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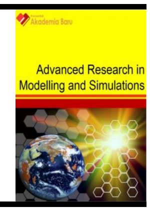

Power Flow Analysis Considering Different Algorithm

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ABSTRACT

Power flow analysis is a very important and fundamental tool for power system. Commercial power systems usually are too complex for manual solution by hands. In addition, due to power flow equation this is nonlinear, more computation time were needed and become complicated as the number of bus increase in a bus system. This can be improvising by power flow solution iterative methods simulation. Iterative algorithm for solving power flow equations were simulated using MATLAB software. The objectives are to obtain the power flow solution in distribution network which is the number of iteration required and system losses; to compare the power flow analysis with Newton Raphson (NR), Gauss Seidel (GS) and Fast Decoupled (FD) method. Three test system were discussed which are IEEE 14-bus system, IEEE 30- bus system, and IEEE 57-bus system and classified to three cases and were tested by three iterative algorithms proposed.

1. Introduction

Power flow analysis is important and fundamental tool for distribution systems. Besides that, it is also useful in calculating the magnitude and phase angle of load busses, active and reactive power in distribution network for each bus systems. Power flow studies also have a very important role in planning and designing the future expansion of power system as well as determine the best operation for the existing system. The principle information obtained from a power flow study is magnitude and phase angle of the voltage at each bus for real and reactive power flowing in each line for each of bus systems [1].

Power flow analysis is a very important and fundamental tool for power system. On top of that, power flow analysis is an importance tool involving numerical analysis applied to a power system. Commercial power systems are usually too complex for manual solution by hands. In addition, due to power flow equation this is non-linear, more computation time were needed and become complicated as the number of bus increase in bus systems. This can be improvising by power flow solution iterative methods simulation. Iterative algorithm for solving power flow equations were simulated using

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MATLAB software.

The objectives are to obtain the power flow solution in distribution network which is the number of iteration required and system losses; to compare the power flow analysis with Newton-Raphson (NR), Gauss Seidel (GS) and Fast Decoupled (FD) method. The iterative algorithm for solving power flow analysis will be simulated using MATLAB programming. Iterative methods are a mathematical procedure that generates a sequence of improving solution for a class of problems. In addition, an iterative method is a convergent due to corresponding sequences convergence for given initials assumptions. Thus, convergence is a speed at which a convergent sequence approaches its limit of computation [2]. Newton Raphson (NR) method is widely used to solve simultaneous non-linear algebraic equations. It is a powerful technique to solve equations numerically. NR is a based idea of linear approximation procedure based on unknown estimate and Taylor's series expansion [3]. NR method is commonly use and introduce in most text book. NR method is a successive approximation procedure based on an initial estimate of one dimensional equation given by series expansion. Liebmann method or the successive displacement method is other terms of Gauss-Seidel (GS) method. In numerical linear algebra, this method is an iterative method for solving linear system of equations. GS method can be applied to any matrix with non-zero element on diagonals. In addition, the converged can be done if the matrix is diagonally, dominant, positive definite and also symmetric [4]. In power transmission line there have a high ratio of impedance to resistance. Fast Decoupled (FD) method is the third method proposed due to changes of real power are less sensitive to voltage magnitude changes however most sensitive to changes in phase angles. In addition, in reactive power, changes are less sensitive to changes in angle and are mainly dependent on changes in voltage magnitude. In the following, the derivations of the fast decouple method from the Newton Raphson method [5].

2. Methodology

Three types of IEEE buses tested system were used for the power flow analysis by using different algorithm, which are NR, GS and FD. In addition, the performance can be obtained for each bus modeling of IEEE 14-Bus Test System, IEEE 30-Bus Test System, and IEEE 57-Bus Test System. The flow, steps and how it is organized are described as shown in Figure 1. Simulations for the power flow analysis by developing programs for power flow solution using MATLAB software were discussed in this paper.

2.2 Case Study 1: IEEE 14-Bus Systems

Figure 2 shows the single line diagram for IEEE 14-Bus system. 100MVA were selected as power base for per unit system, 0.001 for accuracy, 1.6 for acceleration and 100 as maximum number of iterations. Bus data, regulated bus data, transformer tap setting and injected reactive power due to capacitor were tabulated [6].

2.3 Case Study 2: IEEE 30-Bus Systems

Figure 3 shows the single line diagram for IEEE 30-Bus system. 100MVA were selected as power base for per unit system, 0.001 for accuracy, 1.6 for acceleration and 100 as maximum number of iterations. Bus data, regulated bus data, transformer tap setting and injected reactive power due to capacitor were tabulated [7].

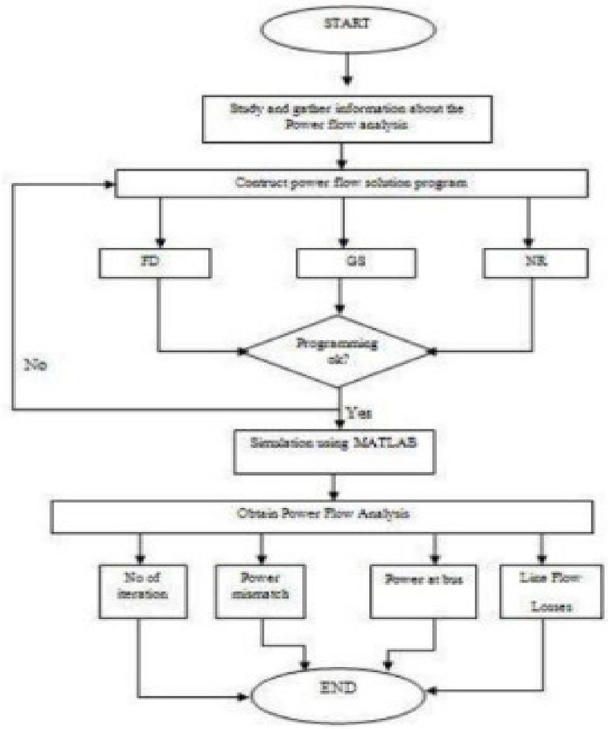

Fig. 1. Flow Chart of Power Flow Solution using Three Different Methods

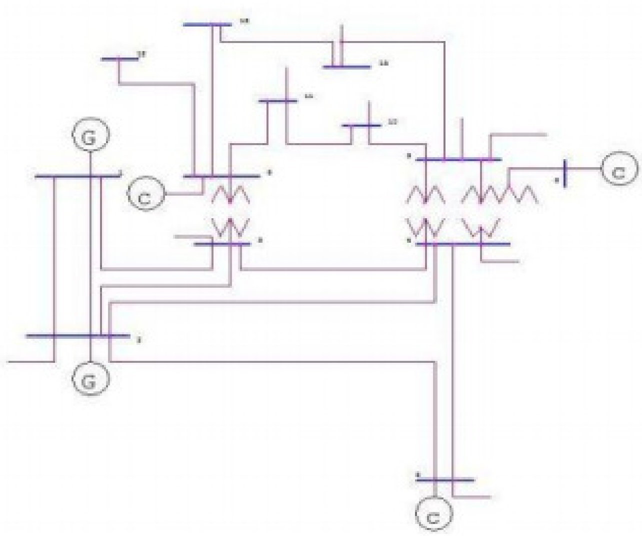

Fig. 2. Single Line Diagram for IEEE 14-Bus System

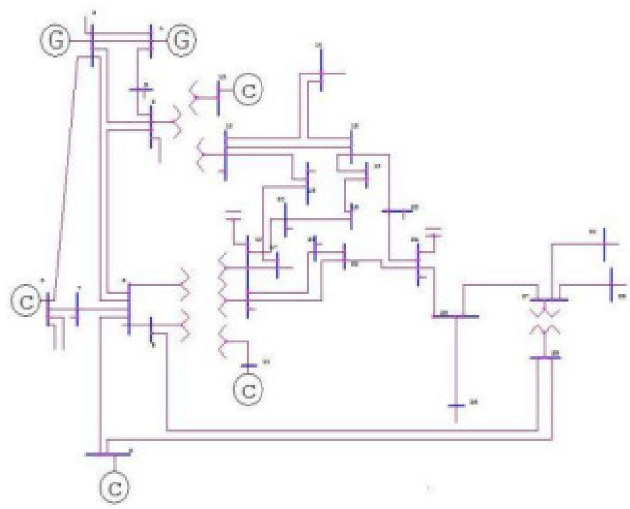

Fig. 3. Single Line Diagram for IEEE 30-Bus System

2.4 Case Study 3: IEEE 57-Bus Systems

Figure 4 shows the single line diagram for IEEE 57-Bus system. 100MVA were selected as power base for per unit system, 0.001 for accuracy, 1.6 for acceleration and 100 as maximum number of iterations. Bus data, regulated bus data, transformer tap setting and injected reactive power due to capacitor were tabulated [8].

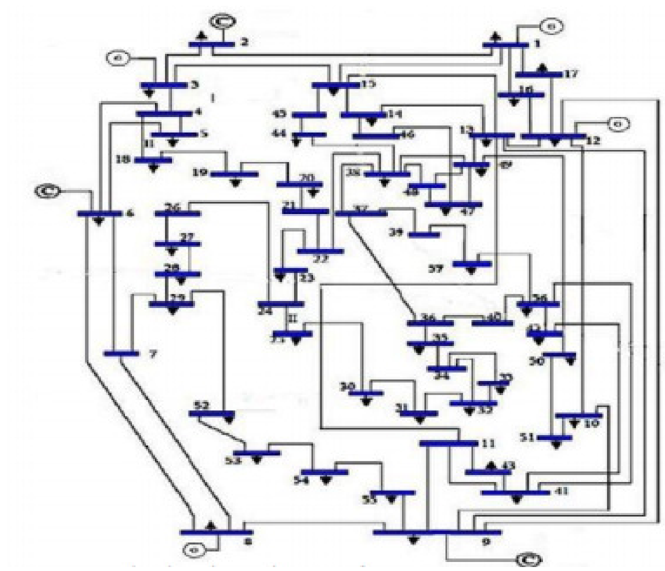

Fig. 4. Single line diagram for IEEE 57-bus system

3. Result and Discussion

All the results are obtained after power flow analysis simulation conducted. The results are including no of iteration, maximum power mismatch, line losses for real power (MW) and reactive power (MVar) for GS, NR and FD methods. 3.1.1 Case Study 1: IEEE 14 – Bus System In case study 1, IEEE 14-bus system was tested by three different algorithms which is GaussSeidel (GS), Newton

Raphson (NR) and Fast Decouple (FD). The comparison between number of iterations required, maximum power mismatch, and total line loss are being tabulated in Table 1.

Table 1
Comparison between Proposed Algorithms for IEEE 14-Bus

IEEE 14 – bus system	Gauss- Seidel Method	Newton- Raphson Method	Fast Decoupled Method
No of iteration	101	9	26
Max power mismatch	0.0218237	0.00037378	0.000628192
Total Line Loss (MW)	19.067	19.152	19.279
Total Line Loss (Mvar)	57.487	58.082	58.806

Maximum power mismatch for GS, FD and NR methods there were slight differences between each of the algorithms proposed which equal to 0.0218237, 0.00037378, and 0.000628192 respectively. Figure 6 shows that FD methods have the lowest power mismatch compared to GS and NR. Maximum power mismatch is the amount of power that will not be available on the output due to the impedances mismatches. NR methods required nine numbers of iteration compared to FD and GS method which equal to twenty-six and one hundred one number of iterations required respectively. It is shown that in the second case using 14-bus systems, NR methods required less number of iterations to perform the computation for power flow analysis compared to the GS and FD methods. It is shows that convergence in NR is very fast compared to other methods. Total line losses in IEEE 14-bus system can be observed. Based on graph in Figure 4.5, it is shown that total line loss for NR, GS and FD methods were slightly difference for each of the algorithms proposed which equal to 19.067MW, 19.152MW and 19.279MW respectively. Based on the Figure 4.5, it is shown that the GS method have the lowest total line losses compared to the NR and FD. It is shown that the formulation and parameters in IEEE 14-bus systems influents results for line loss. It is shown that the GS method is the best method to calculate the system losses. Total line loss (Mvar) for NR, FD and GS were slightly different which equal to 58.082Mvar, 58.806Mvar and 57.487Mvar respectively. Based on the Figure 4.6, it is shows that an NR method gives the lowest line loss for IEEE 14-bus system compared to other methods. It is shows that the results are influent by the formulation parameters in IEEE 14-bus system. It is shown that the GS method is the best method to calculate the system losses. 3.1.2 Case Study 2: IEEE 30 – Bus System IEEE 30-bus system was tested by three different algorithms which are Gauss-Seidel (GS), Newton Raphson (NR) and Fast Decouple (FD). Comparison between number of iterations required, maximum power mismatch, and the total line loss are being tabulated in Table 2.

Table 2
Comparison Between Proposed Algorithms For IEEE 30-Bus

IEEE 30 – bus system	Gauss- Seidel Method	Newton- Raphson Method	Fast Decoupled Method
No of iteration	34	4	15
Max power mismatch	0.000953407	0.0000000733	0.000918146
Total Line Loss (MW)	17.578	17.582	17.582
Total Line Loss (Mvar)	22.165	22.176	22.177

For IEEE 30-bus system, maximum power mismatch for GS method and FD method is nearly matched which are 0.000953407 and 0.000918146. However there is slight difference in NR method which maximum power mismatch is lower than both of GS and FD methods which equal to 0.0000000733. Maximum power mismatch is the amount of power that will not be available on the output due to the impedances mismatches NR methods required four number of iterations required compared to FD and GS method which are fifteen and thirty four number of iterations respectively.

NR methods take less number of iterations required to perform the power flow solution compared to the GS and FD methods. It shows that convergence in NR is very fast. Total line loss in MW for NR and FD methods were equal to 17.582MW respectively. However, GS method shows total line loss of 17.578MW is nearly matched to both NR and FD methods. It is shown that the GS is the best method to calculate the system losses. Total line loss for NR and FD methods were nearly matched which equal to 22.176Mvar and 22.177MVar, respectively. However, the GS methods shows total line loss equal to 22.165MVar which is slightly different compared to both NR and FD methods. From the result it is shown that parameters and formulation in each of iterative methods influents the total line losses for IEEE 30-bus systems. It also shown that the GS method is the best method to calculate the system losses. 3.1.3 Case Study 3: IEEE 57 – Bus System Thirdly, IEEE 57-bus system was tested by three different algorithms which are Gauss-Seidel (GS), Newton Raphson (NR) and Fast Decouple (FD). The comparison between numbers of iterations required, maximum power mismatch, and total line loss are being tabulated in Table 3.

Table 3
Comparison between Proposed Algorithms for IEEE 57-Bus

IEEE 57 – bus system	Gauss- Seidel Method	Newton- Raphson Method	Fast Decoupled Method
No of iteration	101	15	31
Max power mismatch	0.0738906	0.000674927	0.360674
Total Line Loss (MW)	25.000	29.552	30.785
Total Line Loss (Mvar)	36.362	47.90	9.630

Maximum power mismatch for all three methods were varies between each other's. GS method shows that the maximum power mismatches is 0.0738906. However, NR method shows different maximum power mismatch is to 0.000674927 and for FD methods, the maximum power mismatch is equal to 0.360674. Between three methods, it is shown that the FD method have the highest maximum power mismatch compared to other methods. NR methods required fifteen numbers of iterations compared to FD and GS method which are thirty-one and one hundred one, respectively. It is shows for the third case using IEEE 57-bus systems, NR methods required less number of iterations required compared to the GS and FD methods. It shows that convergence in NR is very fast. GS methods have the highest total line loss which equal to 25MW compared to NR and FD which equal to 29.552MW and 30.785MW respectively. It is shown that compared to three iterative methods, GS method shows the lowest total losses (MW) compared to GS and FD. The different values of system losses for IEEE-57 bus system are also due to the power flow equation for each iterative method. It is shown that the GS method is the best method to calculate the system losses. Total line loss (Mvar) for GS, NR and FD are varies between each of the algorithms proposed. GS method shows the highest total loss which equal to 36.362 Mvar and NR methods equal to 47.9Mvar. However, an FD method shows the lowest total line losses which equal to 9.63Mvar. This is shown that computation of line flow and losses using FD method is affected by the high reactance to impedance (R/X) ratios which deteriorates diagonal dominance of Jacobian matrix in FD method.

4. Conclusion and Recommendation

In this paper, power flow analysis using NR, GS and FD methods were compared. The simulation of the power flow analysis was tested using MATLAB software on three different cases; IEEE 14- bus system, IEEE 30-bus system and IEEE 57-bus systems. Comparisons were carried out based on the number of iterations required, maximum number of power mismatch, line and flow losses including total loss for the bus system. Based on the results, three different proposed methods were found to be capable to do the power flow analysis as well as success to give results for the power flow equation. By iterative methods of the different proposed algorithms, power flow analysis can be conducted by power flow programming and can save a lot of computation time compared to manually calculations. On top of that, based on the result for all three cases, it shows that GS method is the best method to calculate the system losses and NR methods are the fastest method for the computation of power flow equation. All objectives of this paper have been achieved. It can be conclude that the proposed algorithms for iterative methods were suitable for power flow solution by simulation using MATLAB programming. The comparison for all three cases were displayed and steady state voltages, voltages angles for all busses in the network, real and reactive power flows into each line and transformer as well as system losses can be compute and it required shorter time compared to manual calculation by hands although it is complicated as the number of bus increase in a bus systems. Power Flow Analysis can be further developed and extended by development of heuristics methods and combine with other features such as optimization techniques performance in terms of total losses and voltage profile can be synthesized by development of heuristics methods such as Artificial Immune System (AIS) and Evolutionary Programming (EP) techniques.

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