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# Flow Analysis of Power in 150kv Transmission Line Using Gauss – Seidel in Substation Madura Region, App Surabaya

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## Abstract

In order to meet the needs of electric power in Madura 162.8 MW, it need an electrical power in the region Madura 162.8 MW hence the need for electric power is supplied from the plant - UJUNG (Indonesia Power) and also from GE Kenjeran of 115 MW and 63.8 MW. Therefore, the method used to analyze the amount of losses is by Gauss Seidel wherein the method is used to solve linear equations. Analysis of the results of the calculation, the value obtained by Gauss Seidel with total active power and reactive power on each bus to Madura is 162.8 MW 38.875 MVA. The value of losses in the transmission network of 4.796 MW and the total value for the voltage drop Madura 2.897%. As for the value voltage drop below the maximum value of ± 5%, or below the value of tolerance.

## Keywords

Gauss-Seidel, Voltage Drop, Power Loss, Active and Reactive Powers

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## 1. Introduction

Supply of electricity in the region of Madura derived from plants end (Indonesia Power) and will be supplied again from GI Kenjeran. In order to meet the needs of the electric power in the territory of Madura. The total power requirements of Madura region is 162.8 MW. To support the demand for electricity it takes two transmit electrical power supply to the region of Madura. Generating tip (Indonesia Power) supplies power to the region of Madura 115 MW while the GI Kenjeran supplying electrical power of 63.8 MW.

Of each substation area of Madura have electrical requirements vary. GI Gilitimur requires electrical power of 9.6 MW, GI Bangkalan requires electrical power of 37.4 MW, GI Sampang requires electrical power of 39.1 MW, GI Pamekasan require electric power of 39.3 MW, whereas GI Sumenep require electrical power of 37.4 MW. Madura electricity demand in the region every year progressed both for facilities and infrastructure so that the electric power needs will increasingly.

Studies on the flow of electric power on the transmission line of 150 KV was mostly done by researchers earlier among others are: [1], [2], [3], [4], [5], [6]. However, the present study analyzes the flow of electrical power using Gauss method Seidel has never been done by previous researchers.

## 2. Literature Review

### 2.1. Power Flow

According to [7], power flow analysis is the determination of a calculation of the active power and reactive power, which are at various points in a network of electricity which occurs in normal operating circumstances, either ongoing or expected in the future. Power flow analysis is very important

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in planning the development of a system for the future, because the good operability of the system is dependent on knowing the effects of interconnection, with other power system. Besides, the new power, new power stations, as well as a new transmission line, before it was installed.

### 2.2. Transmission Line

According [8], Electrical energy is carried by the conductor, namely through the transmission line from the centers of power plants to users. In order for the supply of electricity can be done well, then the electric power system meets some basic requirements.

According [9], the transmission system is functioning deliver electricity from the centers of power plants, which is far from load centers, and also to be a channel of interconnection between the power systems with other electric power system.

### 2.3. Substation (GI)

According to [8], electrical relay station (substation) is also called a load center substation unit which is a combination of transformers and switchgear circuit incorporated in a single unit through the control system of mutual support for operational purposes. Basically substation work to change the voltage generated by power plants to electric power into high voltage or voltage transmission and otherwise change the medium voltage or voltage distribution. Substation is also a sub-system of the distribution system (transmission) power, or an integral part of the distribution system (transmission). Substation is a sub-system of the electric power system. As a sub-system of the distribution system (transmission), the substation has an important role, the operation cannot be separated from the distribution system (transmission) overall. Power setting to the other parent substations via high-voltage substations and distribution substations with medium-voltage feeder.

### 2.4. Implementing Maintenance Area (APP), South Surabaya

Implementing maintenance area Surabaya is the result of the reorganization of PT.PLN (State Electricity Company) is a branch of a parent unit of PT PLN. Executing maintenance area has two base camp in running its business program namely base camp Surabaya which serves only the territory Surabaya and surrounding areas, while for base camp Gresik Serving the Gresik and Madura.

### 2.5. Gauss-Seidel Method

According [10], Gauss Seidel used to solve systems of linear equations (SPL) sized and large proportion of null coefficients, such systems are found in the systems of differential equations. Gauss-Seidel method is developed from the idea of iteration method to the solution of nonlinear equations. Iterative technique rarely used to solve systems of linear equations (SPL) that is small for direct methods such as Gauss elimination method is more efficient than the iterative method. However, for large-sized SPL with a percentage of zero elements, on a large coefficient matrix, iteration techniques more efficient than the direct method in the use of computer memory and computation time. With the method of Gauss- Seidel iteration, rounding errors can be minimized because it can continue iterating until a solution expeditiously as possible in accordance with the permissible error limit.

## 3. Method

### 3.1. Location and Time Research

The research location is at the substation at 150 kV transmission line in the region of Madura. To capture these data held in May 2013 Up to August 2013 in the substation area is Madura / Implementing Maintenance Area (APP), South Surabaya.

### 3.2. Flowchart Research

Here is a flowchart of this study are as follows,

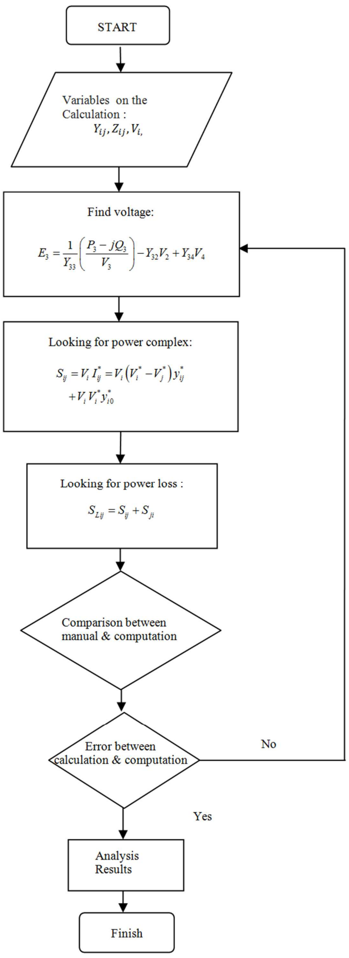


**Figure 1.** Flowchart of the research.

To solve the problems in this study, then made a flowchart as shown in Figure 1. From the pictures it is shown that steps to resolve in from determining the influential variables, then compare between manual and computation. Further analyzes and finishes.

## 4. Result and Discussions

*Calculation of 150 kV Transmission Line, Madura Region*

From the data taken from research at PT PLN can be obtained an admittances data with the following formula:

*Edge- Bangkalan (1 Tracks)*

Known: R = 2,2386

X = 6,4806

Zbase = 180

Find: Y (Admittances)

Solution:

$$Z = R + j\,X$$

$$= 2{,}2386 + j\,6{,}4806$$

$$Z \text{ per unit} = \frac{Z}{ZBase}$$

$$= \frac{2{,}2386 + j\,6{,}4806}{180}$$

$$= 0{,}0124 + j\,0{,}0360$$

$$Y \text{ per unit} = \frac{1}{Z}$$

$$= \frac{1}{0{,}0124 + j\,0{,}0360}\;\frac{0{,}0124 - j\,0{,}0360}{0{,}0124 - j\,0{,}0360}$$

$$= \frac{0{,}0124 - j\,0{,}0360}{0{,}1538.10^{-3} + 1{,}296.10^{-3}}$$

$$= 8{,}5529 + j\,24{,}8310$$

From the above calculation results can be obtained as follows:

**Table 1.** Data admittances of transmission line 150 KV.

| No. | Conductor (Name and Bus number) | admittance channel (per unit) P | B |
|---|---|---|---|
| 1 | Ujung-Bangkalan | 8,5529 | 24,8310 |
| 2 | Kenjeran-Gilitimur | 8,5529 | 24,8310 |
| 3 | Gilitimur-Bangkalan | 8,5529 | 24,8310 |
| 4 | Bangkalan-Sampang | 6,5879 | 8,3079 |
| 5 | Sampang - Pamekasan | 5,1544 | 14,9153 |
| 6 | Pamekasan – Sumenep | 2,9916 | 8,6583 |
| 7 | Sampang – Sumenep | 1,8866 | 5,4633 |

Source: The calculation results

*Calculation of the Load the Substation, Madura Territory*

To simplify the calculation of load analysis on each substation. Then it will use the calculation of the power triangle. Power triangle is a sketch of the complex power, active power and reactive power:

*Bus on East Gili*

$$S = \sqrt{3} * V_L * I_L$$

$$= \sqrt{3} * 20 * 0{,}301$$

$$= 10{,}\ 427 \text{ MVA}$$

$$P = 9{,}6 \text{ MW}$$

$$Q = \sqrt{(S)^2 - (P)^2}$$

$$= \sqrt{(10{,}427)^2 - (9{,}6)^2}$$

$$= \sqrt{16{,}562}$$

$$= 4{,}069 \text{ Mvar}$$

The results of the above calculation, to learn more about the transformer load on each bus. Are shown in Table 3. below:

**Table 2.** The load on each bus (separator rails).

| No. | Name and Bus number | Load (MVA) | P (MW) | Q (Mvar) |
|---|---|---|---|---|
| 1 | Ujung (1) | 0,000 | 0,0 | 0,00 |
| 2 | Kenjeran (2) | 0,000 | 0,0 | 0,00 |
| 3 | Gili Timur (3) | 10,427 | 9,6 | 4,069 |
| 4 | Bangkalan (4) | 38,104 | 37,4 | 7,290 |
| 5 | Sampang (5) | 39,247 | 39,1 | 2,394 |
| 6 | Pamekasan (6) | 44,928 | 39,3 | 21,772 |
| 7 | Sumenep (7) | 37,549 | 37,4 | 3,350 |
| Total load | | 170,225 | 162,8 | 38,875 |

Source: The calculation results

*Analysis of Drop Voltage*

The magnitude of the voltage drop can be calculated by the equation:

*Drop Voltage on Bus (Separator Rails) Kenjeran*

$$V_D = \frac{150-149}{149}\,x100\%$$

$$V_D = 0{,}671$$

**Table 3.** Voltage and drop voltage.

| No. | Name and Bus number | Voltage (pu) | (KV) | Drop (%) |
|---|---|---|---|---|
| 1 | Ujung(1) | 1,000 | 150,000 | 0,000 |
| 2 | Kenjeran(2) | 0,998 | 149,745 | 0,671 |
| 3 | Gili Timur(3) | 0,997 | 149,554 | 0,300 |
| 4 | Bangkalan (4) | 0,990 | 148,500 | 1,010 |
| 5 | Sampang(5) | 0,994 | 149,183 | 0,547 |
| 6 | Pamekasan(6) | 0,993 | 148,956 | 0,700 |
| 7 | Sumenep(7) | 0,998 | 149,745 | 0,170 |

Source: The calculation results

*The Comparison between the Results of Manual Calculation and Computation*

*Comparison Voltage*

Having known the results of the calculations manually and by means of computational calculations, the results obtained are as follows:

**Table 4.** Comparison voltage.

| No. | Channel | Manual calculations | | Computation | |
|---|---|---|---|---|---|
| | | P (MW) | Q (Mvar) | P (MW) | Q (Mvar) |
| 1 | Gili Timur | 0,6086 | -0,0755 | 0,9396 | -0,0027 |
| 2 | Bangkalan | 0,7983 | -0,0921 | 0,9852 | -0,0085 |
| 3 | Sampang | 0,9769 | -0,0595 | 2,2437 | -0,1834 |
| 4 | Pamekasan | 0,9813 | -0,0348 | 0,9741 | -0,0233 |
| 5 | Sumenep | 0,8857 | -0,0478 | 0,9639 | -0,0318 |

Source: The results of the comparison

*Comparison of Power Complex*

From Table 5. below, there is a comparison between the complex power is calculated using manual calculation and computation.

**Table 5.** Comparison of complex power.

| No. | Bus and Bus number | Manual calculations | | Computation | |
|---|---|---|---|---|---|
| | | P (MW) | Q (Mvar) | P (MW) | Q (Mvar) |
| 1 | Gili Timur (3) - Bangkalan (4) | 50.7659 | 65.8932 | 53.6359 | 116.4707 |
| 2 | Bangkalan (4) - Gili Timur (3) | -51.9845 | -76.8492 | -53.3051 | -121.874 |
| 3 | Bangkalan (4) - Sampang(5) | -159.435 | -91.5332 | -168.891 | -91.5332 |
| 4 | Sampang (5) - Bangkalan (4) | 150.9476 | 89.7864 | 168.7712 | 196.7864 |
| 5 | Sampang (5) - Pamekasan (6) | -49.9051 | -68.3409 | -52.8304 | -97.4248 |
| 6 | Pamekasan (6) - Sampang (5) | 46.0765 | 39.6894 | 52.0815 | 43.1674 |
| 7 | Pamekasan (6) - Sumenep (7) | -91,6350 | -68,771 | -91.0935 | -8.3042 |
| 8 | Sumenep (7) - Pamekasan (6) | 88,5730 | 69,6031 | 90.1364 | 8.1916 |
| 9 | Sampang (5) - Sumenep (7) | -120.342 | -45.8569 | -131.896 | -47.5351 |
| 10 | Sumenep (7) - Sampang (5) | 118.7398 | 30.7634 | 130.904 | 20.7761 |

Source: Comparison results

*Comparison of Power Loss*

As for the results of the comparison to find the total value of the power losses in the transmission network are as follows:

**Table 6.** Comparison of power loss.

| No. | Bus and Bus number | Manual calculations | | Computation | |
|---|---|---|---|---|---|
| | | P (MW) | Q (Mvar) | P (MW) | Q (Mvar) |
| 1 | Ujung (1) – Bangkalan (4) | 0,8907 | 4,9629 | 0,8798 | 5,7187 |
| 2 | Kenjeran (2) – Gili Timur (3) | 0,7938 | 9,6748 | 0,8169 | 12,2556 |
| 3 | Gili Timur (3) – Bangkalan (4) | 0,6849 | 0,9515 | 0,3308 | -5,4033 |
| 4 | Bangkalan (4) – Sampang(5) | 2,0692 | 1,2087 | 0,1208 | -105,253 |
| 5 | Sampang (5) – Pamekasan (6) | 0,6398 | 0,7229 | 0,7489 | 54,2579 |
| 6 | Pamekasan (6) – Sumenep (7) | 1,2013 | 0,9224 | 0,9571 | 0,1126 |
| 7 | Sampang (5) – Sumenep (7) | 1,5937 | 0,5107 | 0,9420 | 26,7589 |
| TOTAL | | 7,8856 | 22,2905 | 4,7964 | -11,5527 |

Source: Comparison results

## 5. Conclusions

From the results and discussion, it can be concluded that the distribution system at the substation for the Territory of Madura, the Implementing Maintenance Area (APP) South Surabaya. The results of the calculations, which have been done then obtained for a total value of voltage drop of 2.897%, which for the value of the voltage drop as the above value is below the value of tolerance. For a total value of power losses in units of percentage of 2.059%. According to National Electrical Measurement Units (SPLN) No. 72 of 1987 power losses are allowed is 2% and for the voltage drop of 5%).

## References


[1] Anna Guldbrand.2005. Analysis of an induction regulator for power flow control in electric power transmission systems, Masters Thesis, Department of Physics, Chemistry and Biology Linköpings universitet, SE-581 83 Linköping, Sweden.

[2] Goran Andersson. 2008. Modeling and Analysis of Electric Power Systems: Power Flow Analysis Fault Analysis Power Systems Dynamics and Stability, EEH - Power Systems Laboratory, ETH Zurich.

[3] Achmad Bambang Sumadiyana. 2009. Simulation power flow 150 kV system, region Jakarta – Banten by comparison grid systems and IBT, Under Graduate Thesis, Electrical EngineeringDepartment, Universitas Indonesia.

[4] Lucky Arie Wibowo. 2010. Modeling 150kV Indonesia Power System for Voltage Stability Studies, Master Thesis, Department of Electrical Sustainable Energy, Electrical Power System, Delft University of Technology.

[5] Afandi. 2011. Evaluation of power loss to 150 kV transmission line the feeder Kebonagung – Sengkaling, Seminar On Electrical, Informatics, And Its Education 2011, Electrical Engineering Department, Universitas Negeri.

[6] Wihartady H. 2009. Modeling of short circuit fault arc in 150 kV system and its influent on the performance of distance protection. Delft: TU Delft library.

[7] Anton Y. 2008. Power flow analysis the 150kV transmission network Lampung Province using Gauss Saidel Method, Universitas Jember.

[8] Kadir A. 2011. Electric power transmission (Revised Edition), UI-Press, University of Indonesia.

[9] Berahim H. 2011. Electrical power engineering basic, Graha Ilmu, Yogyakarta.

[10] Cekdin C. 2010. Electricity System (Example Problem and completion Using MATLAB), ANDI Offset, Yogyakarta.