POWER FLOW ANALYSIS CONSIDERING NEWTON RAPHSON, GAUSS SEIDEL AND FAST- DECOUPLED METHODS

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Abstract

Power flow analysis is a very important and fundamental tool for power system. Commercial power systems usually too complex for manual solution by hands. In addition, due to power flow equation which is nonlinear, more computation time were needed and become complicated as the number of bus increases in bus systems. This can be improvising by power flow solution iterative methods simulation. Iterative algorithm for solving power flow equations were simulated using MATLAB software. Objectives of the study 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 9-bus system, IEEE 14-bus system, and IEEE 69-bus system and classified to three cases and were tested by three iterative algorithms proposed. Based on the results from three different cases, NR method required less number of iterations compared to FD and GS methods. Convergence by NR method is very fast and increases in number of bus system do not increase the number of iterations for NR. All three iterative algorithms successful to give the power flow solution for three test case.

Keywords: ***Power Flow, Newton Raphson, Gauss-Seidel, Fast -Decoupled, Power Flow Solution.***

1 INTRODUCTION

The electric power system often consist of many generators, transformers, passive and active load elements such as in a distribution network, all interconnected by transmission line between buses numbering in the hundreds and even in thousand. The basic purpose of the power system is to supply active and reactive electric power to consumer all along the network in a reliable and economical on continuous basis and at a voltage level and frequency that holds within specified limit. Moreover, this must be achieved in a way which ensures that none of the generation units operates in a sustained overloaded condition and that no transmission line is stressed either by excessive line losses or by a serious reduction in its static stability margin.

The model of the power system that is used in a power flow analysis contain of all the busses in the system, the generating unit and load element connected to these various buses, and the transmission lines that interconnect the buses. The information by a power flow analysis is quite simple voltage profile of the system. In other way, the important of the analysis is the determination of voltage magnitude and associated phase angle at each bus. Regarding overloads on any of the system component are obtained at this point in these analysis studies [1-2].

2 LITERATURE REVIEW

2.1 Newton Raphson (NP) Method

The NP method is an effective technique of fixing non-linear algebraic equations; it really works faster and is sure to converge in maximum instances in comparison to the Gauss-Seidel method. It is indeed the practical method of power flow solution of large power networks. It is only drawback is the large requirement of computer memory, which can be overcome through a compact storage scheme [3]. Convergence can be significantly accelerated with the aid of acting the primary iteration via the Gauss Seidel method, and the usage of the values so acquired for solving the Newton Raphson iteration [4].

2.2 Gauss Seidel (GS) Method

In order to know the power flow at any particular time it is necessary to know the bus voltage and the generator voltage with phase angle difference between the two voltages. On the basis of the data received it has to formulate the equations and find the solution. With the advent of computers, different types of programs have been loaded on the same to get quick results [5].

However, some data has to be assumed and then the voltages have to be calculated. If there is difference between the assumed voltage and the calculated value, the calculated value has to take as input for the next calculation and the value calculated again. This process has to be repeated until the error between two successive values reduces below the set level [6].

2.3 Fast-Decoupled (FD) Method

The basic idea of the FD method is expressing the nodal power as a function of voltages in polar form, separately solving the active and reactive power equations by using active power mismatch to modify voltage angle and using reactive power mismatch to modify voltage magnitude. In this way, the computing burden of load flow calculation is alleviated significantly. In the following, the derivations of the fast decouple method from the Newton Raphson method [7].

3 METHODOLOGY

A three type of IEEE buses tested system were used for the power flow analysis by using different method, which are NR, GS and FD as shown in Figure 1. In addition to obtain the performance for each bus modeling of, IEEE 9-Bus Test System, IEEE 14-Bus Test System, and IEEE 69-Bus Test System were used for this paper. All of the development from modeling to simulation for each bus tested was using MATLAB software.

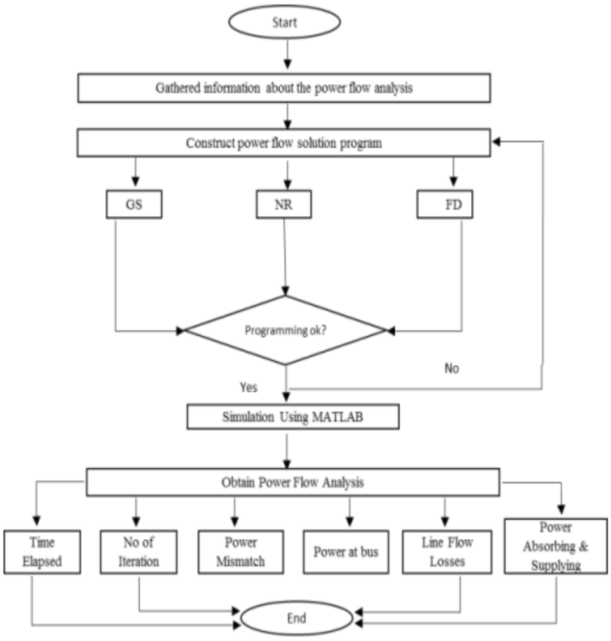

Figure 1: Flow chart of Bus System Using Three Different Method Process

3.1 Case Study 1: IEEE-9 Bus System

Figure 2 shows the single line diagram for IEEE 9-Bus system with two generator buses, which are connected to generator and it subsist of 8 load buses which are connected to load. Bus 5 and 8 act as both load and generator bus because they are connected to generator and the load.

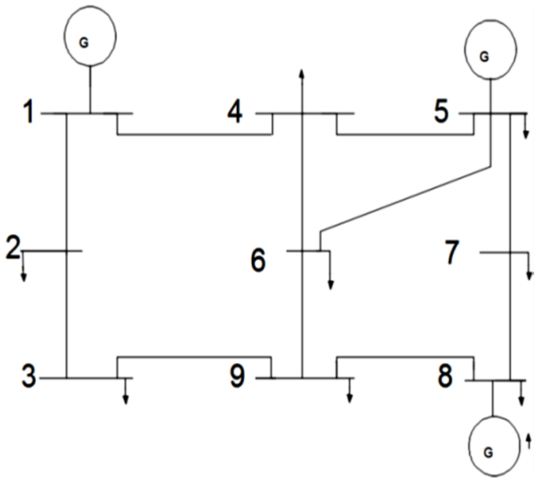

Figure 2: Single-Line Diagram for IEEE 9-Bus System

3.2 Case Study 2: IEEE-14 Bus System

Figure 3 shows the single line diagram for IEEE 14-Bus system. Bus 1 and 2 are considered as generator bus, 3-14 is considered as load bus and 3, 6 and 8 are considered as synchronous compensators.

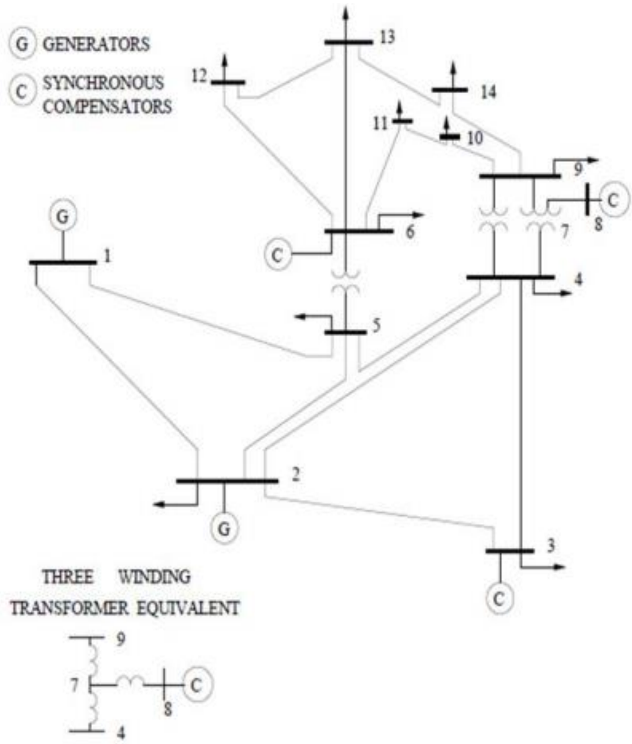

Figure 3: Single-Line Diagram for IEEE 14-Bus System

3.3 Case Study 2: IEEE-69 Bus System

Figure 4 shows the single line diagram for IEEE 69-Bus system. In addition, the base load of 69-bus system is 4659.67 kVA.

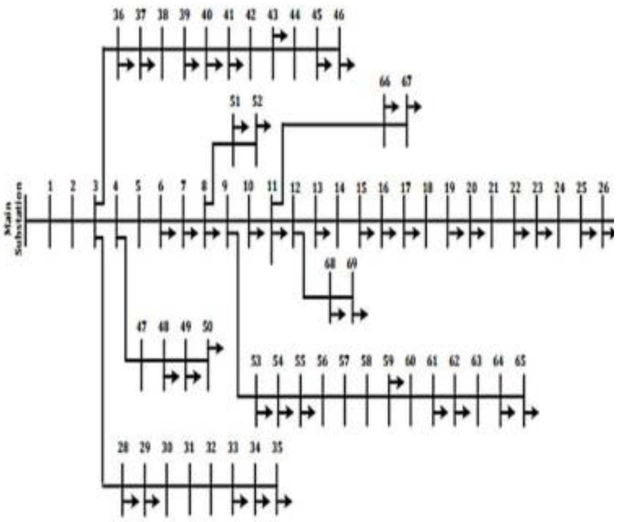

Figure 4: Single-Line Diagram for IEEE 69-Bus System

4 RESULT AND DISCUSSION

All the result after conduct power flow analysis simulation. According to that GS, NR and FD method were shows depends on what type of testing including iteration, maximum power mismatch, time elapsed, line losses for real power (MW) and reactive power (MVar). The three different color shows the effectiveness of output in Table 1.

Table 1: Different of Color Indication in Graph

	Effective Performance
	Intermediate Performance
	Ineffective Performance

4.1 Case Study 1: IEEE-9 Bus System

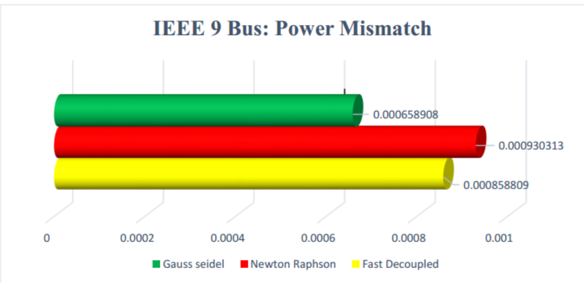

Figure 5: Comparative between Power Mismatch

Figure 5 shows the maximum power mismatch for IEEE 9-Bus system using three different methods. Based on graph illustration related to experimented result shows that GS method more sufficient to diminish the power mismatch then compare with NR and FD, this situation arise due to the impedance mismatch on output.

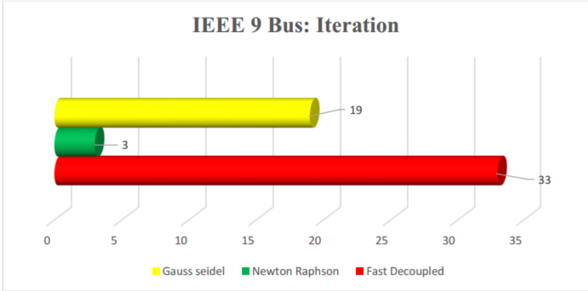

Figure 6: Comparative between Numbers of Iteration Requisite

Figure 6 shows the comparison number of iteration requisite to converge in between three numerical methods to get the effective and fast solution linked to the IEEE 9-Bus system. According to the concern comparison of the three methods shows the NR method took a rapid iterative to converge as better as three iterations to get the output result. Moreover, GS method quite faster to converge than FD, for the slow converge occurs due to formulation and size of bus system which used.

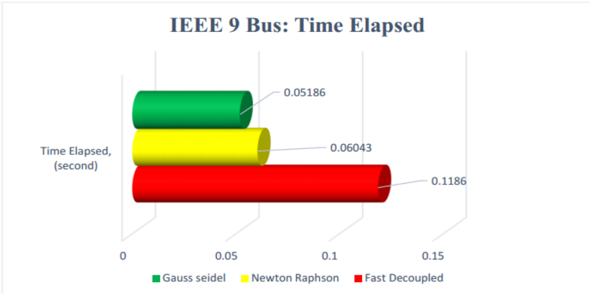

Figure 7: Comparative between Time Elapsed for Complete the Process

Figure 7 shows the time taken for complete the process of formulation to get the output by using three different numerical method respectively with using IEEE 9- Bus system. Based on analysis the graph shows that, GS method process is faster to develop the output solution. Compare to NR method slightly delay 0.00857s than GS method. Moreover, FD method takes slightly more time than GS and NR method for develop the total process of simulation.

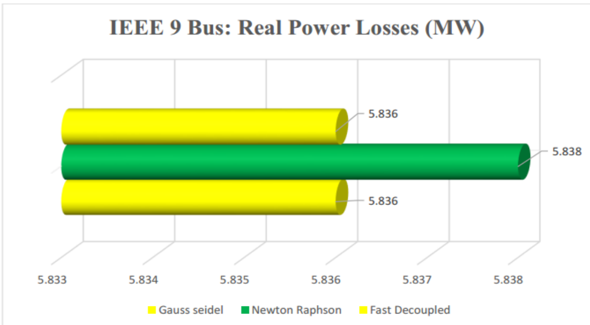

Figure 8: Comparative between Total Line Losses for Real Power (MW)

Figure 8 shows the total real power (MW) line losses for IEEE 9-bus system. According to the graph, the NR method quite effective to ascertain losses between busses. Based on that, the GS and FD method have a same value of power losses with different 0.002 MW than the NR method. Comprehensive the NR method appropriately effective ascertain the losses in IEEE 9-bus system

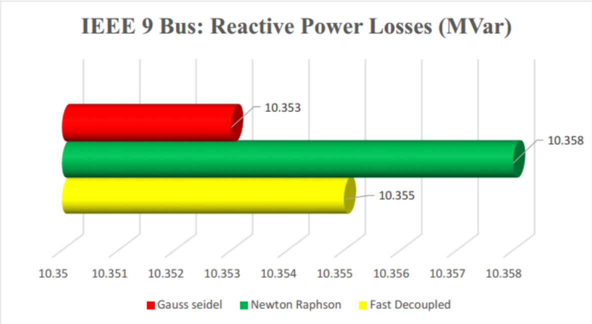

Figure 9: Comparative between Total Line Losses for Reactive Power (MVar)

Figure 9 shows the total reactive power (MVar) line losses for IEEE 9-bus system. Respectively the outcome shows that NR method more effective to bring out the precise reactive power losses which atrophied in between busses. Moreover, GS and FD method slightly less effective where different in between of 0.002 MVar. Comprehensive the NR method appropriately effective ascertain the losses in IEEE 9-bus system.

4.2 Case Study 1: IEEE-14 Bus System

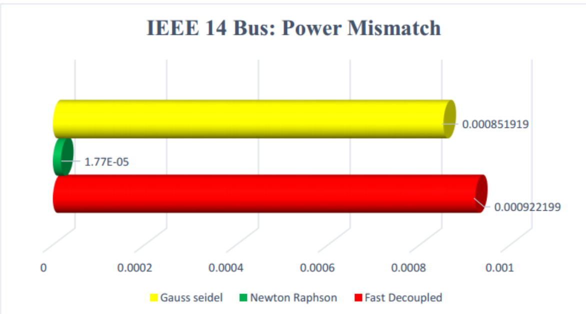

Figure 10: Comparative between Power Mismatch

Figure 10 shows the maximum power mismatch for IEEE 14-Bus system using three different methods. Based on graph illustration related to experimented result shows that NR method more sufficient to diminish the power mismatch then compare with GS and FD, this situation arise due to the impedance mismatch on output

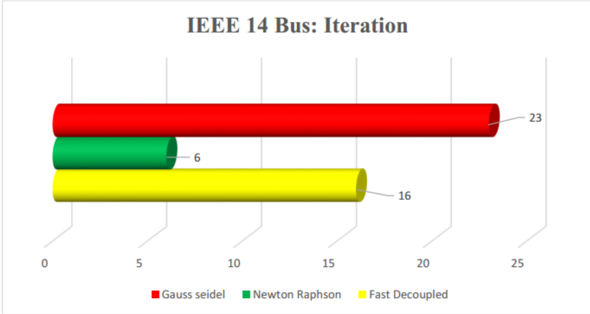

Figure 11: Comparative between Numbers of Iteration Requisite

Figure 11 shows the comparison number of iteration requisite to converge in between three numerical method to get the effective and fast solution linked to the IEEE 14-Bus system. According to the concern comparison of the three methods shows the NR method took a rapid iterative to converge as better as six iterations to get the output result. Moreover FD method quite faster to converge with sixteen iteration than GS took twenty three iteration to converge, for the slow converge occur due to formulation and size of bus system which used.

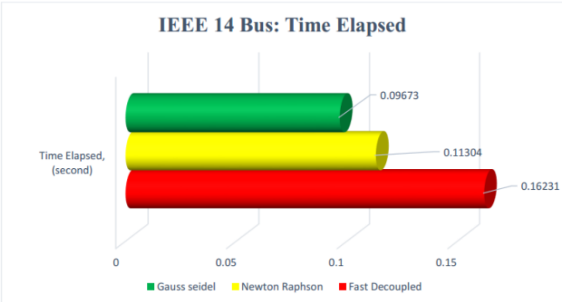

Figure 12: Comparative between Time Elapsed for Complete the Process

Figure 12 shows the time taken for complete the process of formulation to get the output by using three different numerical method respectively with using IEEE 14- Bus system. Based on analysis the graph shows that, GS method process is faster as 0.09673s to develop the output solution. Compare to NR method slightly delay 0.11904s than GS method. Moreover, FD method takes slightly more time 0.16231s than GS and NR method for develop the total process of simulation.

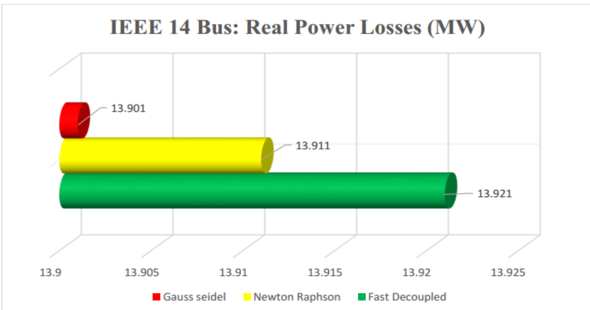

Figure 12: Comparative between Total Line Losses for Real Power (MW)

Figure 12 shows the total real power (MW) line losses for IEEE 9-bus system. Respectively manipulated three different numerical methods which are GS, NR and FD. According to the manipulation shown in graph, the FD method quite effective to ascertain losses between busses. Based on that, the GS and NR method have an approximate value of power losses with different 0.010 MW than the NR method. Comprehensive the FD method appropriately effective ascertain the losses in IEEE 14-bus system.

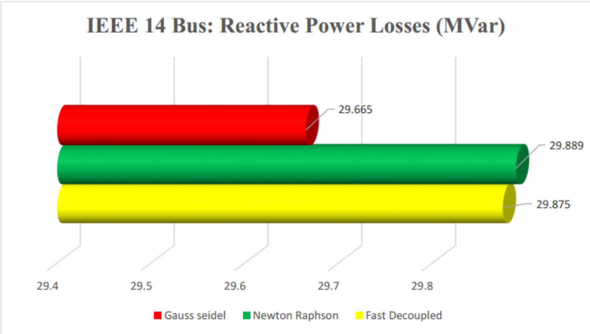

Figure 13: Comparative between Total Line Losses for Reactive Power (MVar)

Figure 13 shows the total reactive power (MVar) line losses for IEEE 14-bus system. Based on the manipulation of three numerical methods which is GS, NR and FD shown in graph form. Respectively the outcome shows that NR method more effective to bring out the precise reactive power losses which atrophied in between busses. Moreover, GS and FD method slightly less effective where different in between of 0.210 MVar. Comprehensive the NR method appropriately effective ascertain the losses in IEEE 14-bus system.

4.3 Case Study 1: IEEE-69 Bus System

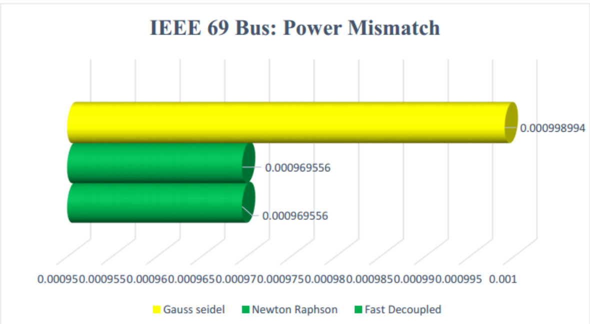

Figure 14: Comparative between Power Mismatch

Figure 14 shows the maximum power mismatch for IEEE 14-Bus system using three different methods. Based on graph illustration related to experimented result shows that NR and FD method more sufficient to diminish the power mismatch then compare with GS method, this situation arise due to the impedance mismatch on output.

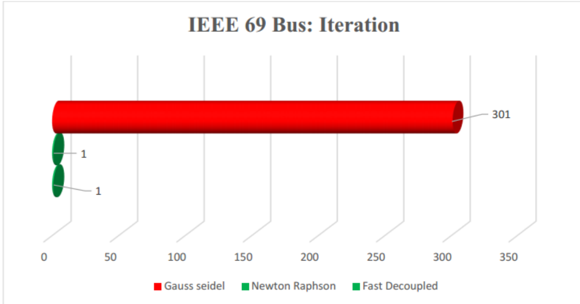

Figure 15: Comparative between Numbers of Iteration Requisite

Figure 15 shows the comparison number of iteration requisite to converge in between three numerical method to get the effective and fast solution linked to the IEEE 69-Bus system. According to the concern comparison of the three method shows the NR and FD method took a rapid iterative to converge as better as one iteration to get the output result. Moreover GS method quite delay to converge with three hundred and one iteration than compare with other two method, for the slow converge occur due to formulation and size of bus system which used

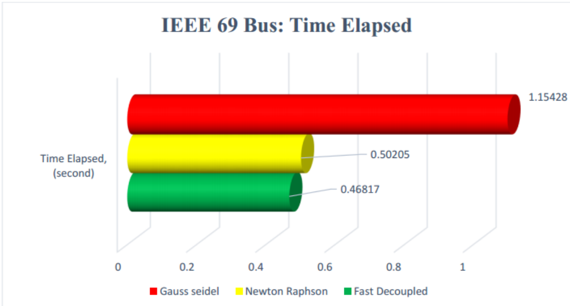

Figure 16: Comparative between Time Elapsed for Complete the Process

Figure 16 shows the time taken for complete the process of formulation to get the output by using three different numerical method respectively with using IEEE 69- Bus system. Based on analysis the graph shows that, FD method process is faster as 0.46817s to develop the output solution. Compare to NR method slightly delay 0.50205s than GS method. Moreover, GS method take slightly more time 1.15428s than NR and FD method for develop the total process of simulation.

Figure 17 shows the total real power (MW) line losses for IEEE 69-bus system. Respectively manipulated three different numerical methods which are GS, NR and FD. According to the manipulation shown in graph, the FD method quite effective to ascertain losses between busses. Based on that, the GS and NR method have an approximate value of power losses with different 0.004 MW than the NR method. Comprehensive the FD method appropriately effective ascertain the losses in IEEE 69-bus system

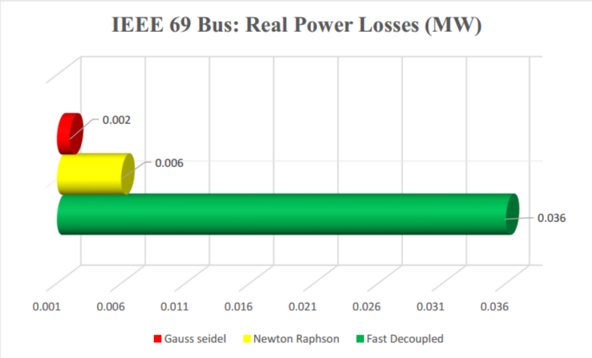

Figure 17: Comparative between Total Line Losses for Real Power (MW)

Figure 18 shows the total reactive power (MVar) line losses for IEEE 69-bus system. Based on the manipulation of three numerical methods which is GS, NR and FD shown in graph form. Respectively the outcome shows that FD method more effective to bring out the precise reactive power losses which atrophied in between busses. Moreover, GS and NR method slightly less effective where different in between of 0.002 MVar. Comprehensive the FD method appropriately effective ascertain the losses in IEEE 69-bus system.

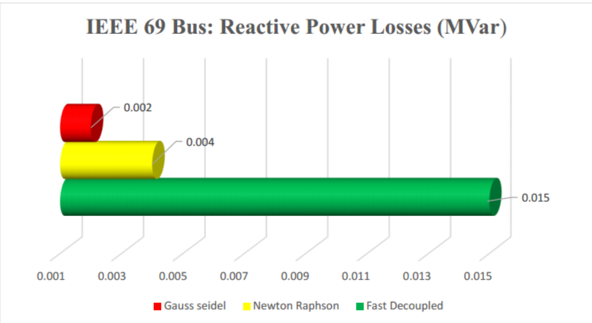

Figure 18: Comparative between Total Line Losses for Reactive Power (MVar)

5 CONCLUSION AND RECOMMENDATION

The key aspect discussed an analysis for numerical methods which done by, use an interconnect bus system of IEEE 9, IEEE 14, and IEEE 69 for manipulate and compare the performance which execute from the simulation. Based on that, in term number of iteration took to converge, NR method shows an exceptional output, because it is need less number of iteration to accomplish load flow analysis than compare other two methods.

Comparatively, the time taken to process the simulation for each methods shows, the GS more effective to execute the output on IEEE 9 and IEEE 14, because small size of bus system the GS method eligible to compute faster, while when it run on IEEE 69 bus system the computational time takes quite delay, based on that it shows due to increase size of bus system, the method take time to compute it. Furthermore, the NR and FD method have an approximate time taken to compute the solutions. Together with, in this case studies have done the comparative losses of real (MW) and reactive (MVar) power. Comprehensively, the NR method can capture approximated the losses in small range of bus system than compare to FD method able to detect higher range of losses in large size of bus system. As high as a numerical method find out the losses as easier to concoct for encounter the losses in system.

Other than that, these case study achieved that all objectives of this analysis has done and successful. MATLAB software was the aid of tool to simulate all the required data. All three numerical methods are suitable for all tested bus system to interconnect the power system.

According to the outcome result and discussion, load flow analysis can be taken to next level of development which considering algorithm method. Based on the statement power flow analysis can extensive to Hybrid Decouple Load Flow Method. The propose recommendation method is more efficient and sufficient than Newton Raphson and Gauss Seidel method, moreover much effective convergence than fast decouple method.

Furthermore, it uses a hybrid procedure to resolve the power flow equations, within which the direct method is employed to resolve the active power equations, and therefore the indirect method is employed to resolve the reactive power equations. It models zero-impedance branches accurately and avoids solution divergence that's typically caused by zero impedance branches in standard method [8]

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