International Journal of
Science and Engineering Investigations vol. 6, issue 60, January 2017

ISSN: 2251-8843

Mathematical Calculation and Graphical User Interface of NEPLAN for Load-Flow in Power System

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Abstract-This paper presents graphical user interface for load flow study by NEPLAN program package, today there is a lot of software are available into markets. But the cost of these software is expensive, so to buy it is difficult to write the educational research purpose. For analysis and implement of small to medium size Electric power systems, load flow is as bread butter of power system. Load flow analysis is used for (real & reactive power flow) in between the two buses, reactive power injection by capacitor, load angle, bus Voltage, power factor, power balance, unknown power generation Calculation, for these graphical user inter face NEPLAN program package used to get result.

Keywords- *Load Flow Studies, Y-matrix and Z-matrix iteration, Newton-Raphson method, guass-siedel method rd*

I. INTRODUCTION

In a power system, power flows from generating stations to load local. So we required to find the bus voltages and amount of power flow through transmission lines. Here it is convenient to work with a power injected at each bus into the transmission system, called the (Bus Power). Power flow study aims at reaching the steady state solution of complete power networks.

Performing a load flow study on an existing system recommends optimized operation of power system [1].

Each transmission line has been presents admittance between the bus and the ground. If there is no transmission line between *i*th and *j*th bus, then the corresponding element of Bus Admittance matrix *Yij* is 0 [2].

$$I_{bus} = Y_{bus} . V_{bus}$$

$$\begin{bmatrix} I_1 \\ \vdots \\ I_i \\ \vdots \\ I_n \end{bmatrix} = \begin{bmatrix} Y_{11} & \cdots & Y_{1i} & \cdots & Y_{1n} \\ \vdots & & \vdots & & \vdots \\ Y_{i1} & \cdots & Y_{ii} & \cdots & Y_{in} \\ \vdots & & \vdots & & \vdots \\ Y_{n1} & \cdots & Y_{ni} & \cdots & Y_{nn} \end{bmatrix} \begin{bmatrix} V_1 \\ \vdots \\ V_i \\ \vdots \\ V_n \end{bmatrix}$$

Where *Yij* is Admittance line between *i*th and *j*th bus, *Vi* is *i*th bus voltage and *Ii* is bus current at *i*th bus. Each method has its advantages and disadvantages. Comparison of these methods has been made useful to select the best method for a typical network. This paper analyses the used graphical user interface NEPLAN for load flow studies of power system. The importance of load flow studies in second section [3] .the bus classification in 3ed section [1] .The some methods have been introduced and analyzed in 4th section [1]-[4]. Proposed work and results have been presented in the 5th section followed by work evaluation and conclusion. The Bus data and Line data required for load flow analysis have been taken from [6].

II. IMPORTANCE OF LOAD FLOW STUDIES

1. Obtaining operating instruction to generating station and substation control room for loading, reactive power compensation, relay setting, tap setting and switching sequence. Selecting the optimum setting of over current relay.

2. Analyzing the effect re-arranging the circuit onto the power flow, bus voltage.

3. Analyzing the effective of temporary losses of generating station, transmission path on the power flow.

4. Knowing the effective of reactive power compensation on the bus voltage

5. Calculating of line losses for different power flow condition.

III. BUS CLASSIFICATION

A node at which one line or many lines, single, two, three or many loads and generators are linked is known as a Bus. All buses in the power system are consist of several quantities that are Voltage (V), Phase angle (δ),Real power (P) and Reactive power (Q).

The different busses classifications in the system are given in Figure 1 below:

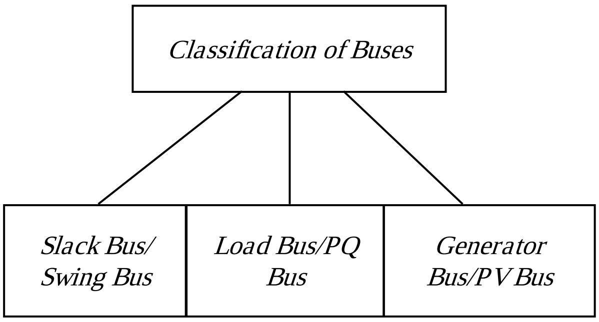

Figure 1. Classification of Buses

A. Swing Bus/ Slack Bus or Reference Bus

Generally slack bus is considered as number one bus for load flow studies of the power system. At this bus set the angular references for the busses in the system define as a reference bus.

If the voltage |V| and δ of the slack bus are known, whereas the real (PG) and reactive (QG) power are obtained by load flow solutions.

B. Load bus / PQ bus

This bus is known as the Load bus that's mean no generator coupled in this bus; hence the value of power generated PGi and QGi taken as zero. Whereas, the load taken by these types of busses are -PLi and -QLi power, the (-) sign shows that power flow outside from the bus, it can be allow to vary with in permitted values.

This bus is referred to PQ bus. Therefore it only needs to calculate magnitude of voltage and phase angle by load flow calculation.

C. Generator bus / PV bus

In this bus the generator are connected on it it's define the generator bus and power generation in such busses is managed due to prime mover. Automatic voltage regulator V is kept stable. Here |V| consequent to generator voltage and PGi corresponding to its value are known at this bus. Hence the load flow solution is required to calculate phase angle of bus voltage δ and the reactive power generation QGi.

The classification of buses described brief in Table 1:

TABLE I. CLASSIFICATION OF BUSES

Bus type	Defined	To Defined
Slack bus	|V| and delta δ	P and Q
PQ bus	P and Q	|V| and Delta δ
PV buss	P and V	Q and Delta δ

IV. SOME OF LOAD FLOW SOLUTION METHODS

The Load Flow Study is an important tool numerical analysis applied to a power system. A load flow study usually uses basic notation such as single line diagram and p.u. system, and focuses on reactive, real and apparent power rather than voltage and current. . It analyses the power systems in normal steady state operation. In view point of mathematical modeling, load flow solution consist the set algebraic equation which are nonlinear that illustrate the system. Over the time many certain techniques have been solving the equation of LF. There exist a number of software implementations of power flow studies.

A. Gauss Seidel Method:

This method is to solve the power system analysis, the equation S=VI* is used where S = P + jQ and thus the equation becomes

$$P + jQ = VI^* \quad (1)$$

$$P - jQ = V^*I \quad (2)$$

From the above equation we can deduce that the current I is given by

$$I = (P - jQ/V^*) \quad (3)$$

Then we also know that

$$I = YV \quad (4)$$

From (3) and (4) we get the equation below to calculate voltages of the buses.

$$VY = (P - jQ/V^*) \quad (5)$$

The swing bus where V is known the voltage equation for that bus is not formulated. For load buses the voltage magnitudes and angles are obtained directly from the power flow equations. But for generator buses where we know the magnitude of the voltage, thus the voltages are calculated in the following way

$$V_{new} = (V_{old}).\ \text{Angle of } (V_{new}) \quad (6)$$

Hence the bus voltages are calculated and the error of their values with the old values are calculated and checked with the tolerance value to decide whether iteration would be needed or not.

B. Newton-Raphson Method:

This method is widely used for solving nonlinear equations. It transforms the original nonlinear problem into a sequence of linear problems. In large scale load flow analysis by this method has proved most successful owing to its strong convergence characteristics. The Newton Raphson algorithm is expressed by:

$$\begin{bmatrix} \Delta P \\ \Delta Q \end{bmatrix} = \begin{bmatrix} \frac{\partial P}{\partial \theta} & V\frac{\partial P}{\partial V} \\ \frac{\partial Q}{\partial \theta} & V\frac{\partial Q}{\partial V} \end{bmatrix} \begin{bmatrix} \Delta \theta \\ \frac{\Delta V}{V} \end{bmatrix}$$

Where; ΔP is the active power and ΔQ is the reactive power mismatches, V and θ are the magnitude of bus voltage magnitude and phase angle of bus voltage respectively. The power flow equation for a generic ith bus of the power system is given by equation (2) and (3). Considered the first element connected between busses i and j in Figure 2, for which self and mutual jacobian terms are calculated by taking the derivates of equation (8) and (9).

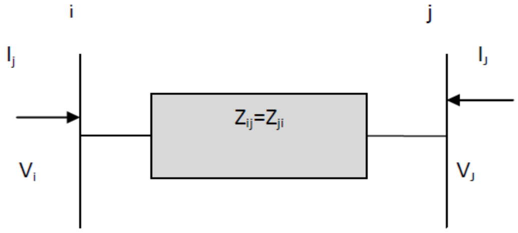

Figure 2. Equivalent Impedance

$$P_i^{cal} = \sum_{j=1}^{N} V_i V_j \left(G_{ij} \cos(\theta_i - \theta_j) + B_{ij} \sin(\theta_i - \theta_j)\right) \quad (8)$$

$$Q_i^{cal} = \sum_{j=1}^{N} V_i V_j \left(G_{ij} \sin(\theta_i - \theta_j) - B_{ij} \cos(\theta_i - \theta_j)\right) \quad (9)$$

The NR method is the most robust power flow algorithm used in practice. However, one drawback to its use is the fact that the terms in the Jacobian matrix must be recalculated each iteration.

Compare G-S method and N-R methods of load flow solutions in table 2:

TABLE II. COMPARE G-S AND N-R

G.S. method	N.B. method
1. The variables are obtained in rectangular co-ordinates. 2. Computation time per iteration is less. 3. It has linear convergence characteristics. 4. The number of iterations required to the convergence increase with size of the system. 5. The choice of slack bus is critical.	1. The variables are obtained in polar coordinates. 2. Computation time per iteration is more 3. It has quadratic convergence characteristics. 4. The number of iterations are independent at size of the system. 5. The choice of slack bus is arbitrary.

V. PROPOSED WORK & RESULTS

By implementing software techniques in the NEPLAN environment, A 3 bus power system is taken as example.

The hand calculations for load flow are done by using any above methods. a graphical user interface NEPLAN is used to calculate the load flow result .The input data is obtain in figure 3 [4] (the impedance in pu on 100-MVA base) . And then, both NEPLAN results and hand calculations results are compared .It is found that these two results are equal. The NEPLAN results, Hand calculations are as follows:

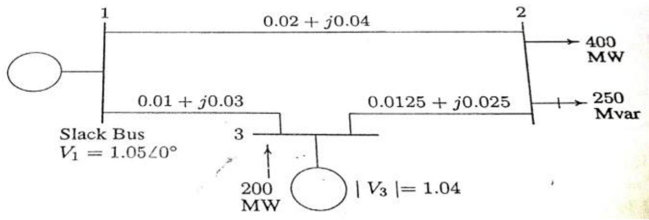

Figure 3. One – line diagram

In NEPLAN software techniques drawing the network above software in figure 4, and enter input same data.

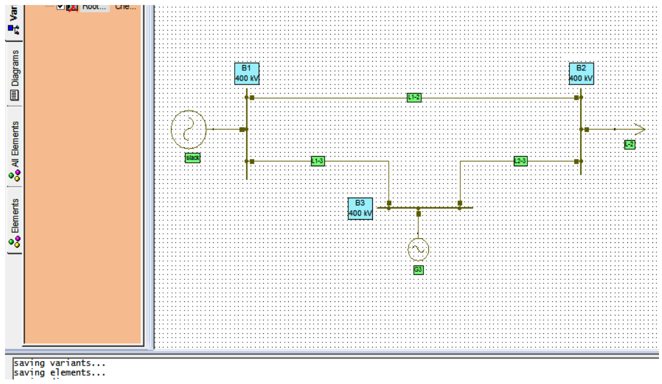

Figure 4. One – line diagram in NEPLAN software

In figure 5 final results power flow in NEPLAN software:

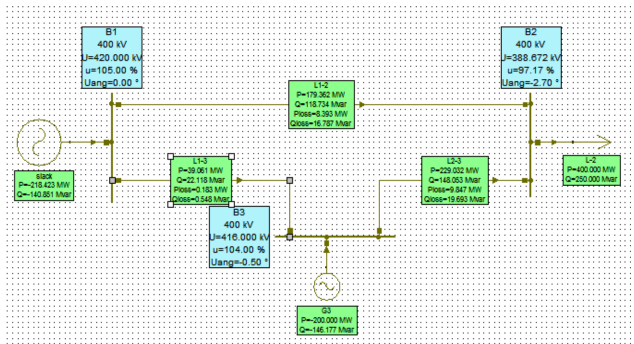

Figure 5. Power flow diagram in NEPLAN

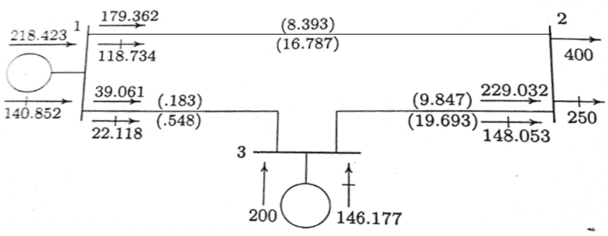

Figure 6. Final results power flow in hand

www.IJSEI.com ISSN: 2251-8843 Paper ID: 66017-22

TABLE III. COMPARE THE RESULTS BETWEEN HAND AND NEPLAN

	NEPLAN MW	*HAND MW*	NEPLAN MVAR	*HAND MVAR*	NEPLAN MW LOSSES	*HAND MW LOSSES*	NEPLAN MVAR LOSSES	*HAND MVAR LOSSES*
SLACK	218.423	*218.423*	140.851	*140.852*	-----------	-----------	------------	------------
G3	200.000	*200.000*	146.177	*146.177*	-----------	-----------	------------	-----------
LOAD	400.000	*400.000*	250.000	*250.000*	----------	------------	------------	------------
L 1-2	179.362	*179.362*	118.734	*118.734*	8.393	*8.393*	16.787	*16.787*
L 1-3	39.O61	*39.061*	22.118	*22.118*	0.183	*0.183*	0.548	*0.548*
L 2-3	229.032	*229.032*	148.053	*148.053*	9.847	*9.847*	19.693	*19.693*

VI. CONCLUSION

In this paper a power system with load flow analyses. The calculations are done by using equations at any method and NEPLAN program for the same inputs. Both these results are found equal, so this type of graphical user interface NEPLAN is very useful for solving huge calculations of the load flow on a power system.

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