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ANALYZED TRANSMISSION POWER FLOW USING MATHLAB SOFTWARE

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ABSTRACT

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Power plants that are located far from community settlements produce their advantages and advantages for electrical energy providers. The non-strategic position makes the producers of electrical energy have to deliver electrical energy to the users or customers who use electrical energy. The power flow calculation system is used to find out how much voltage, current, real power, and reactive power are received by the receiving side. The research method used is the research data approach so that it is by the data in the field. From the results of the above calculations, it can be seen that the difference in the calculation between the MATLAB M-file and the MATLAB Simulink there is a difference in the calculation of the voltage on the bus load 2 of -0.0012 Pu. The difference in calculation data can also be seen in the slack bus which has an active power of 0.02 Pu and reactive power of 0.03 Pu. The difference in calculation data can also be seen in bus load 1 which has an active power of 5.89 Pu and reactive power of 47.29 Pu. The difference in calculation data can also be seen in bus load 2 which has an active power of 60.89 Pu and reactive power of 38.79 Pu.

Keywords: Power Flow, Gauss-Seidel, Matlab.

1. INTRODUCTION

Electricity Is A Necessity That Cannot Be Separated From Human Needs. The Development Of The Times Requires Electrical Energy To Support Its Existence. The Increasing Use Of Increasingly Sophisticated Electronic Devices Must Be Supported By The Relentless Presence Of Electrical Energy. The Electricity Supply Must Be Properly Channeled To The Customer, So That It Is Balanced With The Costs Required To Produce Electrical Energy (Solly & Lubis, 2019).

The Position Of The Power Plant Which Is Located Far From Community Settlements Produces Its Own Advantages And Benefits For The Electricity Provider. The Non-Strategic Position Makes The Producers Of Electrical Energy Have To Deliver Electrical Energy To The Users Or Customers Who Use Electrical Energy. The Substation And The Transmission System Support An Integral System In The Distribution Of Electrical Energy. The Equipment Also Supports (Khairunnisa et al., 2017).

The Delivery Of Energy In Order To Be Maximized In Its Use.The Energy Delivery System Is Always Constrained By The Loss Of Voltage And Electric Power At The Load Center. The Energy Lost Is Influenced By The Distance Of Energy Delivery, The Type And Cross-Sectional Area (Cable) Used. The Power Flow Calculation System Is Used To Find Out How Much Voltage, Current, Real Power And Reactive Power Are Received By The Receiving Side. The Research Method Used Is The Research Data Approach So That It Is In Accordance With The Data In The Field. The Research Carried Out Is The Analysis Of Power Flow Studies Using The Gauss-Siedel Method With Mathlab Software Tools (Pasaribu et al., 2020).

2. LITERATURE REVIEW

Electric Power System

The electric power system is a system consisting of several structures in the form of generation, transmission, and distribution that are interconnected and work together to serve the electricity needs of customers according to their needs. Broadly speaking, the Electric Power System can be described by the scheme below (Miller et al., 2012).

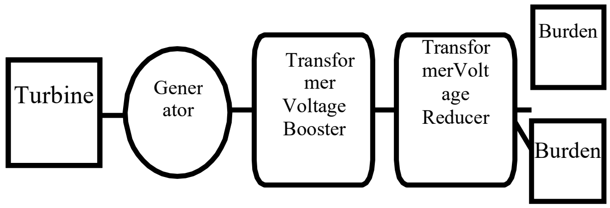

Figure 1. Electric Power System
Source: (Aryza et al., 2017)

For the purpose of providing electricity to customers, various electrical equipment is needed. These various electrical equipment are connected to each other and have an interrelationship and as a whole form an electric power system. The electric power system here is a collection of Electrical Centers and Substations (Load Centers) which are connected to each other by a transmission network so that it is an interconnection unit (Yusmartato et al., 2018).

Power Flow Analysis

Before the power flow analysis is carried out, the system components consisting of generators, transformers, transmission lines, and loads must be represented or modeled through a single line diagram by assuming a three-phase system in a balanced state (Haxhibeqiri et al., 2017). This diagram is intended to provide a brief description of an electric power system as a whole. For that, we need data related to these components. According to Stevenson (1994), the data needed for power flow analysis are as follows (Mukharom et al., 2020):

a. Generator data, namely active power capacity (P) in Megawatts (MW) and reactive (Q) in Megavolt Ampere (MVA) units, terminal voltage (V) in Kilovolts (KV), and synchronous reactance (X) in Ohms (Ω).
b. Power transformer data, namely the capacity of each transformer in Megavolt Ampere (MVA), voltage (V) in Kilovolt (KV), and leakage reactance (X) in Ohm (Ω).
c. Transmission line data, namely resistance (R) in ohms (Ω) and reactance (X) in ohms (Ω).
d. Load data, namely active power (P) in Megawatts (MW) and reactive power (Q) in Megavolt Ampere (MVA).

According to Saadat (Magzoub et al., 2015), in power flow analysis there are four quantities on each network bus that are reviewed and play a role, namely:

1. Active power P (active power) in megawatts (MW).
2. Reactive power Q (reactive power) with units of mega volt-ampere-reactive (MVAR).
3. The magnitude of the voltage V (magnitude) with kilovolts (KV).
4. The voltage phase angle (angle) in radians.

Power Flow Study With Gauss-Seidel Solution Method

The Gauss-Seidel iteration method is a method that uses an iteration process until the values that vary and are relatively constant are finally obtained. The Gauss-Seidel method is used to solve large linear equation systems with large zero coefficient proportions, such as those found in systems of differential equations. The Gauss-Seidel iteration method was developed from the idea of the iteration method on the solution of nonlinear equations. Iteration techniques are rarely used to solve small systems of linear equations because direct methods such as Gaussian elimination are more efficient than iterative methods. However, for a large system of linear equations with a zero element percentage in a large coefficient matrix, Iteration technique is more efficient than direct method in terms of computer memory usage and computation time. With the Gauss-Seidel iteration method, the rounding tolerance can be minimized because it can continue iterations until the solution is as accurate as possible with the allowable tolerance limit.

Equation (2.20) is a nonlinear equation at each node with 2 unknown variables. With the Gauss-Seidel method, to solve V1 iteratively, Equation (1) becomes:

$$V_i^{(k+1)} = \frac{\frac{P_i^{sch} - jQ_i^{sch}}{V_i^{*(k)}} + \Sigma y_{ij} V_j^{(k)}}{\Sigma y_{ij}} \quad j \neq 1 \quad (1)$$

with yij is the actual admittance in units per unit. Psch and Qisch are active power and reactive power expressed in units per unit. In writing Khirchoff's Current Law, the current entering bus i is assumed to be positive. For a loaded bus, the active and reactive power flows away from the P sch bus and Q sch is negative. If equation (1) is solved for P and Q1, then:

$$P_i^{(k+1)} = \Re\left\{V_i^{*(k)}\left[V_i^{(k)} \Sigma_{j=0}^{n} y_{ij} V_j^{(k)}\right]\right\} j \neq 1 \ (2)$$

And :

$$Q_i^{(k+1)} = -\Im\left\{V_i^{*(k)}\left[\Sigma_{j=0}^{n} y_{ij} - \Sigma_{j=0}^{n} y_{ij} V_j^{(k)}\right]\right\} j \neq 1 \ (3)$$

The power flow equation is usually expressed in terms of the bus admittance matrix elements (Ybus). Ybus is indicated by Yij = - yij, and the diagonal elements are Yij = . Equation (2&3) becomes:

$$V_i^{(k+1)} = \frac{\frac{P_i^{sch} - jQ_i^{sch}}{V_i^{*(k)}} + \Sigma y_{ij} V_j^{(k)}}{y_{ij}} \quad (4)$$

And :

$$P_i^{(k+1)} = \Re\left\{V_i^{*(k)}\left[V_i^{(k)} Y_{ii} + \Sigma_{j=1}^{n} y_{ii} V_{ij}^{(k)}\right]\right\} j \neq 1 \ (5)$$

$$Q_i^{(k+1)} = -\Im\left\{V_i^{*(k)}\left[V_i^{(k)} Y_{ii} + \Sigma_{j=1}^{n} y_{ij} V_j^{(k)}\right]\right\} j \neq 1 \ (6)$$

Under normal operating conditions, the magnitude of the voltage for each bus for the initial calculation is assumed to be around 1.00 + j0.0 per unit or close to the magnitude of the slack bus voltage. The imaginary part of (k+1) in equation (5&6) is expressed by:

$$\left(e_i^{(k+1)}\right)^2 + \left(f_i^{(k+1)}\right)^2 = |V_i|^2 \quad (7)$$

Or

$$e_i^{(k+1)} = \sqrt{|V_i|^2 - \left(f_i^{(k+1)}\right)^2}$$

With and are the imaginary components of the voltage). Convergence can be accelerated by applying an acceleration factor for each iteration, i.e

$$e_i^{(k+1)} \ f_i^{(k+1)} \ V_i^{(k+1)}$$

$$V_i^{(k+1)} = V_i^{(k)} + a\left(V_i^{(k)} cal - V_i^{(k)}\right) \quad (8)$$

Here a is the acceleration factor. This a value depends on each system with levels 1.3 to 1.7 adjusted for the type of system. The obtained voltage now replaces the previous stress from each sequence of equations. This process continues until the real and imaginary components of the bus voltage change during the iteration with:

$$\left|e_i^{(k+1)} - e_i^{(k)}\right| \leq \epsilon$$

Or

$$\left|f_i^{(k+1)} - f_i^{(k)}\right| \leq \epsilon \quad (10)$$

where is the epsilon whose price is fixed.

Active power and reactive power on the slack bus are calculated from equations (5) and (6). After determining the voltage from the bus, the next step is to calculate the power flow and power losses in the line. Suppose the line is connected by two buses i and j, as shown in figure 2. The line current is calculated at bus i which is marked positive. I to j is given by:

$$= + 0 = (Vi -) + 0Vi \quad (10)$$

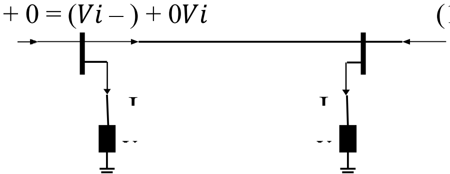

Figure 2 Transmission Line Model for Calculation of Power Flow and Power Loss in Line
Source: (Cekdin, 2007)

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Likewise, the current flow Iji measured on bus j and marked positive

$$= + 0 = (Vj -) + 0Vj$$

Complex power Sijfrom bus i to j and Sijfrom bus j to i is:

$$= = (Vi -)yij = 0$$

$$= = (Vj -)yij + 0$$

The power losses in the i – j line are the algebraic sum of the power flows, namely:

$$= + \qquad (12)$$

3. METHOD

This research is qualitative in nature by using data that has been used previously, namely the data obtained in the form of numbers or numbers sourced from literature and calculations and simulations. The scope of the research is the analysis of power flow in the electric power system. Data collection, including the collection and collection of data obtained from handbooks and journals. The data obtained are source voltage data, active power, reactive power.

Analysis of calculation results. Analyzing the calculation results that have been obtained using the Gaus-Seidel method with the help of the Matlab application using either M-File or Simulink simulation in Matlab. Is there a match with the level of precision between the two methods? If there is no match between the two methods, then repeat the data processing step using the Gaus-Seidel method with the help of the Matlab application using either M-File or Simulink simulation. After obtaining the same results or approaching the same results, the research can be continued.

4. RESULTS AND DISCUSSION

Research data

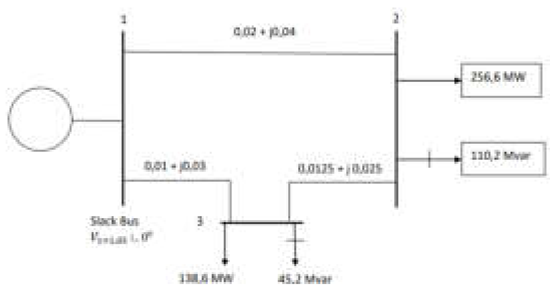

Figure 3. Single line Diagram 3 Bus

Table 1. Research Data

NO	bus	VOLTAGE	ACTIVE POWER (MW)	REACTIVE POWER (Mvar)
1	Slack	1.05∟00	?	?
2	Load 1	?	256.6	110.2
3	Load 2	?	138.6	45.2

From the research data above, it can be seen on the Slack Bus with a voltage of 1.05∟00 and an unknown active and reactive power. At Bus Load 1 the voltage is unknown with an active power of 256.6 MW and a reactive power of 110.2 Mvar And at Bus Load 2 the voltage is unknown with an active power of 138.6 and a reactive power of 45.2 Mvar and for data transmission 1-2 Y12 = 0.02 + j0.04, data transmission 1-3 Y13 = 0.01+j0.03, data transmission 3-2 Y32 = 0.0125+j0.025∪⁰

Data analysis

As for the research data above, it is calculated using the Gauss-Seidel method of power flow formula with the help of the formula that has been made in the MATLAB M-file which is shown as below:

```
%base 100 MVA :
epsilon = 0.00001;
x = 1;
% line impedance data :
z12 = 0.02+h*0.04;
z13 = 0.01+h*0.03;
z23 = 0.0125+h*0.025;
%admittance on channel :
y12 = 1/z12;
y13 = 1/z13;
y23 = 1/z23;
% Load in per unit :
S2 = -(256.6+h*110.2)/100;
S3 = -(138.6+h*45.2)/100;
% Bus 1 as SlackBus :
V1 = 1.05+h*0.0;
Vk1 = conj(V1);
% Estimated initial stress for:
V2 = 1.0+h*0.0;
E3 = 1.0+h*0.0;
iter = 0;
formatshort g
whilex>= epsilon
iter = iter+1;
Vk2 = conj(V2);
Ek3 = conj(E3);
V2 = 1/(y12+y23)*((conj(S2))/(Vk2)+(y12)*(V1)+(y23)*(E3));
V3 = 1/(y13+y23)*((conj(S3))/(Ek3)+(y13)*(V1)+(y23)*(V2));
%Current On Channel :
I12 = y12*(V1-V2);
I21 = -I12;
% Conjugate of Current In Line :
Ik12 = conj(I12);
Ik21 = conj(I21);
% Power in complex number form on bus 1:
S1 = (Vk1*(V1*(y12+y13)-(y12*V2+y13*V3)))*100;
% Power flow in the form of complex numbers on the line:S12 = V1*Ik12*100;S21 =
V2*Ik21*100;x = abs(V3-E3);E3 = V3;fprintf('%i',iter),disp([S1, S12, S21])
end
```

The formula is only partially displayed considering the limitations of the pages in this study. the formula that has been stored in the matlab M-file after being executed will produce data like this:

Table 2. Results of M-File Calculation Values

NO	bus	VOLTAGE (Pu)	ACTIVE POWER (Pu)	REACTIVE POWER (Pu)
1	Slack	1.05	409,48	188.99
2	Load 1	0.98	262.49	157.49
3	Load 2	1	199.49	83.99

From the results of the M-file matkab after running it produces data on the Slack Bus with a voltage of 1.05 Pu and an active power of 409.48 Pu with a reactive power of 188.99 Pu. At Bus Load 1 the voltage is 0.98 Pu with an active power of 262.49 Pu and a reactive power of 157.49 Pu. And at Bus Load 2 the voltage is 1 Pu with an active power of 199.49 Pu and a reactive power of 83.99 Pu.

As for the research data above, it is also simulated using a simulation on the MATLAB simulink which is shown below.

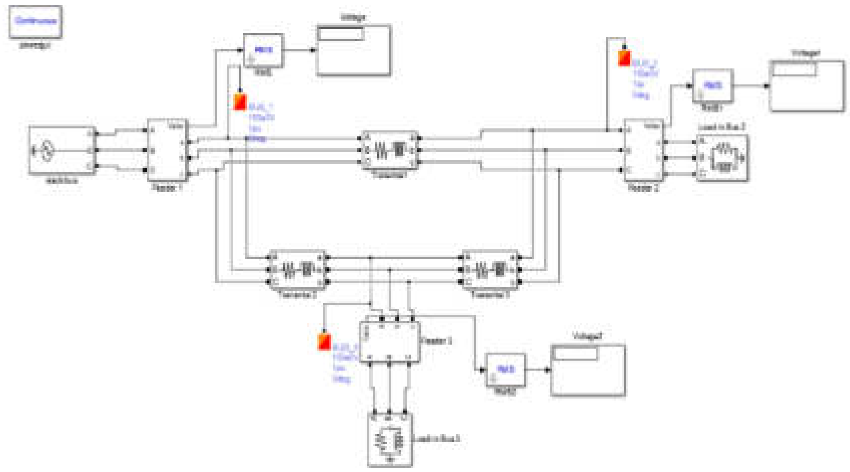

Figure 4. Simulation of Simulink

After running the matlab simulink data, it can be seen in the image below:

Table 3. Calculation Results of Matlab Simulink Sinulation Values

NO	bus	VOLTAGE (Pu)	ACTIVE POWER (Pu)	REACTIVE POWER (Pu)
1	Slack	1.05	409.50	189.02
2	Load 1	0.98	256,60	110,20
3	Load 2	1.0012	138,60	45,60

From the simulation results after running the simulink produces data on the Slack Bus with a voltage of 1.05 Pu and an active power of 409.50 Pu with a reactive power of 189.20 Pu. At Bus Load 1 the voltage is 0.98 Pu with an active power of 256.60 Pu and a reactive power of 110.20 Pu. And at Bus Load 2 the voltage is 1.0012 Pu with an active power of 138.60 Pu and a reactive power of 45.60 Pu.

The results of the calculation of the M-file matlab and simulink simulation obtained a comparison of the results of the two as shown in the table below:

Table 4. The difference between the calculation results of M-file and simulink matlab

NO	bus	VOLTAGE (Pu)	ACTIVE POWER (Pu)	REACTIVE POWER (Pu)
1	Slack	0	0.02	0.03
2	Load 1	0	5.89	47.29
3	Load 2	-0.0012	60.89	38.79

From the results of the above calculations, it can be seen that the difference in the calculation between the MATLAB M-file and the MATLAB simulink there is a difference in the calculation of the voltage on the bus load 2 of -0.0012 Pu. The difference in calculation data can also be seen in the slack bus which has an active power of 0.02 Pu and a reactive power of 0.03 Pu. The difference in calculation data can also be seen in bus load 1 which has an active power of 5.89 Pu and a reactive power of 47.29 Pu. The difference in calculation data can also be seen in bus load 2 which has an active power of 60.89 Pu and a reactive power of 38.79 Pu.

5. CONCLUSION

There is still a significant difference between calculations using M-file matlab and simulink matlab, namely active power of 0.02 Pu and reactive power of 0.03 Pu on the slack bus. active power of 5.89 Pu and reactive power of 47.29 Pu on bus load 1. active power of 60.89 Pu and reactive power of 38.79 Pu on bus load. This difference occurs because the MATLAB M-file calculates using an iteration system, while the MATLAB simulink only displays assumption (estimated) data.

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