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Comparison Between Technique Topology Method, Novel Method and Newton Raphson Method in Order Flow in Power Radial Distribution System Study

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Abstract: *Distribution system is a power system that serves to transmit and distribute electrical energy to load centers or consumers. The problem face show to supply the distribution network with agood quality of power at the present time and in the future. A good analysis of the distribution of urgently needed quality in the distribution system.Power flow studies are very useful for planning and designing the expansion of electric power systems and is also used to determine the operating conditions of a system that meets the economic and technical requirements. There are several methods used to solving the power flow analysis include: 1). Technique Topology, 2). Novel Method, and 3). Newton Raphson Method. Comparison of the three methods used in this study are expected to provide a solution that has a speed in the calculation process and low memory. Comparison of speed and memory required for the above three methods showed that the novel method faster execution time than the two other methods. In the process of computation time is 0.009749 obtained for the novel method. As for the memory required is131,226 bytes.*

Keywords*: Distribution Systems, Power Flow, Technique Topology, Novel Method, Newton Raphson Method.*

I. Introduction

The distribution system is an electric power system that serves to deliver and distribute electrical energy to load centers or consumers. The problem faced by the distribution network is how to supply power (quality and quantity) with both in the presentand in the future. As we know the characteristics of the distribution system generally radial network structure, phase imbalance, and the large number of branches and nodes. Therefore we need a method to analyze the flow of power in accordance with the characteristics of the distribution system. In this study comparing methods Topology Technique, Method of Newton Raphson and Novel Methods for analyzing power flow in the distribution system. Parameters were compared to that speed the time required to perform the calculation process.

Mechanical methods topology is formed of a matrix constants based on network topology and form the bus impedance matrix. This method does not involvea lot of mathematical rules and do not perform matrix multiplication is too large. Matrix size used is very small because it does not form a matrix jakobianas the Newton Raphson method so that the amount of memory used is also small. Topology Mechanical methods have very high speed calculation process since the matrix used is simple: use the bus impedance matrix. So that this method is also in accordance with the characteristics of the radial distribution system.

Novel methods of matrix constants are formed based on the shape of the network topology. Novel Method of forming a matrix on the line impedance. Formulations made is determining the voltage on all buses except the bus voltage source is assumed to be 1 pu with a phase angle of 0 ° in a phase, in phase b +1200 and -1200 in phase c. Based on the voltage value and a certain value of active and reactive power, the current branch that starts from the last bus to the source can be calculated. Then calculate the total voltage drop and calculate the new value of the voltage. Once this process is complete, the error voltage is calculated and compared with the previous value. If there is a difference outside the tolerance limit, then the injection current is calculated back, then obtained the latest value of the voltage drop. This process is repeated until the difference between two voltage values are

within tolerance limits specified calculation then determines the voltage drop, power flow, and loss of power losses in each of each phase in the feeder.

Newton Raphson method in solving the power flow calculation requires the establishment jakobian matrix size is four times the size of the matrix Y bus and need to be recalculated for each iteration, so that the calculation time becomes longer but faster converging. In the distribution system using the conductor size is small, the ratio X/R is small so jakobian matrix can not be simplified (Aliakbar, 2007).

Based on the description on the background of the above, then the problem of this research can be formulated as follows: 1) How does the distribution system modeling method Topology technique, Novel Method and Newton Raphson method. 2) How to calculate the voltage node or bus from the bus source until the last bus. 3) How big is the memory and speed of Engineering Methods Topology, Novel Method and Newton Raphson method in the calculation. 4) How to design a tool Method of Mechanical Topology, Novel Method and Newton Raphson Method. The purpose of this study was to compare the methods of Engineering Topology, Novel Method and Newton Raphson method is used to analyze the flow of power at 20 KV distribution network in Jember substation feeder Gajahmada so they can know the time difference and the memory used of the three methods.

II. Literature Review

Masoud (2007) conducted a study on the study ofthe unbalanced power flow in the distribution system. The method used is novel 3-phase, the method is based on the formation of a constant matrix based on network topology needs to be created only once. This method does not involve complex mathematical equations, and also does not require the inverse matrix. It can be developed in other applications as the development of this method. Analysis and the results showed that the development of this method is simple, accurate, fast, reliable, and has low storage requirementns. It can also be used to control the on-line application.

Sabri, Nur Hidayatand Handini (1990) conducted a study on power flow in radial distribution network. Methods were used that method Topology technique. This method is based on the formation of a constant matrix which is based on network topology that is used to form a bus impedance matrix. Analysis of calculations performed in two ways: with iteration and without iteration at1-phase system. The calculations show that without the iterative calculation results are good enough to be used in the calculation of power flow. users less memory than other methods, since the formation of the inverse matrix topology can be formed directly without doing the inverse matrix A and matrix can be saved as a branch impedance matrix column.

Dibyo (2007) conducted a study on the study of the unbalanced load flow in a network system of 150 KV. In his research comparing Newton Raphson Method and Method Fast decouple. From the discussion on flow studies with Newton Raphson Method and Fast Methods decouple it can be concluded that the Fast method to decouple the power flow problem-solving method that has the simplicity of implementation, the calculation efficiency and high reliability compared to the Newton Raphson method. Sabri et.al (1990) conducted a study on power flow in radial distribution network. The method used is the method Topology technique. This method is based on the formation of a constant matrix which is based on network topology that is used to form a bus impedance matrix. Analysis of calculations performed in two ways: with and without iteration iteration at 1-phase system.

Fast method to decouple the number of iterations that have more than the Newton Raphson method, this is due to a convergence of factors to decouple the Fast method is highly dependent on the condition of the network parameters which is the ratio of R/X of the channel. The larger the ratio between R/X then decouple the Fast Methods to reach convergent iteration that the longer and larger numbers. While the Newton Raphson method is quadratic convergence of factors and does not depend on a comparison of the network parameters. However, when calculating the overall Decopule Fast method is much shorter. In terms of accuracy, use a matrix that is similar to the method Fast Jakobian decouple theoretically no effect when compared with thoroughnesss owned the Newton Raphson method. This is because this approach is not changing point solution but only direction that is used to reach such a solution.

With the increasing complexity of the problems in the electric power system, as a result of increasing consumer demand, the increasing number of transmission and distribution channels, it is necessary to study the flow of power in the system analysis. Studying the flow of power is carried out to determine:

1. The active power flow in the branches of the circuit.
2. There is a circuit that has the burden of over-voltage busbar within the limits of the acceptable.
3. Effect of additions or changes to the system.
4. The effect of the loss of the relationship in an emergency.
5. The optimum conditionsof loading system.
6. Losing power optimum system.

In the operation of electric power systems, electrical parameters that need to be considered in relation to the power flow analysis is the magnitude of the voltage magnitude | V |, the phase angle ɵ voltage, real power P and reactive power Q. real power P has a strong dependence with the phase angle ɵ voltage and reactive power Q has a strong dependence with the magnitude of the voltage | V |. If P and Q are changed, then ɵ and V changed as well and vice versa.

In the distribution of electricity to consumers, the applied voltage varies depending on the type of customer need. For industrial consumers typically use medium voltage 20 kV while for residential consumers use low voltage 220/380 Volt, which is a voltage ready for household appliances. Thus, the power distribution system can be classified into two systems, namely:

1. The primary distribution systems.
2. The secondary distribution system.

Classification of electric power distribution system into two, according to distribution voltage levels.

Equivalent circuitforthree-phasechannelare:

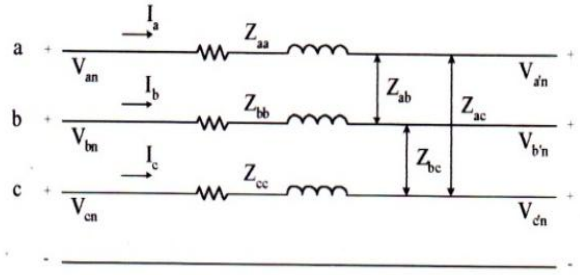

Figure 1 ChannelModelThreePhase
(Source: W.H. Kresting and W.H. Philips, 1995)

Z abc impedance will be shown as an impedance matrix phase. The elements of the matrix determined by the equations of Carson'sand followed by reduction Kron, s. Carson,s equation, is:

$$z_{ii} = r_i + 0{,}0953 + j0{,}12134 \times \left[\ln\left(\frac{1}{GMR_i}\right) + 7{,}934\right]/mile \quad (2.1)$$

$$z_{ij} = 0{,}0953 + j0{,}12134 \times \left[\ln\left(\frac{1}{D_{ij}}\right) + 7{,}934\right]/mile \quad (2.2)$$

with:
ri is the conductor resistance (ohms /mile)
GMR is aconductor Geometric Mean Radius(ft)
Dij is the distance between conductors i and j(ft)

From equation (2.1) and (2.2) for the three-phase with neutral line will produce primitive impedance matrix 4x4:

$$[Z_{prim}] = \begin{bmatrix} Z_{aa} & Z_{ab} & Z_{ac} & Z_{ad} \\ Z_{ba} & Z_{bb} & Z_{bc} & Z_{bd} \\ Z_{ca} & Z_{cb} & Z_{cc} & Z_{cd} \\ Z_{na} & Z_{nb} & Z_{nc} & Z_{nd} \end{bmatrix} \text{. .....(2.3)}$$

Then the matrix is reduced to a 3x3 matrix using Chrome reduction by the equation:

$$[Z_{abc}] = [Z_{abc}] - [Z_{an}].[Z_{nn}]^{-1}[Z_{na}] \text{ .(2.4)}$$

Line impedance represented by impedance 3x3 matrixas follows:

$$z = \begin{bmatrix} (R_{aa} + jX_{aa}) & (R_{ab} + jX_{ab}) & (R_{ac} + jX_{ac}) \\ (R_{ba} + jX_{ba}) & (R_{bb} + jX_{bb}) & (R_{bc} + jX_{bc}) \\ (R_{ca} + jX_{ca}) & (R_{cb} + jX_{cb}) & (R_{cc} + jX_{cc}) \end{bmatrix} \text{.(2.5)}$$

System per unit for a quantity is the ratio of the amount of the basic values. In a one-phase system, because all the impedance in a system must be declared on the basis of the same impedance, then the calculation we need to have a way to be able to change the impedance per unit from one base to another base.

For admittance matrix formation buses and bus impedance matrix which network elements can be expressed in terms of impedance or admittance equation is as follows.

$$\bar{v} + \bar{e} = [z]\bar{i} \text{ .....(2.6)}$$

Where:

$\bar{v}$ = the voltage on the bus

$\bar{e}$ = the voltage on the line

Whereas in the form of admittance are as follows :

$$\bar{i} + \bar{j} = [y]\bar{v} \text{ .....(2.7)}$$

If equation (2.7) from the front multiplied by the transpose of the matrix A, obtained the following results:

$$A^t\bar{i} + A^t\bar{j} = A^t[y]\bar{v} \text{ .....(2.8)}$$

In accordance with Kirchhoff's current law, the algebraic sum of currents that meet at a point equal to zero. So the formula becomes:

$$A^t i = 0 \text{ .....(2.9)}$$

and $A^t j = I_{bus}$ .....……(2.10)

in addition, can also be obtained by the relationship between the voltage drop to the voltage bus network elements as follows:

$$v = A\ V_{bus} \text{ .....(2.11)}$$

Substitution equation. (2.9), (2.10) and (2.11) into the equation (2.8) obtained by the following equation:

$$I_{bus} = A^t [y]\ A\ V_{bus} \text{ .....……(2.12)}$$

The second equation (2.8) and (2.12) are the same, so the equation becomes:

$$Y_{bus} = A^t [y]\ A \text{ .....…… (2.13)}$$

Bus impedance matrix can be obtained by menginvers bus admittance matrix expressed in equation (2:14), namely:

$$Z_{bus} = (Y_{bus})^{-1} = (A^{t}[y]A)^{-1} \quad \text{.....(2.14)}$$

Radial network

In the radial network, if the number of nodes is n, the number of elements is n-1. Thus the matrix A is the matrix:

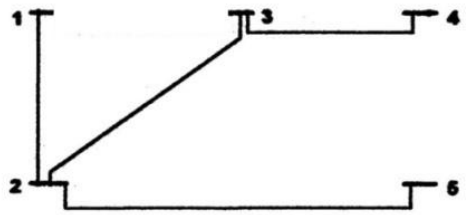

Figure 2 Radial Network

squares with order (n-1), thus the Z bus matrix for radial network is as follows:

$$Z_{bus} = K[z]K^{t} \quad \text{.....(2.15)}$$

With the matrix K = A-1.

Suppose images 2 is a connected graph of a radial network electrical power system. By selecting the node (1) as a reference, then the matrix A is as follows:

$$A = \begin{bmatrix} -1 & 0 & 0 & 0 \\ 1 & -1 & 0 & 0 \\ 0 & 1 & -1 & 0 \\ 1 & 0 & 0 & -1 \end{bmatrix}$$

and the matrix K is as follows:

$$K = \begin{bmatrix} -1 & 0 & 0 & 0 \\ -1 & -1 & 0 & 0 \\ -1 & -1 & -1 & 0 \\ -1 & 0 & 0 & -1 \end{bmatrix}$$

Matrix K can be determined directly by using the following provisions:

- reference node is considered as the sole source node.
- line states node, and a column declared elements.
- kij =-1, if the current passes through the elements in node i j.
- kij = 0, if the current node to node j i do not pass.

Power Flow Equations

The general equation for the current flowing toward a bus is (Pai, 1979):

$$I_1 = Y_{11}V_1 + Y_{12}V_2 + Y_{13}V_3 + \ldots + Y_{1n}V_n$$
$$I_2 = Y_{21}V_1 + Y_{22}V_2 + Y_{23}V_3 + \ldots + Y_{2n}V_n$$
$$I_3 = Y_{31}V_1 + Y_{32}V_2 + Y_{33}V_3 + \ldots + Y_{3n}V_n$$
$$\vdots$$
$$I_n = Y_{n1}V_1 + Y_{n2}V_2 + Y_{n3}V_3 + \ldots + Y_{nn}V_n$$

In the application of the method of Newton Raphson Power Flow Analysis

In the Newton Raphson method, slack bus are omitted from the calculation iterations to determine the stresses, due to the large and angular slack bus voltage at predetermined. In the power flow analysis, there are two equations that must be solved in each bus. Both equations are as in Equation (2.16) and Equation (2.17), as follows:

$$P_p = \left|V_p\right| \sum_{q=1}^{n} \left|V_q\right| \left[G_{pq} \cos(\delta_p - \delta_q) + B_{pq} \sin(\delta_p - \delta_q)\right] \text{.....(2.16)}$$

$$Q_p = |V_p| \sum_{q=1}^{n} |V_q| [G_{pq} \sin(\delta_p - \delta_q) - B_{pq} \cos(\delta_p - \delta_q)] \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2.17)$$

The steps necessary to obtain a bus voltage by using Newton-Raphson method is as follows:

1) Give the initial values of the voltage and voltage angle for all bus voltage load, and initial angle for all angles of bus voltage generator.
2) Calculate the active power and reactive power and subtract to the active and reactive power are known in order to obtain a column vector of power changes. If all elements of a column vector satisfies the given accuracy then go to step 7, otherwise proceed to step 3.
3) Determine the elements of the matrix jakobian.
4) Solve the linear equation to obtain large changes in the voltage and phase angle.
5) Fix large and voltage phase angle.

Formula Novel Method In Power Flow Analysis

In the novel method, slack bus is calculated at iteration calculation to determine voltages, large and angle of the slack bus voltage has been determined. In the analysis of power flow, the equation to be solved at each bus k is the current injection.

$$I_{injeksi}^{(k)} = \frac{S^{*(k)}}{V^{*(k)}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2.18)$$

In the radial network system application of the novel method, there are several conditions that must be carried out as follows:

- Bus source given no 0
- The direction of power flow leaving the source
- No buses = no incoming channel on the respective bus k
- Power on the bus load is negative (injection current into the bus)

To describe the structure of a radial network, it can be seen at figure 4:

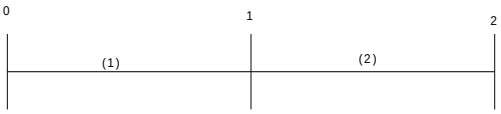

Figure 3. Radial Network Structure

The steps required for power flow analysis using this novel method is as follows:

1. The voltage node k valuable assumed 1 pu, or vk = 1 pu
2. Establish a matrix K
3. Calculate the flow injection
4. Calculate the flow channel
5. Calculate the line voltage)
6. Calculating losses channels
7. Counting error losses
8. Calculate the voltage on the bus with the value of current and impedance new channel
9. Read the value of the error and when it reaches the specified error value calculation is completed.

Implementation Topology Technique Method In Power Flow Analysis

Technique is a technique to analyze the network topology that describe the network element as a segment of a line and point of contact called nodes collectively illustrated in a graph of the network. Compared with other network radial network structure has some special properties that can be utilized to facilitate trouble shooting, namely:

1. On the radial network there is only one resource node and other nodes is a burden.
2. Flow positive injection contained in the resource node, while the other node negative valuable injection.

In the method Topology technique with radial network system, the voltage drop is calculated for each branch and each node to node 0. To describe the structure of a radial network, it can be seen at Figure 4.

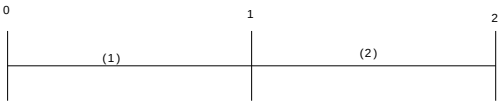

Figure 4: Radial Network Structure

The steps required for power flow analysis using topology technique method is as follows:

1. The voltage node i assumed value 1 pu, or vk = 1 pu
2. Establish a matrix A
3. Establish an impedance matrix Zbus
4. Calculate the injection current at node i
5. Calculate the total voltage drop
6. Calculate the new bus voltage
7. Calculate the error voltage
8. Read the value when the error is greater than the specified value, the calculation back to No. 4 and when it reaches the specified error value calculation is completed.

Variable Operational Definition

Power flow studies in this study to compare the reliability and efficiency of Engineering Methods Topology, Novel Method and Newton Raphson method as a parameter is the accuracy of the calculation, the time taken in the process of calculation and how much memory. To calculate the time spent in the iteration process by adding the "tic" at the beginning of the iteration process and ends by "toc" at the end of the process itersi. Meanwhile, to see the memory used by adding the "whos" at the end of the program.

Hypothesis

The hypothesis that can be arranged in this research is the analysis of the distribution of power flow can be solved using the method Topology Technique, Novel Method and Newton Raphson methods in radial distribution systems. Mechanical methods Novel Topology and faster methods of calculation time and less memory than the Newton Raphson method.

Research Methods

Steps being taken in this research is the study of the theory of the method Topology Technique, Method Novel, Nuwton Raphson method and the study of the distribution system is not balanced.

III. Calculation Results And Analysis

Method of Mechanical Topology

To complete the power flow calculations we used an alternative method called the method Topology technique. Topology Mechanical methods have advantages such as:

- Can be used k radial network.
- Can be used to power the flow of unbalanced load
- fast calculation time.

In the power flow calculations can perform calculations manually and using computer programs. When do the calculations manually then require up to several iterations and time needed lama.tetapi when doing calculations with a computer program with a lot of iterations can be done automatically and does not require a long time.

In principle the use of computer programs can analyze a radial distribution of the number of branches or a limited number of buses which do not depend on the availability of memory available on the computer being used.

Method of Novel

In a novel method of analysis is a method developed by establishing a constant matrix which is based on network topology. This method does not involve complex mathematical equations, and also does not require a matrix inversion.

In the analysis of power flow compared with the novel method Newton Raphson Methods and Techniques topology to determine the accuracy, speed and memory use.

Method of Newton Raphson

In the analysis of power flow Newton Raphson method is often used. In the Newton Raphson method requires the formation of matrix jakobian a size four times the size of the matrix Ybus and need to be recalculated for each iteration so that the calculation time becomes longer but faster converging.

In the analysis of power flow Newton Raphson method is used as a comparison speed and memory use. Newton Raphson method in this study considered a conventional method is best.

Data calculation

This power flow calculations take data from Jember GI who served feeder with a capacity of 60 MVA transformer 150/20 KV-. Radial distribution system owned GI Jember wear distribution voltage 20 KV at 7 bus.

Data Imposition

Data loading is obtained by taking the data from each trofo distribution, where there is a big load on each phase. If a large load is zero, then the node is no distribution transformers but only a knot. At this stage negligible loss in distribution transformers, for data loading as shown in Table 1

Table .1 Data Charging of feeder Gajah Mada

No Node	Voltage Early		Loading		Bus Type
	V (pu)	θ( )	P (kw)	Q (kVAR)	
0	1.0000	0.0000	0.0000	0.0000	Slack
1	1.0000	0.0000	2.528,16	1.076,99	Load
2	1.0000	0.0000	0.0000	0.0000	Load
3	1.0000	0.0000	0.0000	0.0000	Load
4	1.0000	0.0000	16,424.10	7,954.55	Load
5	1.0000	0.0000	5,832.00	4,222.30	Load
6	1.0000	0.0000	0.0000	0.0000	Load
7	1.0000	0.0000	13,853.28	2,813.03	Load

Power Flow Calculation Results

Using the power flow calculation method Topology Technique, Method Novel, Newton Raphson method in this study showed the value of the voltage and power at each node that is the input power, the power to send and load power.

Calculation of time, memory and errors in Newton Raphson method, Method and Method Novel Topology technique for 1-phase systems can see in Tabel 2

Tabel 2 : Calculation of Time, Memory and Error.

Variable	*Newton Raphson*Method	*Novel*Method	*Topologi* Method
Time(s)	0,096259	0,009749	0,014395
Memory(byte)	285482	131226	278074
error	$1,5131.10^{-10}$	$1,4248.10^{-10}$	$1.6324.10^{-10}$

From Table 2 shows that the novel method of memory used at least when compared with the Newton Raphson Methods and Techniques Methods Topology.

IV. Conclusions And Recommendations

Conclusion

After analyzing the calculation of the network of 20 kV radial distribution system, it can take several conclusions including:

1. In the power flow calculation algorithm Engineering Methods and Methods Novel Topology same as requiring the establishment of a constant matrix based on network topology. The difference is in the method Topology technique necessitates the establishment of bus impedance matrix while the novel method requires a line impedance matrix.
2. On Novel Method of calculation times faster than the Newton Raphson Methods and Techniques Methods Topology
3. In the third method is discussed the most efficient method is novel because it only requires a little memory. In addition to slight memory Novel method is very simple because it does not require the completion of a complex mathematical and easy to do calculations with the programming.

Suggestion

From the analysis of power flow calculation using the method Topology Technique,, Novel Method and Newton Raphson methods that have been discussed can be seen faster method Topology technique should be developed and should be applied to planning network expansion.

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