The Comparative Study in Load Flow Analysis in Power System

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***Abstract* - We know that load flow is play a key factor role in power system which is used by engineering for solving the problem and exchange the power between the house hold and utilities company. For making the power system efficient it is necessary to find out the correct method who's solving the load flow equation and problems easily and without any failure. Because the changing the climate as per time the load flow is also changing the climate for this, we need to solve the equation and want accurate result. This paper present that how we distribute the electricity by the help of power flow analysis in electrical power system. The numerical method which is used in solve the load flow analysis system is 1.G-S (gauss seidel) METHOD,2. N-R (newton Raphson) METHOD, 3. FAST DECOUPLED METHOD. These all type of power flow analysis method are differentiated by the no. of iteration and computational time and tolerance value, convergence. By the comparison we can see in this paper the N-R METHOD is more reliable than both (G-S METHOD, FAST DECOUPLED METHOD).**

***Index Terms* - Load Flow, Guass Seidel Method, Power (Active, Reactive), Bus Classification, Newton Raphson Method, Fast Decoupled Method.**

INTRODUCTION

We know that power generate the and then transmit, power flow from generating station to substation by divide in different load in different parameter with different branches. So, when the power generates, we all know that power in the form of reactive power so the power flow of reactive power and active power is called power flow analysis, which is used by the engineer to transmit the power in in power system for planning. The main advantage of load flow analysis is that it is first analysis in the power system and its don on steady state condition. Also, it applicable to find out the impedance and admittance of every branch and also the find out the magnitude of voltage and phase angle. It is divided by the three-category based on the references, 1. Branch reference 2. Loop frame reference 3. Bus frame reference. These all are show how the load flow divided into the frame category. For this reason, this applicable to find out the impedance and admittance for any change in power system. By the help of all three method which is mention in above heading we test the IEEE 9 BUS, IEEE 14 BUS, IEEE 30 BUS system and determine the power system analysis and do the planning based on this analysis.

Real and phantom(reactive) power: -

The active power is defined as to consumed and utilize by the AC circuit is called the active power and it is measured in kilowatt (KW). Basically, its actual outcome run the electrical circuit and load of the electrical system.

The reactive power is defined as the which power react upon itself and work in both direction in the circuit and flows back called reactive power. It measures in kilo volt ampere reactive and mega volt ampere reactive.

LOAD FLOW

We know that when the real and phantom power flow into the bus that is called the load flow. Here main aim of this analysis is to determine the node voltage and phase angle and other quantities which is not given in the any type of bus system which is helpful to stablish the power system in certain area and helpful for that work planning. And it helpful to know about the study of the performance of the transmission line and generator and transformer at steady state condition.

STATIC LOAD FLOW EQUATION

from y-bus, for n bus system

the current at 1^{st} bus…...

$I_1 = y_{11}v_1 + y_{12}v_2 + \cdots \ldots \ldots \ldots \ldots \ldots \ldots + y_{ii}v_i + \cdots \ldots \ldots + y_{1n}v_n$

The current at i[th] bus…………

$I_i = y_{i1}v_1 + y_{i2}v_2 + \cdots \ldots \ldots \ldots \ldots \ldots + y_{ii}v_i + \cdots \ldots \ldots + y_{in}v_n$

$$I_1 = \sum_{k=1}^{n} y_{ik}v_k$$

The complex power at i[th] bus……

$s_i = v_i I_i^* = P_i + jQ_i \quad \therefore V_i = |V_i| < \delta_i,$

$V_k = |v_k| < \delta_{i,}, y_{ik} = |y_{ik}| < \delta_i$

$\therefore S_i = |V_i| < \delta_i \; [\sum_{k=1}^{n} |v_{ik}| \; < \theta_i k \cdot |v_k| < \delta_k]^*$

Then the complex power of static load flow:

$$S_i = \sum_{k=1}^{n} |V_i| \, |y_{ik}| |v_k| < \; \delta_i - \theta_{ik} - \delta_k$$

The active power $P_i = \sum_{k=1}^{n} |V_i| \, |y_{ik}| |v_k| \cos(\, \delta_i - \theta_{ik} - \delta_k)$

The reactive power $Q_i = \sum_{k=1}^{n} |V_i| \, |y_{ik}| |v_k| \sin(\, \delta_i - \theta_{ik} - \delta_k)$

The static load flow equation is nonlinear algebraic equation, and these consisting of 4 parameter real power, phantom power and magnitude of voltage and phase angle. And in these 4, two are specified and two are unknown. The bus system is divided accordingly below,

BUS CLASSIFICATION

Bus is defined as the one or more node, point and transmission line, generating station, loads and machine are connected to that, and every bus contain at least 4 quantities as like magnitude of voltage and phase angle and real power, phantom power. And two of that are present on every bus and two quantities we want to find out by the help of given method. So, these buses are classified in to the three categories in power system. 1. Load bus, 2. Generating bus, 3. Slack bus.

LOAD BUS

Basically, it is non generated bus and used for measurement only. And the total complex power injects in that, and that means load demands and generation are specified when active power and reactive power flow in that bus. It is also called as a P-Q bus because the P and Q are specified in that bus and we want to determine the only the magnitude of voltage and phase angle.

GENERATING BUS

The specified parameter in this bus is active power and voltage magnitude and we want to determine the phase angle and reactive power in this system. That's why it is called P-V bus also. If voltage-controlled device connected to control the voltage then PQ bus is called the voltage-controlled bus. These voltage-controlled buses are always treated as a P-V bus. And PQ bus treated as a PV bus when it unable to supply the required voltage.

SLACK BUS

The specified parameter of this bus is phase angle and voltage magnitude and the calculating parameter is active power and reactive power. According to the survey that found in every power system at least one slack bus is available. One of generator bus with high capacity and centralized to all the buses will always be considered as a slack bus. A voltage-controlled bus should never be a slack bus.

BUS TYPE	QUANTITIES SPECIFIED	QUANTITIES TO BE OBTAINED
LOAD BUS	P, Q	$\|V\|, \delta$
GENERATOR BUS	P, $\|V\|$	Q, δ
SLACK BUS	$\|V\|, \delta$	P, Q

G-S (GAUSS SEIDEL) METHOD

It is based on the GUASS method. This method is based on iteration method which is helpful to find out the nonlinear equation. Basically, in this method we starting with the initial guess for obtaining the new value of a particular variable and then instead of initial guess value the new calculate value and come and these processes continue until the convergence.

The current at i[th] bus…………

$I_i = y_{i1}v_1 + y_{i2}v_2 + \cdots \ldots \ldots + y_{ii}v_i + \cdots \ldots \ldots + y_{in}v_n$

$$I_1 = \sum_{k=1}^{n} y_{ik}v_k + y_{ii}v_i$$

The complex power at i[th] bus,

$s_i = v_i I_i^* = P_i + jQ_i$

$$I_i^* = \frac{P_i + jQ_i}{v_i} \quad , I_i = \frac{P_i - jQ_i}{{v_i}^*}$$

$$\sum_{k=1}^{n} y_{ik}v_k + y_{ii}v_i = \frac{P_i - jQ_i}{{v_i}^*}, y_{ii}v_i$$

$$= \frac{P_i - jQ_i}{{v_i}^*} - \sum_{k=1}^{n} y_{ik}v_k \quad k \neq i$$

$$v_i = \frac{1}{y_{ii}}\left[\frac{P_i - jQ_i}{{v_i}^*} - \sum_{k=1}^{n} y_{ik} v_k\right]$$

$$v_i < \delta_i = \frac{1}{y_{ii<\theta_{ii}}}\left[\frac{P_i - jQ_i}{(v_i < \delta^*)} - \sum_{k=1}^{n} y_{ik} < \theta_{ii} v_k < \delta_k\right]$$

This is GUASS SEIDEL METHOD equation.

N-R (NEWTON RAPHSON) METHOD

The N-R method is more powerful method for solving the nonlinear algebraic equation with compare to the G-S METHOD. It works faster than G-S METHOD and most of the convergence case same as the G-S METHOD. Mostly in large power system network it is very useful, the only the drawback of this method is that some time it has the large computer memory. It has a two system for solving the power system

FOR SINGLE VARIABLE SYSTEM: -

$$\Delta x = -\frac{f(x_0)}{f'(x_0)}$$

FOR TWO VARIABLE SYSTEM: -

$f_1(x_{1,}, x_2) = 0$

$f_2(x_{1,}, x_2) = 0$

Let the initial guess value are x_1°, x_2° , let the change in the variable after first iteration are $\Delta x_1, \Delta x_2$

$x_{1new} = x_1^\circ + \Delta x_1$

$x_{2new} = x_2^\circ + \Delta x_2$

$f_1(x_{1new}, x_{2new}) = f_1(x_1^\circ + \Delta x_1, x_2^\circ + \Delta x_2)$

$f_2(x_{1new}, x_{2new}) = f_2(x_1^\circ + \Delta x_1, x_2^\circ + \Delta x_2)$

Expand the above equation by using the TAYLOR's series by neglecting higher order terms,

$$f_1(x_1^\circ, x_2^\circ) + \Delta x_1 \frac{\delta f_1}{\delta x_1} + \Delta x_2 \frac{\delta f_2}{\delta x_1} = 0$$

$$f_2(x_1^\circ, x_2^\circ) + \Delta x_1 \frac{\delta f_1}{\delta x_2} + \Delta x_2 \frac{\delta f_2}{\delta x_2} = 0$$

$$\begin{pmatrix} f_1(x_1^\circ, x_2^\circ) \\ f_2(x_1^\circ, x_2^\circ) \end{pmatrix} + \begin{bmatrix} \frac{\delta f_1}{\delta x_1} & \frac{\delta f_1}{\delta x_2} \\ \frac{\delta f_2}{\delta x_1} & \frac{\delta f_2}{\delta x_2} \end{bmatrix} \begin{pmatrix} \Delta x_1 \\ \Delta x_2 \end{pmatrix} = 0$$

$$\begin{pmatrix} \Delta x_1 \\ \Delta x_2 \end{pmatrix} = -\begin{bmatrix} \frac{\delta f_1}{\delta x_1} & \frac{\delta f_1}{\delta x_2} \\ \frac{\delta f_2}{\delta x_1} & \frac{\delta f_2}{\delta x_2} \end{bmatrix}^{-1} \begin{pmatrix} f_1(x_1^\circ, x_2^\circ) \\ f_2(x_1^\circ, x_2^\circ) \end{pmatrix}$$

$$\begin{pmatrix} \Delta x_1 \\ \Delta x_2 \end{pmatrix} = -\begin{bmatrix} \frac{\delta f_1}{\delta x_1} & \frac{\delta f_1}{\delta x_2} \\ \frac{\delta f_2}{\delta x_1} & \frac{\delta f_2}{\delta x_2} \end{bmatrix}^{-1} \begin{pmatrix} f_1^\circ \\ f_2^\circ \end{pmatrix}$$

In power system

$P(\delta, |v|) = 0$

$Q(\delta, |v|) = 0$

The above equation is the NEWTON RAPHSON METHOD equation when two variables are present in the system.

THE SIZE OF JACOBIAN MATRIX

Basically, it used in newton Raphson method for finding the large power system problem. But for different buses it gives the different size of matrix as like: -For n bus system, if all bus is load bus, then there will be 2n variable so size of Jacobian is 2m×2m.For PV bus where active power and voltage magnitude are specified and variable will be reduced, so one equation have to be reduced and the matrix size is (2m-1×2m-1).For p PV bus the size of the Jacobian matrix 2m-p×2m-p.For a slack bus where voltage magnitude and phase angle are specified the size of matrix reduced by two and the size of Jacobian matrix is 2m-p-2×2m-p-2.For s slack bus the size of the jacobian matrix 2m-p-2q×2m-p-2q.

Here m= no. of buses

P= no. of PV/ generated / voltage-controlled bus

Q= no. of slack bus

For PQ bus= no. of load bus+ PV bus with reactive power +fixed shunt+ capacitor.

FAST DECOUPLED METHOD

It is extension of N-R method which is calculate the power flow analysis in polar coordinates with certain approximation. We can say that this is modified version of newton Raphson method due its fast algorithm.in some case where resistance to reactance is high ratio and heavy voltage the fast-decoupled method not work properly because it is an approximation method.

$$\begin{pmatrix} \Delta P \\ \Delta Q \end{pmatrix} = \begin{bmatrix} J_1 & 0 \\ 0 & J_4 \end{bmatrix} \begin{pmatrix} \Delta\delta \\ \Delta|V| \end{pmatrix}$$

$$\Delta P = J_1 \Delta\delta = \left(\frac{\partial P}{\partial \delta}\right) \Delta\delta$$

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

$$\frac{\Delta P}{V_i} = -B' \Delta\delta$$

$$\frac{\Delta Q}{V_i} = -B'' \Delta|V|$$

$$\Delta\delta = -[B']^{-1}\frac{\Delta P}{V_i}$$

$$\Delta|V| = -[B'']^{-1}\frac{\Delta Q}{V_i}$$

CONCLUSION

Power system load flow analysis is the most important tool for future planning and solving the large area network. After the study in deep of load flow we state that the load flow analysis having a four quantities voltage magnitude, phase angle active power and reactive power. and to calculate the various method are present but in this paper we already study in three method 1. G-S METHOD 2. N-R METHOD 3. FAST DECOUPLED METHOD. We can say that N-R method is faster than the both method and solve the large power system network problem. Gauss seidel method having a simple calculation of iteration based but in newton Raphson method having a complex calculation but suitable for large system.

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