The comparation drop voltage analysis in power flow of gandul substation

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Abstract. This study aims to determine the results of the drop voltage transformer 4 with 10 bus power at the Gandul Substation of PT. PLN (Persero) with MATLAB Power System Analysis Toolbox (PSAT) 2.1.7 and ETAP software 12.6. Data analysis technique used in this study is quantitative descriptive analysis method. Power flow simulation with MATLAB PSAT 2.1.7 software completed at 0.066 s with two iterations (first iteration shows Maximum Convergence Error 0.0011257 and second iteration shows Maximum Convergence Error 1.2621e-06), and ETAP 12.6 software complete in three iterations. Meanwhile, the results of voltage drop with MATLAB PSAT 2.1.7 software and ETAP 12.6 have a fairly small error. Almost every feeder has the same error. The conclusion in this study is that the results of the simulation of drop voltage with MATLAB Power System Analysis Toolbox 2.1 to ETAP 12.6 software has a difference of 0.02 with a percentage error of 0.1%. Each feeder has a small error.

1. Introduction
Electricity has become one of the basic human needs in daily life. Almost all basic needs that support and help everyday human activities require electrical energy. In Indonesia, the basic needs of people who need electricity are found in household sector of 97.832,28 GWh, commercial sector of 44.027,4 GWh, public sector of 15.811,7 GWh, and industry sector of 76.946,5 GWh [1]. In the industrial world, electricity has become a primary need as its main source that functions to run all tools and machines [2], and robot in the industry [3]. State-Owned Enterprises (BUMN) that have electricity companies, namely PT. PLN (Persero) is a company engaged in the supply of electricity whose existence is needed by the community to distribute electricity to the public (consumers). Where the main source of electrical energy comes from power plants that are channeled through the transmission network to the substation continues to strive for the development of electricity, especially in the power flow, which also means increasing the amount of burden that must be borne[4-5]. In this case the increasing demand for electrical energy, the power must be balanced with an increase in the quality of electrical energy supplied [6]. Currently, power flow studies are very useful in electric power system planning, one of which simulates electrical energy (power flow) using computer peripheral software such as, ETAP (Electrical Transient Analysis System) and MATLAB (Matrix Laboratory). According to (William D. Stevenson, Jr., 1994: 6) the process of analyzing network parameters is determined by the study of load flow [7]. Study of power flow is the determination or calculation of current, power, complex, active power and reactive
power that is found at various points in an electricity network under normal operating conditions, both current and expected to occur in the future [8-10].

From existing research and developed from various methods regarding voltage drop, the results obtained in the study of power flow include, (i) voltage values on each bus, (ii) phase angle, and (iii) number of iterations and maximum convergence errors. However, in the research conducted the specific results only include the value of the maximum convergency error using the Newton-Raphson method.

To get optimal power flow, the thing to note is that the voltage profile of each bus in the system must remain within the permitted limit by allocating resources [11].

Based on the description above, the researcher discusses the voltage drop by simulating the electric power system at the Gandul Main Station at PT. PLN (Persero) using MATLAB Power System Analysis Toolbox (PSAT) 2.1.7 software with Newton-Raphson method [12]. Voltage drop is done by making a Single Line Diagram for subsequent modeling until the feeder. Data entered from the Gandul substation is entered into the MATLAB PSAT software (2.1.7) which is then simulated to get the voltage drop value. This voltage drop simulation is also compared with ETAP 12.6 software [13] to find out the optimal power flow value.

2. Method
Data analysis technique used in this study is quantitative descriptive analysis method. Descriptive will only describe the state of a symptom that has been recorded and then processed according to its function. Descriptive method according to (Sugiyono, 2015: 3) states that descriptive research is research intended to investigate the state of conditions or other things that have been mentioned, the results of which can be presented in the form of research reports [14]. The results of the processing are then presented in the form of numbers so as to give an impression of being more easily grasped by anyone who needs information about the presence of these symptoms. Thus the results of processed data with statistics are only up to the descriptive stage, not yet generalized.

The data collection techniques used in this study are:
2.1. Interview
Interviews were conducted with officers at Gandul PT. PLN (Persero) to get data that is not in the field.
2.2. Observation
Observations were made at the Gandul substation at PT. PLN (Persero) which aims to collect data.
2.3. Literature Study
Literature study is information obtained by reading, systematic notes relating to the calculation of drop voltage obtained from certain sources.
2.4. Documentation
Documentation is a data collection technique by looking for evidence of sources from non-humans related to the object being examined (Afifudin & Saebani, 2012: 141). The intended documentation study is in the form of collecting written data objectively from PLN's data that contains report on repeater load, transformer voltage, transformer load, length of each segment.
3. Result and discussion

3.1. Result

Based on the research focus of the subject under study is a 20 kV Transformer 4 substation with 10 buses and feeder, a Single Line Diagram (SLD) for Gandul GI PT. PLN (Persero) whose function is to determine the shape of the Transformer 4 network as well as the data needed as data entered in the voltage drop in the MATLAB PSAT 2.1.7 and ETAP 12.6 software. The simulation results of MATLAB PSAT 2.1.7 Transformer 4 radial system with a total of 11 buses flowing on each bus. The amount of power flow depends on the load installed on the bus. The simulation results with MATLAB PSAT 2.1.7 software are completed in Power Flow Completed 0.066 s with a number of 2 iterations, iteration 1 shows Maximum Convergency Error 0.0011257 and iteration 2 shows Maximum Convergency Error 1.2621e-06.
From Figure 2 is a Single Line Diagram of the Gandul GI radial system with MATLAB PSAT 2.1.7 software, totaling 11 buses. Sourced from bus 2 with a voltage of 150 kV contained in Transformer 4 has a power of 60 MVA which has a voltage of 150/20 kV (step down) to 20 kV.

![Figure 2. Single Line Diagram of the Gandul GI radial system with MATLAB PSAT 2.1.7 software.](image)

From Figure 3 is a Single Line Diagram of the Gandul GI radial system with ETAP 12.6 software, totaling 11 buses. The picture is the same as MATLAB 2.1.7 software.

**Table 1. PSL MATLAB Simulation Results 2.1.7**

| Feeder    | Voltage (kV) | Bus Type | To From Bus |
|-----------|--------------|----------|-------------|
| Trans. 4  | 150          | 2        | 1-2         |
| Pelangi   | 19.98        | 3        | 3-1         |
| Canggah   | 19.98        | 4        | 4-1         |
| Besan     | 19.98        | 5        | 5-1         |
| Sepupu    | 19.98        | 6        | 6-1         |
| Sahabat   | 19.98        | 7        | 7-1         |
| Teman     | 19.98        | 8        | 8-1         |
| Kemilau   | 19.98        | 9        | 9-1         |
| Icon 1    | 19.98        | 10       | 10-1        |
| Keponakan | 19.98        | 11       | 11-1        |

**Table 2. ETAP Simulation Results 12.6**

| Feeder    | Voltage (kV) | Bus Type | To From Bus |
|-----------|--------------|----------|-------------|
| Trans. 4  | 150          | 2        | 1-2         |
| Pelangi   | 20.00        | 3        | 3-1         |
| Canggah   | 20.00        | 4        | 4-1         |
| Besan     | 20.00        | 5        | 5-1         |
| Sepupu    | 20.00        | 6        | 6-1         |
| Sahabat   | 20.00        | 7        | 7-1         |
| Teman     | 20.00        | 8        | 8-1         |
| Kemilau   | 20.00        | 9        | 9-1         |
| Icon 1    | 20.00        | 10       | 10-1        |
| Keponakan | 20.00        | 11       | 11-1        |

From table 1 it can be seen that the simulation results in MATLAB PSAT 2.1.7 software are in normal condition, and from table 2 it can be seen that the simulation results on the ETAP 12.6 software are in normal conditions.

### 3.2. Discussions

From table 1 and 2, the error value of PSL MATLAB Simulation Results 2.1.7 and ETAP Simulation Results 12.6 is shown in table 3 below.
Table 3. Error of PSL MATLAB Simulation Results 2.1.7 to ETAP Simulation Results 12.6

| Feeder  | MATLAB PSAT 2.1.7 (kV) | ETAP 12.6 (kV) | Error (%) |
|---------|------------------------|----------------|-----------|
| Trans. 4 | 150                    | 150            | 0         |
| Pelangi | 19.98                  | 20.00          | -0.1      |
| Canggah | 19.98                  | 20.00          | -0.1      |
| Besan   | 19.98                  | 20.00          | -0.1      |
| Sepupu  | 19.98                  | 20.00          | -0.1      |
| Sahabat | 19.98                  | 20.00          | -0.1      |
| Teman   | 19.98                  | 20.00          | -0.1      |
| Kemilau | 19.98                  | 20.00          | -0.1      |
| Icon 1  | 19.98                  | 20.00          | -0.1      |
| Keponakan | 19.98              | 20.00          | -0.1      |

Figure 4. Comparison Graph of MATLAB 2.1 and ETAP 12.6.

Based on the validation in figure 4, it can be seen that the results of the MATLAB PSAT 2.1.7 and ETAP 12.6 software drop voltage simulation have a fairly small error. Every feeder has the small error from the “Pelangi” feeder to the “Keponakan” feeder. Its means the calculation of MATLAB PSAT 2.1.7 and ETAP 12.6 is same. The value of drop voltage accordance to PLN Standar (under 5% for radial system)[15].
Table 4. MATLAB Software Simulation Results 2.1.7 For Magnitude Voltage (p.u) and Phase Angle (Degrees)

| Feeder     | Magnitude Voltage (p.u) | Phase Angle (degree) | Bus Type |
|------------|-------------------------|----------------------|----------|
| Trans. 4   | 1.00                    | 0                    | 2        |
| Pelangi    | 0.99935                 | -0.05119             | 3        |
| Canggah    | 0.99915                 | -0.06455             | 4        |
| Besan      | 0.99923                 | -0.06138             | 5        |
| Sepupu     | 0.99922                 | -0.06167             | 6        |
| Sahabat    | 0.99932                 | -0.05287             | 7        |
| Teman      | 0.99927                 | -0.05914             | 8        |
| Kemilau    | 0.99935                 | -0.05914             | 9        |
| Icon 1     | 0.99936                 | -0.04972             | 10       |
| Keponakan  | 0.99935                 | -0.05075             | 11       |

Table 5. ETAP Software Simulation Results 12.6 For Magnitude Voltage (% Mag) and Phase Angle (Degrees)

| Feeder     | Magnitude Voltage (p.u) | Phase Angle (degree) | Bus Type |
|------------|-------------------------|----------------------|----------|
| Trans. 4   | 100.00                  | 0.0                  | 2        |
| Pelangi    | 97.680                  | -1.9                 | 3        |
| Canggah    | 95.780                  | -2.3                 | 4        |
| Besan      | 96.067                  | -2.2                 | 5        |
| Sepupu     | 96.663                  | -2.1                 | 6        |
| Sahabat    | 97.507                  | -1.9                 | 7        |
| Teman      | 95.632                  | -2.3                 | 8        |
| Kemilau    | 97.720                  | -1.9                 | 9        |
| Icon 1     | 0                       | 0                    | 10       |
| Keponakan  | 97.634                  | -1.9                 | 11       |

4. Conclusion
The simulation results of voltage drop with MATLAB Power System Analysis Toolbox 2.1.7 software show a value of 19.98 kV from the Pelangi feeder to the “Keponakan” feeder. While the simulation results of voltage drop with ETAP 12.6 software showed a value of 20 kV from the Pelangi feeder to the “Keponakan” feeder. Comparison of simulation results of voltage drop in MATLAB Power System Analysis Toolbox 2.1.7 to ETAP 12.6 has a difference of -0.02 with a percentage error of 0.1%. Each feeder has a small error from a “Pelangi” feeder to a “Keponakan” feeder.

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