International Journal of Electrical and Electronics Engineers
Vol. No. 9, Issue No. 01, January-June 2017
ISSN (O) 2321-2055
ISSN (P) 2321-2045

POWER FLOW ANALYSIS USING NR METHOD

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ABSTRACT

Power is generated in generating station, transmitted through transmission line and then distributed to consumers. Power system contains of 3 types of buses. They are generator bus, load bus and slack bus. Each bus is categorized by four parameters. They are bus voltage, phase angle, active power and reactive power. These buses are classified according to known parameters. Unknown parameters are found using Power flow studies. The power system analysis and design is generally done by using power flow analysis .This analysis is carried out at the state of planning, operation, control and economic scheduling .they are useful in determining the magnitude and phase angle of load buses, and active and reactive power flows over transmission lines, and active and reactive powers that are injected at the buses. For this work the Newton-Raphson (NR) method is used for numerical analysis. The objective of this project is to develop a MATLAB program to calculate voltages, active and reactive power and losses at each Bus for 3 bus systems.

Keywords: Newton Raphson (NR), Gauss-Seidel (GS), Optimal Power Flow (OPF)

I. INTRODUCTION

Power flow calculations are performed in power systems for planning, operational planning, and operation/control. Power flow equations, commonly referred to as power flow are the backbone of power system analysis and design. The power flow problem consists of the calculation of power flows and voltages of a network for a specified terminal or bus conditions [1].Load flow studies are used to ensure that electrical power transfer from generators to consumers through the grid system is stable, reliable and economic. Conventional techniques for solving the load flow problem are iterative using the Newton-Raphson methods Load flow analysis forms an essential prerequisite for power system studies. Considerable research has already been carried out in the development of computer programs for load flow analysis of large power systems [3]. Power flow analysis is very important in planning stages of new networks or addition to existing ones like adding new generator sites, meeting increase load demand and locating new transmission sites.The load flow solution gives the nodal voltages and phase angles and hence the power injection at all the buses and power flows through interconnecting power channels [4]. It is helpful in determining the best location as well as optimal capacity of proposed generating station, substation and new lines. It determines the voltage of the buses. The voltage level at the certain buses must be kept within the closed tolerances.

1.1 Objective of the Work

The main aim of this paper is to calculate voltages, active and reactive power and losses using NR Method.

II LOAD FLOW ANALYSIS

Load flow studies art done under steady conditions. Load flow solutions are essential for designing a novel power system, and planning for the extension of the existing one for increased load demand. The main information obtained from the load flow studies is the [5] :

- Magnitude of voltage
- Phase angle
- Real power and reactive power.

According to these four parameters, the buses of the system are classified as:

1. Load Bus
2. Generator Bus
3. Slack Bus

BUS	SPECIFIED QUANTITIES	OBTAINING QUANTITIES
Load Bus	P,Q	$\lvert V\rvert,\delta$
Generator Bus	P, $\lvert V\rvert$	Q, δ
Slack Bus	$\lvert V\rvert$, δ	P,Q

Table 1 Classification of Buses

According to these specified quantities at a bus in a system, these buses are also named as:

i. Load Bus as PQ bus
ii. Generator Bus as PV bus
iii. Slack bus as reference bus

i. PQ bus:

The specified quantities for the load bus are real and reactive power and the determining quantities are magnitude of voltage and phase angle with the help of load flow solution [1]. Voltage at load bus can be allowed to vary within a prescribed value 6%

ii PV bus:

The specified quantities in the generator bus are real power and the magnitude of the voltage and the determining quantities are reactive power and phase angle.

iii. Reference bus:

The specified quantities are magnitude of voltage and the phase angle and the determining quantities are real and reactive power. Usually the value of slack bus is taken as $1\angle 0$ p.u. in every bus there must be one slack bus there must be one slack bus and others may be the PQ or PV according to the requirement of the system.

Methods used for load flow studies are:

1. Gauss seidal method
2. Newton Rapshan method
3. Decoupled Load Flow method
4. Fast Decoupled Load Flow method

III. COMPARISON OF GAUSS-SEIDEL AND NEWTON-RAPHSON METHOD

PROPERTIES	GS METHOD	NR METHOD
Accuracy	Lesser	Higher
Convergence rate	Slow	Fast
Number of iterations	improves with the size of power system	Remains fixed
Type of convergence	Linear	Quadratic
Stability	For small power system	For large power system
Effect of slack bus selection	More dependent	Less dependent
Guarantee of convergence	Not guaranteed	Guaranteed
Acceleration	External	Internal
Time for each iteration	Less	More

Table 2 Comparison of GS and NR Method

IV. PROBLEM FORMULATION

4.1 NEWTON-RAPHSON METHOD

NR method is used for solving the nonlinear algebraic equations. It provides fast response and sure convergence as compared to Gauss Seidel method.

Power flow equations [2] :

$$P_i \text{ (Real Power)} = |V_i| \sum_{j=1}^{m} (|V_j||Y_{ij}|\cos(\phi_{ij} + \delta_j - \delta_i))$$

$$Q_i\text{(Reactive Power)} = -|V_i| \sum_{j=1}^{m} (|V_j||Y_{ij}|Sin(\phi_{ij} + \delta_j - \delta_i))$$

Where,

V_i = voltage at i^{th}bus

V_j = voltage at j^{th} bus

Y_{ij} = admittance of i^{th} and j^{th} bus

ϕ_{ij} = angle of the admittance

Δ_j = phase angle of the j^{th} bus

Δ_I = phase angle of the i^{th} bus

J is the jacobian matrix which is used for solving the NR method.

$$J = \begin{bmatrix} \frac{dp}{d\delta} & \frac{dp}{|V|} \\ \frac{dQ}{d\delta} & \frac{dp}{|V|} \end{bmatrix}$$

Y_{ij} bus matrix

$$Y_{bus} = \begin{bmatrix} Y_{11} & .... & Y_{ij} \\ .... & .... & .... \\ Y_{ji} & .... & Y_{jj} \end{bmatrix}$$

4.2 Iteration Algorithm

Step 1: Consider one bus is slack bus in a system whose voltage and phase angle are $1\angle 0$ and assume the all other buses as PQ and PV buses.

Step 2: In the r^{th} iteration,

$$P_i^r = |V_i|^r \sum_{j=1}^{m} (|V_j||Y_{ij}|\cos(\phi_{ij} + \delta_j - \delta_i))$$

$$Q_i^r = -|V_i|^r \sum_{j=1}^{m} (|V_j||Y_{ij}|\sin(\phi_{ij} + \delta_j - \delta_i))$$

Let,

$e_i^r = |V_i|^r \cos\delta_i^r$ And $f_i^r = |V_i|^r \sin\delta_i^r$

$G_{ij} = |Y_{ij}|\cos\phi_{ij}$

$B_{ij} = |Y_{ij}|\sin\phi_{ij}$

Then Calculate,

ΔP_i^r =P_i (scheduled) - P_i^r for PV and PQ buses

ΔQ_i^r =Q_i (scheduled) - Q_i^r for PQ buses

Here if all the values of ΔP_i^r and ΔQ_i^r are less than the tolerance, iterations are stopped, calculate P1 and Q1 and the solution is obtained.

Step 3: If the convergence criteria is not obtained, calculate the Jacobian matrix elements.

Step 4: correction of voltage magnitude and phase angles.

Step 5: Next update the voltage magnitude and phase angles.

$$|V|^{(r+1)} = |V|^r + \Delta|V|^r$$

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$$\delta^{(r+1)} = \delta^{r} + \Delta\delta^{r}$$

Again go to step 2 and continue the process unless the convergence is obtained.

4.3 Flow Chart for NR Method

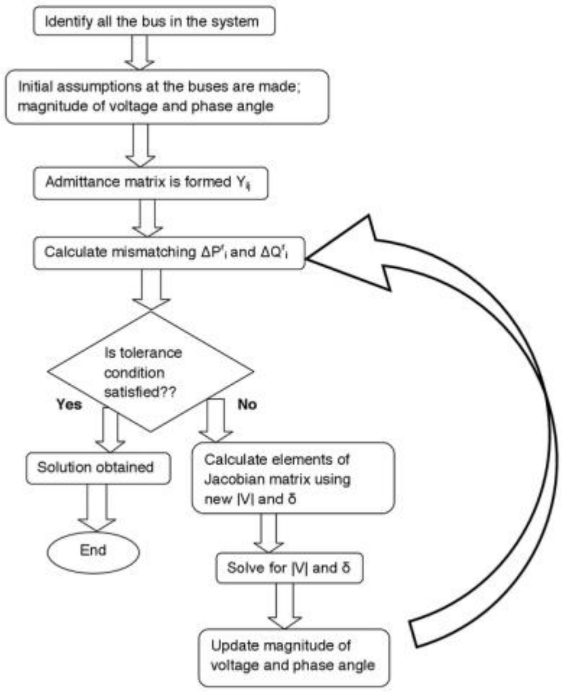

Figure 1. Flow chart of NR Method

V. RESULTS

In this paper, the 3 bus system is analyzed by using NR method. The main work of this paper is to develop a MATLAB program to calculate voltages, active and reactive power and losses at each bus for 3 bus systems. In first stage determine the active and reactive power at each unit and in the next stage Line Losses is determined. This method is tested on 3 unit system. The complete result is shown in Table 5.1

Newton Raphson Load flow Analysis								
Bus No.	V pu	Angle Degree	Injection		Generation		Load	
			MW	MVAR	MW	MVAr	MW	MVAr
1	1.0500	0.0000	218.423	140.852	218.423	140.852	0.000	0.000
2	0.9717	-2.6965	-400.000	- 250.000	-0.000	-0.000	400.000	250.000
3	1.0400	-0.4988	200.000	146.177	200.000	146.177	0.000	0.000
Total			18.423	37.028	418.423	287.028	400.000	250.000

Line Flow and Losses									
From Bus	To Bus	P MW	Q MVAr	From Bus	To Bus	P MW	Q MVAr	Line Losses	
								MW	
1	2	179.362	118.734	2	1	- 170.968	- 101.947	8.393	16.787
1	3	39.061	22.118	3	1	-38.878	-21.569	0.183	0.548
2	3	- 229.032	- 148.053	3	2	238.878	167.746	9.847	19.693
Total								18.423	37.028

Table 3 Load flow analysis result using NR method in 3 unit system

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VI. CONCLUSIONS

The main work of this paper is to develop a MATLAB program to calculate voltages, active and reactive power and losses at each bus for 3 bus systems. In first stage determine the active and reactive power at each unit and in the next stage Line Losses is determined. This method is tested on 3 unit system.

REFERENCES

[1] P. Srikanth, O. Rajendra, A. Yesuraj, M. Tilak, and K.Raja (2013) "Load Flow Analysis of Ieee14 Bus System Using MATLAB" Vol- 2 Issue. 5 Page 149-155 International Journal of Engineering Research & Technology

[2] Sunil Joseph P., and C.DineshBalaji (2013) "Transmission Loss Minimization Using Optimization Technique Based On Pso"Vol- 6 Issue-1 Page 01-05 IOSR Journal of Electrical and Electronics Engineering

[3] L.Ramesh, S.P.Chowdhury, S.Chowdhury, A.A.Natarajan, and C.T.Gaunt (2009) "Minimization of Power Loss in Distribution Networks by Different Techniques" Vol-3 Page 521-527 International Journal of Electrical and Electronics Engineering

[4] Hassan Kubba (2014) "Assessment and Comparative Study of Different Enhanced Artificial Neural Networks Based Power Flow Solutions" Vol- 03 Issue-03 Page 2446-2462 International Journal of Engineering Research & Technology

[5] DaljeetKaur, Dr. S. K. Bath and Darshan Singh Sidhu (2014) "Open Circuit Fault Analysis of Electrical Power System Using MATLAB" Vol- 03 Issue-03 Page 1738-1744 International Journal of Engineering Research & Technology