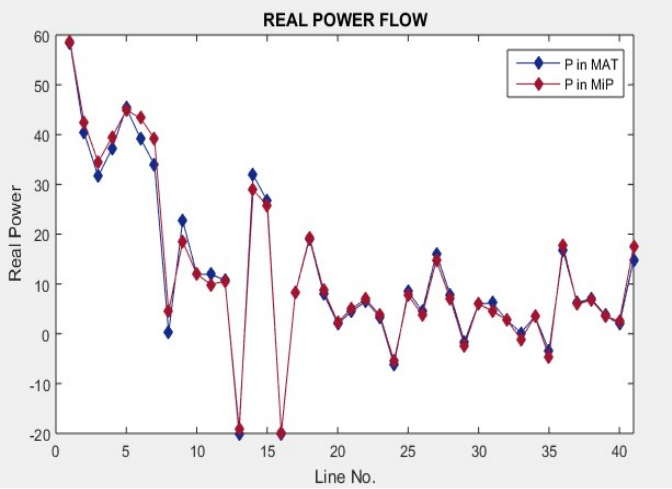

Fig 4.Comparision of Real Power Flow in MiPower with MATLAB

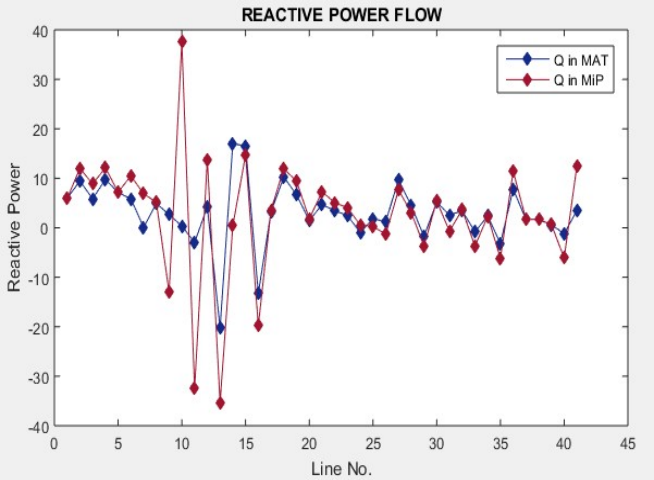

Fig 4.Comparision of Reactive Power Flow in MiPower with MATLAB

VI. CONCLUSION

The improvement test system device models utilizing MiPower programming can be connected to understand control stream arrangement framework. These models have been utilized to consider and investigate the power stream parameter, for example, generator node, load bus, slack node, impedance at transmission line and transformers. Also, the test system device was produced by consolidating each node. Keeping in mind the end goal to dissect control stream in this power framework, all parameter was set by IEEE affirmed. The entire outcome from MiPower was more precise contrasted with the hypothesis of cycle strategy. In power networplans, the MiPower reproduction is the best giving snappy and prudent aftereffects of high exactness. Better economy in power stream estimation; along these lines depend basically on fast and practical PCs and in addition precise and effective PC supported programming. The proposed investigation of intensity stream arrangement additionally can be connected to industry and worldwide utilized. Furthermore, MiPower technique still should be investigated and enhance for better application.

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