IJIREEICE

ISSN (Online) 2321-2004
ISSN (Print) 2321-5526

International Journal of Innovative Research in
Electrical, Electronics, Instrumentation and Control Engineering

Vol. 9, Issue 7, July 2021

DOI 10.17148/IJIREEICE.2021.9734

Study of the Load Flow Problem in Power System Planning Studies

Harsh Verma[1], Ravi Mishra[2], V. V. Mehtre[3]

[1-3]Department of Electrical Engineering, Bharati Vidyapeeth (Deemed to Be) University, Pune

Abstract: Load flow could also be a valuable tool employed by power engineers for planning, to work out the sole operation for an influence system and exchange of power between utility companies. To possess an efficient operating power grid, it is necessary to work out which method is suitable and efficient for the system's load flow analysis. An influence flow analysis method may take an extended time and thus prevent achieving an accurate result in an influence flow solution because of continuous changes in power demand and generations. This paper presents an analysis of the load flow problem in power grid preparation studies. The numerical methods: Gauss-Seidel, Newton-Raphson and Fast Decoupled methods were compared for an influence flow analysis solution. I ran a simulation using MATLAB for test cases of IEEE 9-Bus, IEEE 30-Bus and IEEE 57-Bus systems. I compared the simulation results for kind of iteration, computational time, tolerance value and convergence. The compared results show that Newton-Raphson is the foremost reliable method because it is the slightest number of iterations and converges faster.
Keywords: Load Flow, Bus, Gauss-Seidel, Newton-Raphson, Fast Decoupled, Voltage Magnitude, Voltage Angle, Active Power, Reactive Power, Iteration, Convergence

I. INTRODUCTION

A. Bus Classification

A bus may be a point or node during which one or many transmission lines, loads and generators are connected. during a power grid study, every

bus is related to 4 quantities, like the magnitude of voltage (|V|), the phase of voltage (δ), active power (P) and reactive power (Q) [2] [3] [11] [12]. Two of those bus quantities are specified and therefore the remaining two are required to be determined through the answer of equation [13]. The buses are classified by counting on the 2 known quantities that are specified. "Buses are divided into three categories as shown in Table 1." ("Analysis of the Load Flow Problem in Power System Planning ...")

B. Generator (PV) Bus

This is a voltage control bus. The bus is connected to a generator unit during which output power generated by this bus is often controlled by adjusting the first cause and therefore the voltage is often controlled by adjusting the excitation of the generator. Often, limits are given to the values of the reactive power depending upon the characteristics of a private machine. The known variable during this bus is P and |V| and therefore the unknown is Q and δ [8] [12].

Sr.no	Type of Bus	Variables			
		P	Q	|V|	δ
1.	Slack Bus	Unknown	Unknown	Known	Known
2.	Generator Bus (PV)	Known	Unknown	Known	Unknown
3.	Load Bus (PQ)	Known	Known	Unknown	Unknown

C. Load (PQ) Bus

This is a non-generator bus which can be obtained from historical data records, measurement or forecast. The real and reactive power supply to a power system is defined to be positive, while the power consumed in a power system is

IJIREEICE

ISSN (Online) 2321-2004
ISSN (Print) 2321-5526

International Journal of Innovative Research in
Electrical, Electronics, Instrumentation and Control Engineering

Vol. 9, Issue 7, July 2021

DOI 10.17148/IJIREEICE.2021.9734

defined to be negative. The consumer power is met at this bus. ("Analysis of the Load Flow Problem in Power System Planning ...") ("LAB (Lactic Acid Bacteria) (Lactic Acid Bacteria) 4 Load Flow Analysis on Simulink 17032021 024542pm ...") The known variable for this bus is P and Q and the unknown variable is |V| and δ [8] [12]
.

II. POWER FLOW ANALYSIS METHODS

The numerical analysis involving the answer of algebraic equations forms the idea for the answer of the performance equations in computer-aided electric power system analyses e.g., for load flow analysis [4]. The primary step in performing load flow analysis is to make the Y-bus admittance using the cable and transformer input file. The nodal equation for an influence system network using Y bus is often written as follows:

$$I = Y_{\text{Bus}} V \quad (1)$$

The nodal equation is often written during a generalized form for an n bus system.

$$I_i = \sum_{j=1}^{n} Y_{ij} V_j \quad \text{for } i = 1,2,3,n \quad (2)$$

The complex power delivered to bus i is

$$P_i + jQ_i = V_i I_i^* \quad (3)$$

$$I_i = \frac{P_i - jQ_i}{V_i^*} \quad (4)$$

Substituting for Ii in terms of, the equation gives

$$\frac{P_i - jQ_i}{V_i^*} = V_i \sum_{j=1}^{n} y_{ij} - \sum_{j=1}^{n} y_{ij} V_j \quad j \neq i \quad (5)$$

The above equation uses iterative techniques to unravel load flow problems. Hence, it is necessary to review the overall sorts of the varied solution methods; Gauss-Seidel, Newton Raphson, and Fast decoupled load flow.

A. Gauss-Seidel Method

This method is developed supported by the Gauss method. it is an iterative method used for solving a group of nonlinear algebraic equations [14]. the tactic makes use of an initial guess for the worth of voltage, to get a calculated value of a specific variable. The initial guess value is replaced by a calculated value. the method is then repeated until the iteration solution converges. ("Assignment_1_Load_Flow_Analysis_217000352.pdf - 2020 ...") The convergence is sensitive to the starting values assumed. But this method suffers from poor convergence characteristics [15]. this is often an iterative method that is wanting to solve Equation (5) for the worth of Vi, and therefore the iterative sequence becomes

$$V_i^{(k+1)} = \frac{\frac{P_i^{sch} - jQ_i^{sch}}{V_i^*} + \sum y_{ij} V_j^{(k)}}{\sum y_{ij}} \quad j \neq i \quad (6)$$

Using Kirchhoff current law, it is assumed that the present injected into bus i is positive, then the important and therefore the reactive powers supply into the buses, like generator buses, and have a positive value. the important and therefore the reactive powers flowing far away from the buses, like load buses and have a negative value. Pi and Qi are solved from Equation (5) which gives

$$P_i^{(k+1)} = \text{Real}\left[V_i^{*(k)} \left\{ \sum_{i=0}^{n} y_{ij} - \sum_{ji}^{n} V_i^{(k)} \right\} \right] \quad j \neq i \quad (7)$$

$$Q_i^{(k+1)} = \text{Imaginary}\left[V_i^{*(k)} \left\{ \sum_{j=1}^{n} y_{ij} - \sum_{ji}^{n} V_i^{(k)} \right\} \right] \quad j \neq i \quad (8)$$

The power flow equation is typically expressed in terms of the bus admittance matrix, using the diagonal elements of the bus admittance and therefore the non-diagonal elements of the matrix, then the Equation (6) becomes,

$$V_i^{(k+1)} = \frac{\frac{P_i^{sch} - jQ_i^{sch}}{V_i^{*(k)}} - \sum Y_{ij} V_j^{(k)}}{Y_{ii}} \quad (9)$$

and

$$P_i^{(k+1)} = \text{Real}\left[V_i^{*(k)} \left\{ V_i^{*(k)} Y_{ii} + \sum_{i=1, j=1}^{n} y_{ij} V_j^{(k)} \right\} \right] \quad j \neq i \quad (10)$$

ISSN (Online) 2321-2004
ISSN (Print) 2321-5526

International Journal of Innovative Research in
Electrical, Electronics, Instrumentation and Control Engineering

Vol. 9, Issue 7, July 2021

DOI 10.17148/IJIREEICE.2021.9734

$$P_i^{(k+1)} = \text{Imaginary}\left[V_i^{*(k)}\left\{V_i^{*(k)}Y_{ii} + \sum_{i=1,j=1}^{n} y_{ij}V_j^{(k)}\right\}\right] \quad j \neq i \qquad (11)$$

The admittance to the bottom of line charging susceptance and other fixed admittance to the bottom are included into the diagonal element of the matrix.

B. Newton-Raphson Method

This method was named after Sir Isaac Newton and Joseph Raphson. ("A fuzzy levelized energy cost method for renewable energy ...") The origin and formulation of the Newton-Raphson method were dated back to the late 1960s [7]. it is an iterative method that approximates a set of the non-linear equation to a gaggle of the equation using Taylor's series expansion and the terms are limited to the first approximation. it is the foremost iterative method used for the load flow because its convergence characteristics are more powerful compared to other alternative processes and thus the reliability of the Newton-Raphson approach is comparatively good since it can solve cases that lead to divergence with other popular processes [15]. If the assumed value is near the solution, then the result is obtained very quickly, but if the assumed value is farther removed from the solution, then the strategy may take longer to converge [12]. this can be often another iterative load flow method that is widely used for solving the nonlinear equation. The admittance matrix is utilized to write equations for currents entering an influence system.

Equation (2) is expressed in an exceedingly very polar form, within which j includes bus I

$$I_i = \sum_{j=1}^{n} |Y_{ij}||V_i| < \theta_{ij} + \delta_j \qquad (12)$$

The real and reactive power at bus i is

$$P_i - jQ_i = V_i^* I_i \qquad (13)$$

Substituting for Ii in Equation (12) from Equation (13)

$$P_i - jQ_i = |V_i| < -\delta_i \sum_{j=1}^{n} |Y_{ij}||V_j| < \delta_{ij} + \delta_j \qquad (14)$$

The real and imaginary parts are separated:

$$P_i = \sum_{j=1}^{n} |V_i||V_j||Y_{ij}|\cos\left(\theta_{ij} - \delta_i + \delta_j\right) \qquad (15)$$

$$Q_i = \sum_{j=1}^{n} |V_i||V_j||Y_{ij}|\sin\left(\theta_{ij} - \delta_i + \delta_j\right) \qquad (16)$$

The above Equation (15) and (16) constitute a gaggle of non-linear algebraic equations in terms of |V| in per unit and δ in radians. Equations (15) and (16) are expanded in Taylor's series about the initial estimate and neglecting all higher-order terms, the next set of linear equations are obtained.

$$\begin{bmatrix} \Delta P_2^{(k)} \\ \vdots \\ \Delta P_n^{(k)} \\ \Delta Q_2^{(K)} \\ \vdots \\ \Delta Q_n^{(k)} \end{bmatrix} = \left[\begin{array}{ccc|ccc} \frac{\partial P_2^{(k)}}{\partial \delta_2} & \cdots & \frac{\partial P_2^{(k)}}{\partial \delta_n} & \frac{\partial P_2^{(k)}}{\partial |V_2|} & \cdots & \frac{\partial P_2^{(k)}}{\partial |V_n|} \\ \vdots & \ddots & \vdots & \vdots & \ddots & \vdots \\ \frac{\partial P_n^{(k)}}{\partial \delta_2} & \cdots & \frac{\partial P_n^{(k)}}{\partial \delta_n} & \frac{\partial P_n^{(k)}}{\partial |V_2|} & \cdots & \frac{\partial P_n^{(k)}}{\partial |V_n|} \\ \hline \frac{\partial Q_2^{(K)}}{\partial \delta_2} & \cdots & \frac{\partial Q_2^{(K)}}{\partial \delta_n} & \frac{\partial Q_2^{(K)}}{\partial |V_2|} & \cdots & \frac{\partial Q_2^{(K)}}{\partial |V_n|} \\ \vdots & \ddots & \vdots & \vdots & \ddots & \vdots \\ \frac{\partial Q_n^{(K)}}{\partial \delta_2} & \cdots & \frac{\partial Q_n^{(K)}}{\partial \delta_n} & \frac{\partial Q_n^{(K)}}{\partial |V_2|} & \cdots & \frac{\partial Q_n^{(K)}}{\partial |V_n|} \end{array}\right] \begin{bmatrix} \Delta P_2^{(k)} \\ \vdots \\ \Delta P_n^{(k)} \\ \Delta Q_2^{(K)} \\ \vdots \\ \Delta Q_n^{(k)} \end{bmatrix}$$

In the above equation, the slack bus variable voltage magnitude and angle element are omitted because they are already known. ("Analysis of the Load Flow Problem in Power System Planning ...") The element of the Jacobian matrix is obtained after partial derivatives of Equations (15) and (16) are expressed which supplier supplies minors in voltage magnitude and voltage angle. This equation is going to be written in matrix form as:

$$\begin{bmatrix} \Delta P \\ \Delta Q \end{bmatrix} = \begin{bmatrix} J_1 & J_3 \\ J_2 & J_4 \end{bmatrix} \begin{bmatrix} \Delta\delta \\ \Delta|V| \end{bmatrix} \qquad (17)$$

J1, J2, J3, J4 are the weather of the Jacobian matrix. The difference between the schedule and calculated values cited as power residuals for the terms and is represented as:

$$\Delta P_i^{(k)} = P_i^{sch} - P_i^{(k)} \qquad (18)$$

ISSN (Online) 2321-2004
ISSN (Print) 2321-5526

IJIREEICE

International Journal of Innovative Research in
Electrical, Electronics, Instrumentation and Control Engineering

Vol. 9, Issue 7, July 2021

DOI 10.17148/IJIREEICE.2021.9734

$$\Delta Q_i^{(k)} = Q_i^{sch} - Q_i^{(k)} \quad (19)$$

The new estimates for bus voltage are

$$\delta^{(k+1)} = \delta_i^{(k)} + \Delta\delta_i^{(k)} \quad (20)$$

$$\left|V^{(k+1)}\right| = \left|V_i^{(k)}\right| + \Delta\left|V_i^{(k)}\right| \quad (21)$$

C. Fast Decoupled Method

The Fast Decoupled Power Flow Method is one of the improved methods, which is predicated on the simplifying Raphson method and reported by Stott and Alsace in 1974 [16]. This method, a small amount just like the Newton-Raphson method, offers calculation simplifications, fast convergence and reliable results and have become a widely used method in load flow analysis. However, fast decouple for decouples cases, where high resistance-to-reactance (R/X) ratios or heavy loading (low voltage) at some buses are present, does not convdon'tll because it is an approximation method and make consumption to simplify Jacobian matrix. For these cases, many efforts and developments are made to beat these convergence obstacles. style of them targeted the convergence of systems with high R/X ratios, et al. with low voltage buses [17] [18]. This method could even be a modification of Newton-Raphson, which takes the advantage of the weak coupling between and since of the high X: R ratios. The Jacobian matrix of Equation (17) is reduced to half by ignoring the element of J2 and J3. Equation (17) is simplified as:

$$\begin{bmatrix} \Delta P \\ \Delta Q \end{bmatrix} = \begin{bmatrix} J_1 & 0 \\ 0 & J_4 \end{bmatrix} \begin{bmatrix} \Delta\delta \\ \Delta|V| \end{bmatrix} \quad (22)$$

Expanding Equation (22) gives two separate matrixes,

$$\Delta P = J_1 \Delta\delta = \left[\frac{\partial P}{\partial \delta}\right]\Delta\delta \quad (23)$$

$$\Delta Q = J_4 \Delta|V| = \left[\frac{\partial P}{\partial |V|}\right]\Delta|V| \quad (24)$$

$$\frac{\Delta P}{V_i} = -B'\Delta\delta \quad (25)$$

$$\frac{\Delta Q}{V_i} = -B''\Delta|V| \quad (26)$$

B' and B" are the imaginary parts of the bus admittance. it is better to ignore all shunt connected elements, to make the formation of J1 and J4 simple. ("Analysis of the Load Flow Problem in Power System Planning ...") this might leave only one single matrix than performing a repeated inversion. The successive and voltage magnitude and phase changes are

$$\Delta\delta = -[B']^{-1}\frac{\Delta P}{|V|} \quad (27)$$

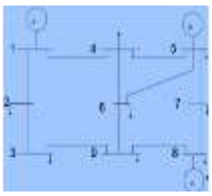
$$\Delta|V| = -[B'']^{-1}\frac{\Delta Q}{|V|} \quad (28)$$

("Analysis of the Load Flow Problem in Power System Planning ...")

III. SIMULATION RESULTS

The simulation for Gauss-Seidel, Newton-Raphson and Fast Decouple is carried out using MATLAB for test cases of IEEE 9. The base mva, selected valve for iteration (tolerance), and maximum numbers of iterations is specified.

Figure1



IJIREEICE

ISSN (Online) 2321-2004
ISSN (Print) 2321-5526

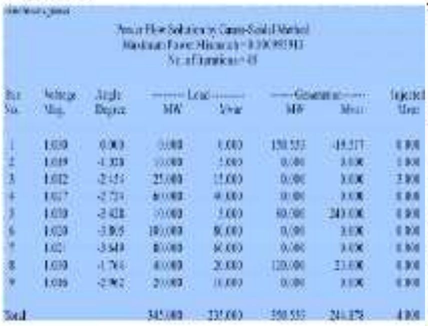
International Journal of Innovative Research in
Electrical, Electronics, Instrumentation and Control Engineering

Vol. 9, Issue 7, July 2021

DOI 10.17148/IJIREEICE.2021.9734

show IEEE 9-Bus System one line diagram, [12]. The simulation results are shown in

Figure 2



, Figure 3

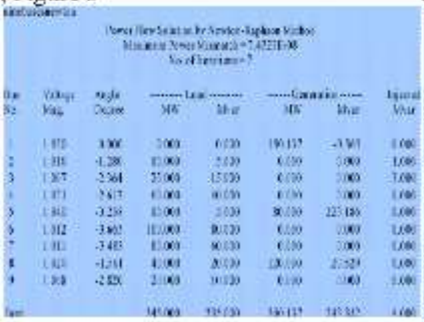
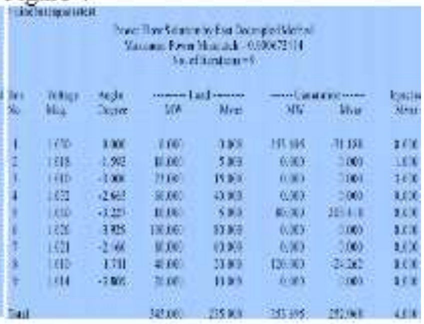


Figure 4



for Gauss-Seidel, Newton-Raphson and Fast Decouple, respectively.

IEEE 9 bus system represented in Table 2 consist of Bus 1 which act as a slack bus. It consists of 8 load buses, which are bus connected to load and 2 generator buses which are connected to generator. Bus 5 and 8 acts as both load and generator bus because they are connected to generator and load.

IEEE 9-bus system consists of eleven-line data as represented in Table 3, which shows the values for resistance, reactance, and half susceptance per unit for the transmission line connected. It also shows the tap setting values for transformers and the position of the transformers on the transmission line. The information is used to form the admittance bus matrix. ("Analysis of the Load Flow Problem in Power System Planning ...")

Table 4 represents the line flow and line losses for each of the IEEE 9 bus systems. The line losses are compared for the three numerical methods: Gauss-Seidel, the Newton-Raphson, and the Fast Decoupled method. ("Analysis of the Load Flow Problem in Power System Planning ...") Fast Decoupled method has the highest total losses of 6.279 MW, 14.893 Mvar, followed by Gauss-Seidel with total losses of 4.809 MW, 10.798 Mvar and Newton Raphson method with the least losses of 4.585 MW and 10.789 Mvar.

Table 2.

Load Data							
Bus	Type of Bus	Voltage		Load		Generation	
		|V|(PU)	Δ(θ)	P(MW)	Q(MVAR)	P(MW)	Q(MVAR)
1	Slack	1.0300	0	0	0		
2	PQ	1.0000	0	10	5		
3	PQ	1.0000	0	25	15		
4	PQ	1.0000	0	60	40		
5	PQ	1.0600	0	10	5	80	
6	PV	1.0000	0	100	80		
7	PQ	1.0000	0	80	60		
8	PV	1.0100	0	40	20	120	
9	PQ	1.0000	0	20	10		

Table 3.

Line Data					
Bus No	Bus No	*R, PU*	*X, PU*	1/2 *B, PU*	Transformer Tap
1	2	0.180	0.0540	0.0045	1
1	4	0.0150	0.0450	0.0038	1
2	3	0.180	0.0560	0	1
3	9	0.0200	0.0600	0	1
4	5	0.1300	0.0360	0.0030	1
4	6	0.0200	0.0660	0	1
5	6	0.0600	0.030	0.0028	1
5	7	0.0140	0.0360	0.0030	1
6	9	0.0100	0.0500	0	1
7	8	0.0320	0.0760	0	1
8	9	0.0220	0.0650	0	1

Table 4.

		Gauss-Seidel Method				Newton-Raphson Method				Fast Decouple Method			
From Bus	To Bus	P	Q	Lines loss		P	Q	Lines loss		P	Q	Lines loss	
		MW	Mvar	MW	Mvar	MW	Mvar	MW	Mvar	MW	Mvar	MW	Mvar
1	2	47.024	5.514	0.381	0.199	46.912	10.350	0.393	0.238	47.411	8.677	0.396	0.244
1	4	103.50	−25.023	1.600	3.997	103.225	−10.714	1.522	3.766	104.675	−37.340	1.742	4.418
2	3	36.633	1.317	0.233	0.725	36.519	6.113	0.239	0.743	37.018	4.435	0.242	0.752
3	9	11.390	−11.405	0.051	0.152	11.280	−6.631	0.034	0.101	11.775	−8.317	0.041	0.123
4	5	11.520	−70.300	0.620	1.070	11.585	−59.488	0.454	0.620	12.085	−84.209	0.877	1.771
4	6	30.343	1.251	0.175	0.577	30.119	5.009	0.179	0.591	30.860	2.456	0.180	0.594
5	7	38.216	68.414	0.786	1.376	38.188	68.302	0.798	1.422	40.374	96.919	1.382	2.903
6	9	−27.806	13.579	0.092	0.460	−27.670	12.022	0.089	0.445	−29.323	34.386	0.194	0.972
7	8	−42.572	7.039	0.571	1.357	−42.610	6.880	0.583	1.385	−40.984	34.028	0.870	2.066
8	9	36.846	9.327	0.300	0.885	36.806	6.024	0.294	0.869	38.138	−13.924	0.355	1.050

ISSN (Online) 2321-2004
ISSN (Print) 2321-5526

IJIREEICE

International Journal of Innovative Research in
Electrical, Electronics, Instrumentation and Control Engineering

Vol. 9, Issue 7, July 2021

DOI 10.17148/IJIREEICE.2021.9734

IV. CONCLUSION

All the simulations were administered using MATLAB and implemented for IEEE 9-bus, IEEE 30-bus and IEEE 57-bus test cases for Gauss-Seidel, Newton-Raphson and Fast Decouple. within the load flow analysis methods simulated, the tolerance values used for simulation are 0.001 and 0.1 for all the SIMULATIONS administered apart from the IEEE 57-bus using the fast decoupled method, which did not CONVERGES with the tolerance values. This explains why the Fast Decoupled method is not as accurate as of the Newton-Raphson method because a lower tolerance value of 0.1 was wont to perform the simulation for the IEEE 57-bus Fast Decoupled Method. The time for iteration in Gauss-Seidel is that the longest compared to the opposite two methods, Newton-Raphson and Fast Decouple. The time for iterations in Gauss-Seidel increases because the number of buses increases. The Gauss-Seidel method increases in progression, Newton-Raphson increases in quadratic progression while the fast decoupled increases in progression. This explains why it takes an extended time for Gauss-Seidel to converge. The computational time for Gauss-Seidel is low compared to the opposite two methods; Newton-Raphson and fast decouple. Newton-Raphson has more computational time thanks to the complexity of the Jacobian matrix for every iteration but still converges fast enough because fewer iterations are administered and required. The results of this paper suggest that the design of an influence system is often administered by using the Gauss-Seidel method for a little system with less computational complexity thanks to the great computational characteristics is exhibited. The effective and most reliable amongst the three load flow methods is that the Newton-Raphson method because it converges fast and is more accurate.\

V. REFERENCES

[1] Maheswaran, R., Ragland, I.J., Yuvraj, V., Rizwan khan, P.G., Vijayakumar, T. and Sudheera (2008) Implementation of Non-Traditional Optimization Techniques (PSO, CPSO, HDE) for the Optimal Load Flow Solution. TENCON2008-2008 IEEE Region 10 Conference, 19-21 November 2008.

[2] Elgerd, O.L. (2012) Electric Energy Systems Theory: An Introduction. 2nd Edition, Mc-Graw-Hill.

[3] Kothari, I.J. and Nagrath, D.P. (2007) Modern Power System Analysis. 3rd Edition, New York.

[4] "Keyhani, A., Abur, A. and Hao, S. (1989) Evaluation of Power Flow Techniques for Personal Computers." ("Analysis of the Load Flow Problem in Power System Planning ...") IEEE Transactions on Power Systems, 4, 817-826. [Citation Time

[5] Hale, H.W. and Goodrich, R.W. (1959) Digital Computation or Power Flow—Some New Aspects. Power Apparatus and Systems, Part III. Transactions of the American Institute of Electrical Engineers, 78, 919-923. ("Analysis of the Load Flow Problem in Power System Planning ...")

[6] Sato, N. and Tinney, W.F. (1963) Techniques for Exploiting the Sparsity of the Network Admittance Matrix. IEEE Transactions on Power Apparatus and Systems, 82, 944-950. ("Analysis of the Load Flow Problem in Power System Planning ...")

[7] Aroop, B., Satyajit, B. and Sanjib, H. (2014) Power Flow Analysis on IEEE 57 bus System Using MATLAB. International Journal of Engineering Research & Technology (IJERT), 3.

[8] Milano, F. (2009) Continuous Newton's Method for Power Flow Analysis. IEEE Transactions on Power Systems, 24, 50-57. ("Milano, F. (2009) Continuous Newton's Method for Power ...")

[9] Grainger, J.J. and Stevenson, W.D. (1994) Power System Analysis. McGraw-Hill, New York.

[10] Tinney, W.F. and Hart, C.E. (1967) Power Flow Solution by Newton's Method. IEEE Transactions on Power Apparatus and Systems, PAS-86, 1449-1460.

[11] Bhakti, N. and Rajani, N. (2014) Steady-State Analysis of IEEE-6 Bus System Using PSAT Power Toolbox. International Journal of Engineering Science and Innovation Technology (IJESIT), 3.

[12] Hadi, S. (2010) Power System Analysis. 3rd Edition, PSA Publishing, North York. ("1. Introduction - SCIRP")

[13] Kabisama, H.W. Electrical Power Engineering. McGraw-Hill, New York.

[14] Gilbert, G.M., Bouchard, D.E. and Chikhani, A.Y. (1998) A Comparison of Load Flow Analysis Using Dist. Flow, Gauss-Seidel, and Optimal Load Flow Algorithms. Proceedings of the IEEE Canadian Conference on Electrical and Computer Engineering, Waterloo, Ontario, 24-28 May 1998, 850-853. ("Analysis of the Load Flow Problem in Power System Planning ...")

[15] Glover, J.D. and Sarma, M.S. (2002) Power System Analysis and Design. 3rd Edition, Brooks/Cole, Pacific Grove.

[16] Stott, B. and Alsac, O. (1974) Fast Decoupled Load Flow. IEEE Transactions on Power Apparatus and Systems, PAS-93, 859-869. ("Stott, B. and Alsac, O. (1974) Fast Decoupled Load Flow ...")

[17] Stott, B. (1974) Review of Load-Flow Calculation Methods. Proceedings of the IEEE, 62, 916-929. ("Stott, B. (1974) Review of Load-Flow Calculation Methods ...")

[18] Adejumobi, I.A., et al. (2014) Numerical Methods in Load Flow Analysis: An Application to Nigeria Grid System. International Journal of Electrical and Electronics Engineering (IJEEE), 3

[19] Olukayode A. Afolabi, Warsame H. Ali, Penrose Cofie, John Fuller, Pamela Obiomon, Emmanuel S. Kolawole (2015) Analysis of the Load Flow Problem in Power System Planning Studies. ("Warsame Shigow Ali | Facebook") Energy and Power Engineering,**07**,509-523. Doi: 10.4236/epe.2015.710