Development of Graphical User Interface Load Flow Studies for Educational Research

Mohammad Nayeem A Tahasildar

Assistant Professor, Department of Electrical Engineering, Sanjay Ghodawat Group of Institution, India

Abstract : This paper present graphical user interface software for load flow study, today there is lots of software is available in market. But the cost of these software cost is in million, so it impossible to buy for educational research purpose. For analysis and design of small to medium size Electric power systems, load flow is as bread butter of power system. Load flow analysis is actually 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 software both Newton Rapson, fast decoupled load flow method used. The fast decoupled load flow in that a more broad range of power systems can be solved.

Keyword: Load flow Analysis design parameter, graphical user interface.

I. INTRODUCTION

SOFTWARE packages for power system analysis can be basically divided into two classes of tools: commercial software's and educational/research-aimed software's. Commercial software packages available on the market (e.g. PSS/E,EuroStag, Simpow, and CYME) [1]follows an "all-in-one" philosophy and are typically well-tested and computationally efficient. Despite their completeness, these software's can result cumbersome for educational and research purposes. Even more important, commercial software is "closed", i.e., do not allow changing the source code or adding new algorithms. For research purposes, the flexibility and the ability of easy prototyping are often more crucial aspects than computational efficiency. However, extending and/or modifying this kind of scientific tools also requires keen programming skills, in addition to a good knowledge of a low level language (C in thecae of UWPFLOW[2]) and of the structure of the program. In the last decade, several high-level scientific languages, such as Matlab have become more and more popular for both research and educational purposes. Any of these languages can lead to good results in the field of power system analysis (see, for example, [[3][4][5][6]); The load flow calculation is one of the most commonly used tools in power system engineering. For that reason, the history of load flow calculation is a relatively long one. The Newton method was a landmark which, basically, comprises the repeated solution of a large set of linear equations [7].

If these are solved, taking into account the sparsity of the Jacobian matrix, the computation time increases only linearly with the system size. One of the most extreme versions of such an approximated Newton method is the Fast Decoupled Load flow (FDL) [8][9]It is characterized by a However, it was soon clear that the decoupling of the liberalized load flow equations with constant load flow matrices. This method is an alternative to the Newton method provided that three conditions are met: first, the voltages are around their nominal values, second, the angle differences across the lines are small, and third, the R/X ratios are small for all branches. The first and the second condition are a serious problem only in a very small number of cases. But the third condition is rather crucial. It constitutes a limitation to the use of the FDL in those systems where a small number of branches have relatively high resistances. the handling of the Resistances when building the B' and the **B''** matrices and the iteration scheme that is used. The FDL converge sat best if the resistances are ignored when forming B'. as the R/X ratios are increased, the new form will converge much faster than the old one. , a certain type of cycling behavior occurs and the number of iterations needed to solve the load flow raises far more than could be expected from the general trend of the improved performance. . As a general iteration scheme it seems to be the best as it will hardly the presentation of test results. Two series of tests have been made: one by raising the resistance sand one by lowering the reactances. Both uniform and no uniform scaling has been used. The created test systems thus range from "normal" systems to systems with the highest possible R/X ratios. The latter comprise both high-loaded systems, near to the limits of voltage stability, and (very) low-loaded systems.

II. IMPORTANCE OF LOAD FLOW STUDIES

1. Providing 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 on the power flow, bus voltage.
3. Online operation, control and monitoring of the power system.
4. Analyzing the effect of temporary loss of generating station or transmission path on the power flow.
5. Knowing the effect of reactive power compensation on bus voltage
6. Calculating of line loss for different power flow condition.
7. Planning expansion of system .introducing HVDC line, inter-connection, EHVAC line.

8. Evaluation of the operating performance of power system under normal steady state.
9. Obtaining initial input data for various other power system studies such as economic load dispatch, reactive power and voltage, control, state estimation, fault calculation generation planning, transmission planning.[10]

III. DESIGN PARAMETER
1.0. The Admittance Matrix (Y bus matrix)
Current injections at a bus are analogous to power injections. Current injections may be either positive (into the bus) or negative (out of the bus). Unlike current flowing through a branch (and thus is a branch quantity), a current injection is a nodal quantity. The admittance matrix, a fundamental network analysis tool that we shall use heavily, relates current injections at a bus to the bus voltages. Thus, the admittance matrix relates nodal quantities. We motivate these ideas by introducing a simple example. We assume all Electrical variables in document given in per unit system. Fig. 1 shows a network represented in a hybrid fashion using one-line diagram representation for the nodes (buses 1-4) and circuit representation for the branches connecting the nodes and the branches to ground. The branches connecting the nodes represent lines. The branches to ground represent any shunt elements at the buses, including the charging capacitance at either end of the line. All branches are denoted with their admittance values Y_{ik} for a branch connecting bus i to bus k and Y_i for a shunt element at bus i. The current injections at each bus i are denoted by I_i.
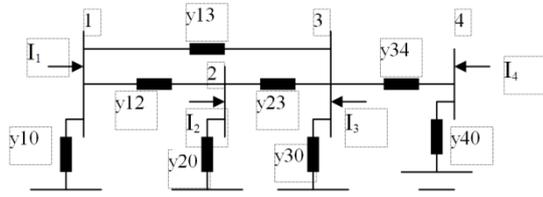

Fig. 1: Network for Motivating Admittance Matrix

The matrix containing the network admittances is the admittance matrix, also known as the Y-bus, and denoted as:

$$\underline{Y} = \begin{bmatrix} y_1 + y_{12} + y_{13} + y_{14} & -y_{12} & -y_{13} & -y_{14} \\ -y_{21} & y_2 + y_{21} + y_{23} + y_{24} & -y_{23} & -y_{24} \\ -y_{31} & -y_{32} & y_3 + y_{31} + y_{32} + y_{34} & -y_{34} \\ -y_{41} & -y_{42} & -y_{43} & y_4 + y_{41} + y_{42} + y_{43} \end{bmatrix} \quad (1)$$

Denoting the element in rows i, column k, as Y_{ij} we rewrite eq. (1) as:

$$\underline{Y} = \begin{bmatrix} Y_{11} & Y_{12} & Y_{13} & Y_{14} \\ Y_{21} & Y_{22} & Y_{23} & Y_{24} \\ Y_{31} & Y_{32} & Y_{33} & Y_{34} \\ Y_{41} & Y_{42} & Y_{43} & Y_{44} \end{bmatrix} \quad (2)$$

Where, the terms Y_{IK} are not admittances but rather elements of the admittance matrix.

1.1. Network Analysis for Y bus
For admittance matrix Kirchhoff's Current Law (KCL) requires that each of the current injections be equal to the sum of the currents flowing out of the bus and into the lines connecting the bus to other buses, or to the ground. Therefore, recalling Ohm's Law, I=V/Z=V/Y the current injected into bus 1 may be written as:
$I_1 = (V_1-V_2)y_{12}+(V_1-V_3) y13+ V_1y_{10}$

$$I_i = \sum_{k=1, k \neq i}^{N} y_{ik} V_k \quad (3)$$

This can be also written as,
Then we get simply representation as,

$$\begin{bmatrix} I_1 \\ I_2 \\ I_3 \\ I_4 \end{bmatrix} = \begin{bmatrix} Y_{11} & Y_{12} & Y_{13} & Y_{14} \\ Y_{21} & Y_{22} & Y_{23} & Y_{24} \\ Y_{31} & Y_{32} & Y_{33} & Y_{34} \\ Y_{41} & Y_{42} & Y_{43} & Y_{44} \end{bmatrix} \begin{bmatrix} V_1 \\ V_2 \\ V_3 \\ V_4 \end{bmatrix} \quad (4)$$

I bus=Y bus*V bus

We make several observations about the admittance matrix given in equations. (1) & (2) These observations hold true for any linear network of any size.
1. The matrix is symmetric,$Y_{ik} = Y_{ki}$ i.e.,
2. A diagonal element Y_{ii} is obtained as the sum of admittances for all branches connected to bus i, including the shunt branch, i.e.,

$$Y_{ii} = y_i + \sum_{k=1, k \neq i}^{N} y_{ik}$$, where we emphasize

once again that is non-zero only when there exists a physical connection between buses i and k.
3. The off-diagonal elements are the negative of the admittances connecting buses i and k, i.e., $Y_{ik} = -y_{ik}$ these observations enable us to formulate the admittance matrix very quickly from the network based on visual inspection. The following example will clarify.

Y bus, also represent in polar and also rectangular form.

$$\underline{Y} = G + jB = \begin{bmatrix} |Y_{11}|\angle\theta_{11} & |Y_{12}|\angle\theta_{12} & |Y_{13}|\angle\theta_{13} & |Y_{14}|\angle\theta_{14} \\ |Y_{21}|\angle\theta_{21} & |Y_{22}|\angle\theta_{22} & |Y_{23}|\angle\theta_{23} & |Y_{24}|\angle\theta_{24} \\ |Y_{31}|\angle\theta_{31} & |Y_{32}|\angle\theta_{32} & |Y_{33}|\angle\theta_{33} & |Y_{34}|\angle\theta_{34} \\ |Y_{41}|\angle\theta_{41} & |Y_{42}|\angle\theta_{42} & |Y_{43}|\angle\theta_{43} & |Y_{44}|\angle\theta_{44} \end{bmatrix} \quad (5)$$

2.0 The power flow equations
Define [11] the net complex power injection into a bus as $S_i = S_{Gi} - S_{Di}$ In this section, we desire to derive an expression for this quantity in terms of network voltages and admittances. We begin by reminding the reader that all quantities are assumed to be in per unit, so we may utilize single-phase power relations. Drawing on the familiar relation for complex power we may express S_k as:
$$S_i = V_i I_i^* \quad (6)$$
From eq. (4), we see that the current injection into any bus k may be expressed as

$$I_i = \sum_{i=1}^{N} Y_{ik} V_k \quad (7)$$

Where, again, we emphasize that the Y_{ki} terms are admittance matrix elements and not admittances. Substitution of eq. (6) into eq. (7) yields:

$$S_i = V_i I_i* = V_i \left(\sum_{k=1}^{N} Y_{ik} V_k \right)^*$$
$$(8)$$

$$= V_i \sum_{k=1}^{N} Y_{ik}^* V_k^* = P_i + jQ_i$$

$$P_i = P_{Gi} - jP_{Di}$$
$$(9)$$
$$Q_i = Q_{Gi} - jQ_{Di}$$

For load flow, conveniently, we take complex conjugate V* instead of I then we get simple solution by load flow studies,

$$P_i - jQ_i = V_i * I_i = V_i * \left(\sum_{k=1}^{N} Y_{ik} V_k \right) = V_i * \sum_{k=1}^{N} Y_{ik} V_k$$

i=1,2,3…n   )
$$(10)$$

Then real power of $i^{th\ bus}$ given by,

$$P_i = real\{V_i * \left(\sum_{k=1}^{N} Y_{ik} V_k \right)\}$$

And reactive power $i^{th\ bus}$ given by,

$$Q_i = -imag\{V_i * \left(\sum_{k=1}^{N} Y_{ik} V_k \right)\}$$

We denotes, the magnitude & angle of each variable,

$$V_i = |V_i| \angle \delta_i = |V_i|\cos(\delta_i) + j\sin(\delta_i)$$

$$V_k = |V_k| \angle \delta_k = |V_i|\cos(\delta_k) + j\sin(\delta_k)$$

$$Y_{ik} = |Y_{ik}| \angle \theta_{ik} = |Y_{ik}|\{\cos(\theta_{ik}) + j\sin(\theta_{ik})$$

Then real power of ith bus is given by ,

$$P_i = |V_i| \sum_{i=1}^{N} |Y_{ik}||V_k|\left(\cos(\delta_j + \theta_{ik} - \delta_k)\right)$$
(i=1,2,3…………..n)
$$(11)$$

Similarly, we computes, the reactive power of ith bus,

$$Q_i = -|V_i| \sum_{i=1}^{N} |Y_{ik}||V_k|\left(\sin(\delta_j + \theta_{ik} - \delta_k)\right)$$
(i=1,2,3…………..n)
$$(12)$$

2.1. Computation power flow in between two bus:
We get current flow in between two bus, here i & k are two bus,

$$I_{ik} = I_{ik1} + I_{ik0} = (V_i - V_k)Y_{ik} + V_i Y_{ik0}$$
$$(13)$$

The apparent power flow in between two bus is given by,

$$S_{ik} = P_{ik} + jQ_{ik} = V_i I*_{ik}$$
$$(14)$$

Apparent power flow interchanging bus is given by,

$$S_{ik} = -S_{ki},$$
$$(15)$$

Real power flow & reactive power flow in between two bus is given by,

$$P_{ik} = -P_{ki},$$
$$Q_{ik} = -Q_{ki},$$
$$(16)$$

2.2 Computation power loss & reactive power injection:
1. Resistive loss between two bus i& k is given by, [12]

$$P_{Rloss} = I_{ik} R_{ik} * 100$$
$$(17)$$

2. Reactive power loss between two bus i& k is given by,

$$P_{Xloss} = I_{ik} X_{ik} * 100$$
$$(18)$$

3. Reactive power injection by shunt capacitor (admittance) is given by,

$$Q_{injection} = I_{ik} y_{10} * 100$$
$$(19)$$

IV.   TYPE OF BUS
In power system mainly three type bus:
1. PQ bus
2. PV bus
3. Slack bus

1. **PQ bus (load bus):**
In power system there is 85% load bus of total system bus ,as the name indicate P denotes real power ,Q denotes reactive power , in this bus both P_i & Q_i are specify, P_{Di}, Q_{Di} are known by the load forecasting P_{Gi} & Q_{Gi} are specified. The unknown is voltage V_i magnitude of bus & load angle d_i we calculate the unknown parameter by using any load flow method. For pure load bus there no generating facility.

2. **PV bus**: is also known as (**generating bus)** or (**voltage controlled bus):**
In power system there is 15% generator bus of total system bus,as the name indicate P denotes real power V denotes voltage magnitude , in this bus both P_i & V_i are specify, P_{Di}, Q_{Di} are known by the load forecasting P_{Gi} & V_i are specified.   The unknown is Q_{Gi} of bus & load angle d_i we calculate the unknown parameter by using any load flow method.

3. **Slack bus**: is also known as (**reference bus**) or (**swing bus**):
In power system there is 1 slack bus of total system bus, slack bus taken for long system having n^{th} bus calculation purpose take slack bus as a referenced bus .generally, the slack bus of system start with 1st number. [11]

V.   OPERATING CONSTRAINT
The load flow solution is come practical significance all variable lie within specified particular limit. These limit, which dictated by specification of power system hardware and operating constraints, are describe below,

1. **Voltage magnitude Operating constraint**
Voltage magnitude $|V_i|$ must satisfy the inequality constraint

$$|V_i|_{min} \leq |V_i| \leq |V_i|_{max}$$
$$(20)$$

The power system equipment is design to operate at fixed voltage with allowable variation $\pm$ (5-10) % of the rated value.

2. **Power angle operating constraint:** certain of (state variable) must satisfy the inequality constraint, $\delta_i s$

$$\delta_i - \delta_k \leq |\delta_i - \delta_k|_{max}$$
$$(21)$$

This constraint limit the maximum permissible power angle of transmission line connecting bus i and k and is imposed by consideration of system stability.

3. Power Operating constraint:

Owing to physical limitation of P and/or Q generation source, P_{GI} and Q_{GI} are constraints as follow:

$$P_{Gi,\min} \leq P_{Gi} \leq P_{Gi,\max} \tag{22}$$

$$Q_{Gi,\min} \leq Q_{Gi} \leq Q_{Gi,\max} \tag{23}$$

It of course, obvious that the total generation of real and reactive power must equal the total load
Demand Plus losses [11] i.e.

$$\sum_i PGi = \sum_i PDi + PL \tag{24}$$
$$\sum_i QGi = \sum_i QDi + QL \tag{25}$$

VI.   COMPARISON OF LOAD FLOW METHOD

In this section GS (gauss-seidel method) and (NR) newton rapson method are compared when both use Y_{BUS} as the network model. it is experienced that the GS method work well when programmed using rectangular coordinate ,where as NR require more memory when rectangular Coordinate are used . Hence, polar coordinates are preferred for the NR method. The GS method requires the fewest number of arithmetic operations to complete iteration. This is because of sparsity of the network matrix and the simplicity of the solution techniques consequently, this method require less time per iteration, so the time is considerably longer. For typical large system, the time per iteration in the NR method is roughly equivalent to 7 times that of the GS method. The time per iteration of both these method increase almost directly as the number of buses of network.

The rate of convergence of GS method is slow (linear convergence characteristic),requiring a considerably greater number of iteration to obtain a solution than the NR method which has quadratic convergence characteristic and is the best among all method from the standpoint of convergence in addition ,the number of iteration for the GS method increases directly as the number of bus in network ,where as the number of iteration for NR method remain practically constant ,independent o system size .the NR method need 3 to 5 iteration to reach an acceptable solution for a large system .in the GS method and other method ,convergence is affected by choice of slack bus and the presence of series capacitor, but the sensitivity of NR method is minimal to these factor which cause poor convergence .

Therefore, for large system the NR method s faster, more accurate and more reliable than the GS method or any other known method, in fact, it work for any size kind of problem and is able to solve a wider variety of ill conditioned problem its progmming logic is considerably more complex and it has the disadvantage of requiring a large computer memory even when a compact storage scheme is used for the Jacobean and admittance matrices. In fact it can be made even faster by adopting the scheme of optimally renumbered bus. The method is probably best suited for optimal load flow studies because

of its high accuracy which is restricted only by round- off error.

The chief advantage of the GS method is the ease of programming and most efficient utilization of core memory. it is however ,restricted in use of small size system because of its doubtful convergence and longer time needed for solution of large power network .

Thus the NR method is decidedly more suitable than the GS method for all but very small system.

For FDLF, the convergence is geometric, two to five iteration are normally required for practically accuracies, and its more reliable than the formal NR method .this is due to the fact that the element of [B'] and [B''] are fixed approximation to tangent of defining function ΔP/V and ΔQ/V, and are not sensitive to any 'humps' in the defining function.

If ΔP/V and ΔQ/V are calculated efficiently ,then speed for iteration of FDLF is nearly five times that of the formal NR or about two-third that of the GS method. Storage requirement are around 60% of formal NR, but slightly more than decoupled NR method. Change in system configuration can be easily taken into account and though adjusted solution take many more iteration ,each one of them taken less time and hence the overall solution time is still low.

The FDLF can be employed in optimization studies and is specially used for accurate information of both real & reactive power for multiple load flow studies, as in contingency evaluation for system security assessment and enhancement analysis. When a series of load flow calculation are performed, the final value of bus voltage in each case are normally used as the initially voltage of the next case. this reduces the number of iteration ,particularly when there are minor change in system condition.

From above comparison we conclude that only the FDLF, NR polar method best suited for software for more accuracy result. There is some drawback of NR method, FDLF.[11]

VII.   NEWTON RAPSON METHOD

Up to that point we discuss the NR method we now skip all the discussion of the NR method. Here, now we discuss only the "Load Flow solution step for newton rapson method "so that's why we analyze ease the NR method. Following step are carried out while performing the load flow studies by NR method.

Step-1: Choose the initial values of the voltage magnitudes $|V|^{(0)}$ of all n_p load buses and $n-1$ angles $\delta^{(0)}$ of the voltages of all the buses except the slack bus and also cal. bus in other way**,** Assume, for first iteration voltage as flat, means unity magnitude for PQ bus only& for PV, slack bus take given specified value for voltage. For load angle Assume, for first iteration angle as zero for PQ & PV bus

$$V_1^{(0)} = V^0_2 = \ldots = V_n^0 = 1$$

$$\delta_1^{(0)} = \delta^0_2 = \ldots = \delta_n^0 = 0$$

Step-2: Use the estimated $|V|^{(0)}$ and $\delta^{(0)}$ to calculate a total $n-1$ number of injected real power $P_{calc}^{(0)}$ and equal number of real power mismatch $\Delta P^{(0)}$ .by using following equation,

$$P^0_{i(calculated)} = \left|V_i^0\right| \sum_{i=1}^{N} |Y_{ik}| \left|V^0_k\right| \left(\cos(\delta^0_j + \theta_{ik} - \delta^0_k)\right) \quad (26)$$

$$\Delta P_i^0 = P_{i(specified)} - P^0_{i(calculated)} \quad (27)$$

Step-3: Use the estimated $|V|^{(0)}$ and $\delta^{(0)}$ to calculate a total n_p number of injected reactive power $Q_{calc}^{(0)}$ and equal number of reactive power mismatch $\Delta Q^{(0)}$

$$Q^0_{i(calculated)} = -\left|V^0_i\right| \sum_{i=1}^{N} |Y_{ik}| \left|V^0_k\right| \left(\sin(\delta^0_j + \theta_{ik} - \delta^0_k)\right) \quad (28)$$

$$\Delta Q_i^0 = Q_{i(specified)} - Q^0_{i(calculated)} \quad (29)$$

Note :(this step if input is specified for only PQ bus)

Step-4: Use the estimated $|V|^{(0)}$ and $\delta^{(0)}$ to formulate the Jacobian matrix $J^{(0)}$.

JACOBEAN MATRIX: Jacobean matrix carried out for first iteration, for second, third, so on iteration take updated value after solution of matrix ,

$$(30)$$

NOTE: Here, ΔP for both PQ&PV bus. ΔQ alone for PQ bus

Step-5: Solve for $\Delta\delta^{(1)}$ and $\Delta |V|^{(1)}$.by taking inverse of above matrix.

Step-6: Obtain the updates from:

$$V^{(1)} = V^{(0)} + \Delta V^{(1)} \quad (31)$$

$$\delta^{(1)} = \delta^{(0)} + \Delta\delta^{(1)} \quad (32)$$

Update value take for next iteration, <u>TAKE AT LEAST 3 ITERATION FOR MORE ACCURATE RESULT.</u>

Step-7: Check if all the mismatches are below a small number,(tolerance=0.01)"$\epsilon \geq \partial$,V". Terminate the process if yes. Otherwise go back to step-1 to start the next iteration with the updates given by (31) and (32). Calculate loss, reactive power injection, power flow.[13],[7]

VIII. FAST DECOUPLED LOAD FLOW METHOD

Most accurate method of load flow method, more ease so we discuss more about the FDLF method then we go on

through step a derivation of any decoupled load flow always starts with the decoupling of the liberalized load flow equations. In order to obtain this decoupling, two conditions are assumed to have been satisfied: first, the resistances of the branches are small with respect to their respective reactances and, second, the angle differences are small. On the decoupled load flow matrices, more approximations have to be made several voltage magnitudes are set to =**1** -the influence of the phase shifting effect of the phase shifters is ignored while building the B" matrix; transformers is ignored while forming the B' matrix.

- The influence of the off-nominal tap ratios of the
This then results in the following sets of equations to be solved:
ΔP/V = B' Δδ $^{(1)}$
ΔQ/V = B"Δ $|V|$ $^{(1)}$

Where, ΔP/v, ΔQ/V active and reactive power mismatches vectors where each mismatch is divided by its respective voltage modulus B', B" constant load flow matrices corrections to angle argument and voltage argument $\Delta\delta^{(1)}$ $\Delta |V|^{(1)}$ Both the load flow matrices are derived from the Jacobian matrix, but they can be seen as formed out of the negated of the imaginary part of the admittance Matrix where:- shunts are omitted while forming B' and are doubled while forming B" - the influence of the phase shifters is ignored while forming the B" matrix and - the influence of the off-nominal tap ratios is ignored while forming the B' matrix. Both load flow matrices are built from network elements. The final, and rather important, approximation that is to be made is concerned with the handling of the branch resistances, and this is one of the topics of this paper. In doing so, it is worthwhile to use the following indication of the possible variants: BB: resistances are not ignored thus the branch susceptances are used for both B' and B". This form of the FDL usually suffers from an bad convergence; unfortunately, it is still found in the literature;

XB: the resistances are ignored in the B' only so this matrix is made of the branch reactances. This version is the standard FDL and has excellent convergence properties for the normal cases;

BX: the resistances are ignored in the B" matrix only. This version is the proposed new version. For normal cases the iteration count will be like that of the XB scheme, but for systems with a few or with general high R/X ratios the number of iterations needed to solve the load flow is considerably smaller than the number of the XB scheme;

XX: the resistances are ignored in both B' and B" matrices. This version will never be better than the XB or BX scheme, but it is used in some of the comparisons for the sake of completeness.

The difference between XB and BX is concerned with the treatment of the branch property as well. For modified network solutions any network changes, regardless its complexity, resistances only. The structure of both B' and B" remains the same and the symmetric can always be

expressed as a rank-1 or a rank-2 modification. There is no difference between the two schemes as far as this aspect is concerned. The standard iteration scheme leaves the possibility to skip one or more P and/or Q iterations as soon as the related power mismatches are converged. Such a policy can create a cycling behavior when BX is used. To prevent this, a different iteration scheme is preferable. This scheme solves the P and Q problems in a strictly successive way. In the algorithm we used, after each sub solution both P and Q are checked for convergence. As soon as both are converged, the procedure terminates following step to be carried out for FDLF [8][9] load flow studies but neglecting phase shifting. Take [B$'$]&[B$''$] as symmetrical, assume [-B]

Step-1: Choose the initial values of the voltage magnitudes $|V|^{(0)}$ of all n_p load buses and $n-1$ angles $\delta^{(0)}$ of the voltages of all the buses except the slack bus.& also cal. bus in other way, Assume, for first iteration voltage as flat, means unity magnitude for PQ bus only& for PV, slack bus take given specified value for voltage. For load angle Assume, for first iteration angle as zero for PQ & PV bus

$$V_1^{(0)} = V^0_2 = \ldots = V_n^0 = 1$$
$$\delta_1^{(0)} = \delta^0_2 = \ldots = \delta_n^0 = 0$$

Step-2: Use the estimated $|V|^{(0)}$ and $\delta^{(0)}$ to calculate a total $n-1$ number of injected real power $P_{calc}^{(0)}$ and equal number of real power mismatch $\Delta P^{(0)}$ .by using following equation,

$$\Delta P_i^0 = P_{i(specified)} - P^0_{i(calculated)}$$

$$P^0_{i(calculated)} = \left|V_i^0\right| \sum_{i=1}^{N} \left|Y_{ik}\right|\left|V^0_k\right| \left(\cos(\delta^0_j + \theta_{ik} - \delta^0_k)\right)$$

Step-3: Use the estimated $|V|^{(0)}$ and $\delta^{(0)}$ to calculate a total n_p number of injected reactive power $Q_{calc}^{(0)}$ and equal number of reactive power mismatch $\Delta Q^{(0)}$

$$\Delta Q_i^0 = Q_{i(specified)} - Q^0_{i(calculated)}$$

$$Q^0_{i(calculated)} = -\left|V^0_i\right| \sum_{i=1}^{N} \left|Y_{ik}\right|\left|V^0_k\right| \left(\sin(\delta^0_j + \theta_{ik} - \delta^0_k)\right)$$

Note :(this step if input is specified for only PQ bus)

Step-4: Use the estimated $|V|^{(0)}$ and $\delta^{(0)}$ to formulate the susceptances [B] matrix.

$$
\begin{bmatrix} \Delta P_2^0 / \Delta V_2^0 \\ \Delta P_3^0 / \Delta V_3^0 \\ \Delta P_4^0 / \Delta V_4^0 \\ \cdot \\ \cdot \\ \Delta P_n^0 / \Delta V_n^0 \end{bmatrix} =
\begin{bmatrix} -B_{22} & -B_{23}\ldots & \ldots & -B_{2n} \\ -B_{32} & -B_{33}\ldots & \ldots & -B_{3n} \\ -B_{42} \cdot & -B_{43}\ldots & \ldots & -B_{4n} \\ \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot \\ -B_{2n}\ldots & -B_{3n} \ldots & \ldots & -B_{nn} \end{bmatrix}
\begin{bmatrix} \Delta \delta_2^1 \\ \Delta \delta_3^1 \\ \Delta \delta_4^1 \\ \cdot \\ \cdot \\ \Delta \delta_n^1 \end{bmatrix}
\quad (33)
$$

$$
\begin{bmatrix} \Delta Q_2^0 / \Delta V_2^0 \\ \Delta Q_3^0 / \Delta V_3^0 \\ \Delta Q_4^0 / \Delta V_4^0 \\ \cdot \\ \cdot \\ \Delta Q_n^0 / \Delta V_n^0 \end{bmatrix} =
\begin{bmatrix} -B_{22} & -B_{23}\ldots & \ldots & -B_{2n} \\ -B_{32} & -B_{33}\ldots & \ldots & -B_{3n} \\ -B_{42} \cdot & -B_{43}\ldots & \ldots & -B_{4n} \\ \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot \\ -B_{2n}\ldots & -B_{3n} \ldots & \ldots & -B_{nn} \end{bmatrix}
\begin{bmatrix} \Delta V_2^1 \\ \Delta V_3^1 \\ \Delta V_4^1 \\ \cdot \\ \cdot \\ \Delta V_n^1 \end{bmatrix}
\quad (34)
$$

Step-5: Solve for $\Delta \delta^{(1)}$ and $\Delta |V|^{(1)}$ .by taking inverse of above matrix.

Step-6: Obtain the updates from:
$$V^{(1)} = V^{(0)} + \Delta V^{(1)} \quad (35)$$
$$\delta^{(1)} = \delta^{(0)} + \Delta \delta^{(1)} \quad (36)$$
Update value take for next iteration, TAKE AT LEAST 3 ITERATION FOR MORE ACCURATE RESULT.

Step-7: Check if all the mismatches are below a small number,(tolerance=0.01)"€≥∂,V". Terminate the process if yes. Otherwise go back to step-1 to start the next iteration with the updates given by (35) and (36). Calculate loss, reactive power injection, power flow.[6][8]

IX.   CONCLUSION

The developed graphic user interface program has the feature of designing one line diagram, enabling the load flow analysis to be shown after the load flow analysis is completed. The program also allows undertaking different analyses for single system. The program is completely prepared by an object oriented programming language, The features of object oriented programming facilitated to add new power system elements to the program without deteriorating the structure of the program. In the program, it is prevented to enter wrong parameters in to wrong fields, such as transformer data to the line data card. That minimizes the user error. Since the graphical data and physical data are saved in the different files, analyses can be done with different data for the same system without changing one line diagram. The use of GYTE Load Flow Analysis Program is rather easy. It is considered that can be easily used in the lab Sessions of the power system analysis course and would be beneficial in the conception of the subject. The developed code forms the basis of a web based visual simulator that is proposed to be used for internet based distance learning courses.

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BIOGRAPHY

Mohammad Nayeem A Tahasildar received B.E. Electrical degree from Government College of Engineering Karad, India in 2011. and M.Tech. In the Power System from the Walchand College Engineering Sangli India in 2013. He is Assistant Professor In Sanjay Ghodawat group of Institution India. His research interest are the electromagnetic transient protection, power quality and load flow study.