Profile Voltage Analysis in the GKB 2 Universitas Muhammadiyah Semarang with Simulation ETAP 12.6.0

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Abstract. The electrical power system in a structure must be carefully inspected. Building electrical installations must adhere to standardized criteria; PUIL 2011 (SNI 0225:2011) is a reference in the electrical design process for buildings in Indonesia. According to PUIL 2011, the standard tolerance level for voltage decreases is 4%. This study seeks to provide additional development evaluation material for the Universitas Muhammadiyah Semarang by collecting data for 6 days. Manual calculations were performed and compared to network simulation system calculations using ETAP 12.6.0. Based on the findings of this study, The resulting voltage drop is still less than the tolerance level, therefore voltage profile value is still below the tolerance standard, and the largest average load used is at 09.00 due to the heavy use of lectures. Apart from that, the comparison of the load and the resulting voltage drop value is also said to be still in good condition because it is stated that when the load value increases, the voltage drop value also increases and is followed by a decrease in the voltage profile value by reviewing the tolerance limits. The results of the discussion indicated that the voltage system at GKB 2 Universitas Muhammadiyah Semarang was still in good condition because each factor was still below the standard tolerance limit.

Keywords: Profile Voltage, Drop Voltage, ETAP 12.6.0, Load Flow.

1. Introduction

Electrical energy is a type of energy that is extremely vital in modern society. The ever-increasing population growth factor has given rise to many influences, especially in the field of electrical energy. This increases the demand for energy capacity every year [1]. This situation is not supported by the availability of Indonesia's energy reserves because the majority of power plants in Indonesia still use fossil fuels. The solution to this problem is energy diversification, one of which is the development of renewable energy [1] [2].

The current industrial revolution is very rapid, almost every day, hour or even minute. Technological developments not only compete with good human resources, but also with

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the cooperation of renewable machines and technical devices [2]. When carrying out work, you should pay attention to correct work standards.

It is hoped that the benefit of this research will be a reference and evaluation in the implementation of electrical installations, especially at Universitas Muhammadiyah Semarang, the research is expected to become a reference to make it safer and better, because it will carry out large-scale development [1]–[3].

1.1. Profile Voltage and Drop Voltage

Voltage Profile is a representative graph of changes in electrical voltage over a period of time. And also being an indicator for monitoring and analyzing voltage distribution in certain electrical circuits, as well as in the process of understanding variations in electrical voltage over a certain period of time [4], [5]. Voltage drop has standard rules with a tolerance limit of <4% which has been regulated in PUIL 2011 (SNI 0225: 2011) [6].

Calculation of data to determine the result of a voltage drop or a decrease in voltage level with the difference in values resulting from the sending voltage and receiving voltage[6],[8],[9]. Expressed as a voltage drop proportional to the voltage difference between the send and receive voltages divided by the receive voltage [9]–[11].

$$\%V = \frac{VS - VR}{VR} \, x \, 100\% \tag{1}$$

1.2. Power and Power Factor

The power measured is apparent power or complex power S in Volt Ampere (VA), real power or active power P in Watts (W), and reactive power Q in Reactive Volt Amperes (VAR), like:

$$S = V \times I \tag{2}$$

$$P = S.cos\varphi \tag{3}$$

$$Q = S.sin\varphi \tag{4}$$

$$S = \sqrt{P^2 + Q^2} \tag{5}$$

Power factor (pf) or cosϕ is the relationship between the three pieces of electrical power which can be depicted with a power triangle as in the picture below:

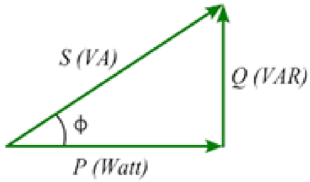

Fig 1. Power Triangle.

Where the power factor or cosϕ can be formulated:

$$pf = cos\varphi = \frac{P}{S} \tag{6}$$

Power flow provides a systematic approach through various bus voltages, phase angles, active and reactive power flows through branches, generators, transformer arrangements, and loads under steady conditions. Analysis of load flow or power flow includes the magnitude and phase angle of the load bus voltage, reactive power and phase angle of the voltage on the generator bus[12], [13].

2. Methods

The method used in conducting this research is by collecting data on the LVMDP panels in the transformer house, SDP/SDP AC panels on each floor in the GKB 2 in Universitas Muhammadiyah Semarang. Data collection was carried out over a period of 6 days in the morning at 09.00, afternoon at 12.00, afternoon at 15.00, and evening at 18.00 Indonesian West Time starting on Friday, June 16th 2023 until Thursday, June 22th 2023, except for Sundays after which the data was averaged every day.

To carry out the wiring in the ETAP 12.6.0 simulation design model, pay attention to the circuit path in the field, beginning with the transformer used by completing the rating value as well as the impedance / model, LVMDV (low Voltage Main distribution Panel), length, type, and number of cables used for distribution for the building on each floor, and the static load component is used to enter the load value on each floor. After adjusting these settings, a simulation test may be run to determine the voltage profile value, and the voltage drop value can be calculated using the voltage profile value's results. At each time, simulations are run alternately.

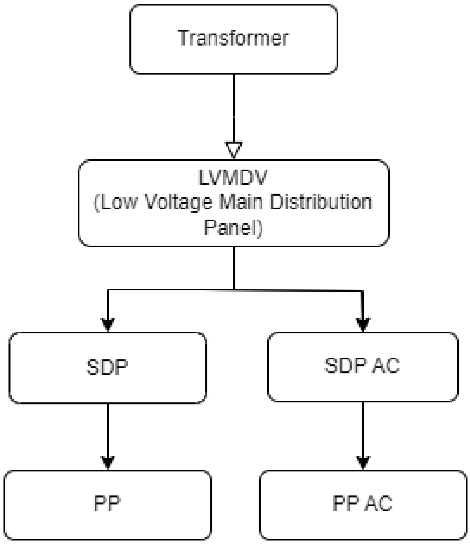

Fig 2. ETAP 12.6.0 Network Modeling block diagram

2.1. Electrical Transient Analysis Program (ETAP) 12.6.0

ETAP 12.6.0 (Electrical Transient Analysis Program) Power Station is software for power systems that work based on plants (projects). Each plant must provide modeling equipment and supporting tools related to the analysis to be carried out. For example, generator data, motor data, transformer data, cable data and others. A plant consists of an electrical sub-system that requires a set of specialized and interconnected electrical components. In a Power Station, each plant must provide a data base for this purpose[14],[15].

ETAP 12.6.0 Power Station can graphically present single line diagrams and perform a variety of analyses/studies, including load flow, short circuit, motor starting, harmonics, transient stability, protective device coordination, and cable derating [15] [16]. ETAP 12.6.0 Power Station also has a library, which helps with the design of an electrical system. If necessary, this library can be modified or expanded with equipment information [17].

3. Results and Discussions

3.1. Analysis of Voltage Profile Calculations and Voltage Drops Using Microsoft Excel

Based on the data and carrying out a calculation analysis, the calculation data was obtained as stated in the data calculations at 09.00, 12.00, 15.00 and 18.00. Data calculation by looking for the voltage profile and voltage drop from each data using Microsoft Excel media. Calculation data using sample data from the SDP panel and SDP AC from each zone in the building.

The voltage drop is calculated at each time sample starting from 09.00, 12.00, 15.00, 18.00. In the calculation results for the data at 09.00 there is one data that almost touches the 4% tolerance limit, namely on the 5th floor zone A of the SDP AC panel where the voltage drop value reaches 3.1% but it can still be said to be good and the average drop in the data at 09.00 the voltage is quite good because it does not exceed the tolerance limit, the lowest voltage drop value falls on the roof floor of zone A of the SDP panel with a voltage drop value of 0.307%. The calculation results at 12.00 saw an increase in the value to the highest value which almost touched the voltage drop tolerance value of 4%, namely on the 4th floor of zone B, the SDP AC panel had a voltage drop value reaching 3.55%, compared to the lowest value on the 2nd floor of zone B panel. AC SDP with a value of 0.27% of the value in the data at 12.00 experienced many changes from 09.00. Meanwhile, in the data at 15.00 there are 2 data that have the highest value reaching 3.57%, namely on the 6th floor of SDP AC zone A and the 5th floor of zone B of the SDP panel, apart from the highest value there is the lowest value which has decreased drastically to a value of 0.065% on the panel SDP floor 8 Zone A. In the last data at 18.00 with the highest data value almost touching 4% with a voltage drop value of 3.91% on the 5th floor zone A SDP AC, the data was of course also found to have the lowest value reaching 0.05% at SDP AC zone A floor 8. However, the voltage drop value is based on calculations using Microsoft Excel, with the drop not exceeding the tolerance limit, it can be said that the voltage consistency is in good condition.

The calculated value of the voltage profile with good profile quality also correlates with the voltage drop value, ranging from the voltage drop value with the highest value of 3.57%, then also the voltage profile value of 96.43% is the percentage value of the less good voltage profile found in the calculation data. Overall data, this value is found on the 6th floor of Zone A of the SDP AC panel and the 5th floor of Zone B of the SDP panel. The lowest value of the voltage drop is a good voltage profile in this data calculation, the voltage drop value reaches 0.05 so the voltage profile value becomes 99.95%, which is a good voltage profile value in the data calculation this time.

3.2. Analysis of Calculation of Voltage Profiles and Voltage drops with ETAP 12.6.0 Simulation

Based on data calculated via ETAP 12.6.0, it uses calculation data from the power triangle calculation mechanism to determine the load used on each floor in each zone of the building. Data is entered on the loads/static loads in ETAP 12.6.0 as well as by entering all qualifications for the types of components/supporting equipment used in a building which are arranged in such a way that they are in accordance with what is available in the field. After doing everything, the resulting voltage profile value will appear in accordance with each existing load.

The voltage profile value produced for each load starting from the single line diagram (SLD) at 09.00 has the lowest value which is still classified as being in good condition on the 8th floor of zone A of the SDP panel with a value of 99.24%, while the highest voltage profile value is good until it reaches 99.92% on roof floor B zone SDP panels. At SLD at 12.00 with the same model but with different nominal loads, the lowest voltage profile value was 99.33% found on the SDP AC panel in zone A on the 8th floor, while the highest value reached 99.94% on the roof floor of zone B panel. SDP. In the data at 15.00 there is the lowest value which is quite high, reaching 99.5% on the 3rd floor of zone A of the SDP panel, in SLD the data at 15.00 is the voltage profile value where the average of all floor data is almost the same but the voltage profile value is the highest still on the SDP panel roof floor in zone B with a value of up to 99.95%. At 18.00 the voltage profile value increased not too far from the previous data so that the lowest value was 99.52% on the SDP zone A panel on the 4th floor, while the highest value increased by 1% at a value of 99.96% on the roof floor of the SDP zone B panel.

The profile voltage produced in the modelling simulation with ETAP 12.6.0 has a standard value above 99%, so that the voltage drop value does not reach 1% with the highest voltage drop reaching 0.76% in the data at 09.00 zone A of the 8th floor SDP panel, while the lowest voltage drop value reached 0.04% at 18.00 on the roof floor of zone b of the SDP panel. The data above with the results of the voltage profile and voltage drop is said to be still in good condition.

3.3. Comparative Analysis of Differences in Calculation Results of Voltage Profiles and Voltage drops with ETAP 12.6.0 Simulation with Calculations Using Microsoft Excel

Based on the findings of Microsoft Excel computations and ETAP 12.6.0. There are differences between the results of the voltage drop value and the voltage profile.

Table 1. Calculation data for the difference in voltage profile at 09.00 and Ms. Excel with ETAP 12.6.0.

Floor	SDP A	SDP AC A	SDP B	SDP AC B
1	0,14	0,48	0,52	1,1
2	0,79	0,62	1,19	1,08
3	1	1,99	0,96	1,3
4	1,7	2,24	1,7	2,6
5	2,02	2,77	1,8	1,41
6	2,06	2,44	1,48	2,37

Floor	SDP A	SDP AC A	SDP B	SDP AC B
7	1,5	2,1	1,33	2,19
8	0,95	1,48	1,38	1,35
Atap	0,167		0,238	

From the table above is an example of a comparison value for the results of voltage Profile calculations via Ms. Excel and ETAP 12.6.0 values contain values that have a very large difference between the calculations produced in calculations using the ETAP 12.6.0 simulation and manual calculations using Ms. Excel. The lowest difference in the SDP panel for zone B on the 8th floor is data at 18.00 with a value of 0.06, however there is some data which states that the value from manual simulation calculations is greater than the simulation, such as: data at 09.00 for the 1st floor of zone A SDP panel with a difference of 0.14, data at 15.00 floor 8 zone A SDP panel, SDP AC, and zone B SDP panel with a value of 0.365, 0.2, and 0.02. And the data at 18.00 floor 8 zone A panel SDP and SDP AC with values of 0.2 and 0.12. From the highest difference value in the data at 18.00 floor 5 zone A SDP AC panel with a difference value of 3.66.

The difference value of the voltage drop will be the same as the difference value of the voltage profile because the two are correlated.

3.4. Load Flow Analysis of Loading Capacity Use

The results of the loading calculations this time are useful as supporting data for the ETAP 12.6.0 design simulation series which is used on static load components so that the stress profile values can be adjusted to the loading coefficient. The following is the average load for each floor in each time period.

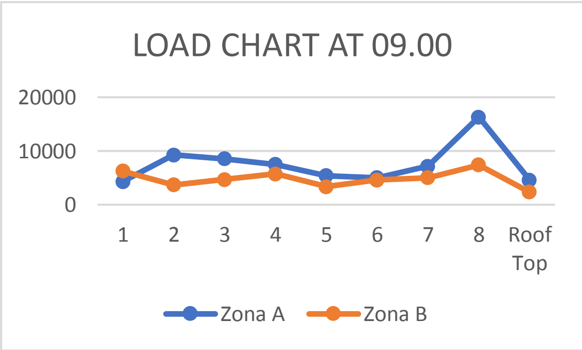

Fig 3. Load Chart At 09.00

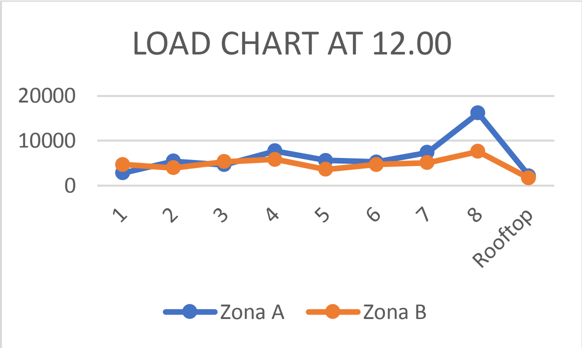

Fig 4. Load Chart At 12.00

In the data loading results at 09.00 and 12.00 there was a high load usage on the 8th floor of zone A, because there is a fairly large hall with the use of the hall making the resulting load large, also on the 8th floor of zone B there is a music studio with equipment can cause the burden to be high.

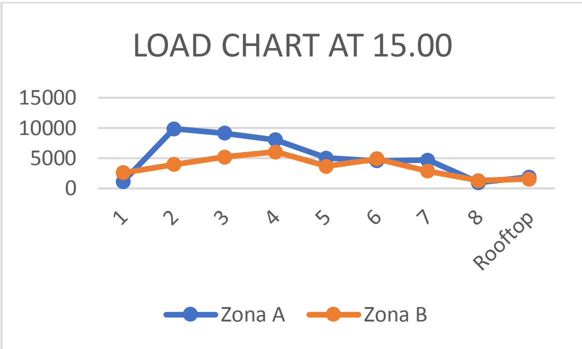

Fig 5. Load Chart At 15.00

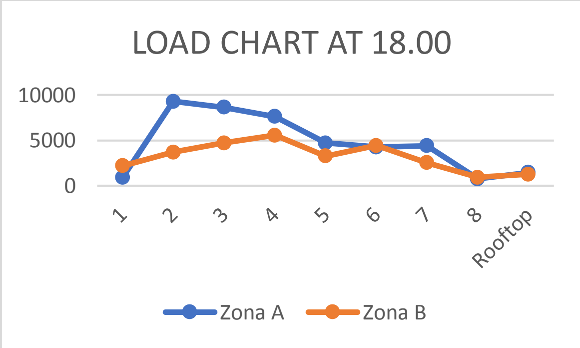

Fig 6. Load Chart At 18.00

In the data load graph at 15.00 and 18.00 there is a difference where on the 2nd floor zone A the largest load is used and experiences a constant decrease up to the 4th floor zone A with the best comparison with zone B where on the 2nd floor to the 4th floor zone B experiences a significant increase in load. constant.

3.5. Analysis of Load Flow Against Voltage Drop

The results of the calculations and analysis assume that the electrical conditions are in good condition, however the load data is based on calculation analysis entered into the simulation process via ETAP 12.6.0 with the highest average load falling on the average data at 09.00. The load at 09.00 is due to the average use of buildings and equipment that has been active since that time range, there for 09.00 is the highest load usage value compared to the others.

Then a comparison of the load flow with the voltage drop data is carried out, with when the load flow increases, the voltage drop will also increase, so the voltage profile will decrease. The comparison results are in the image below:

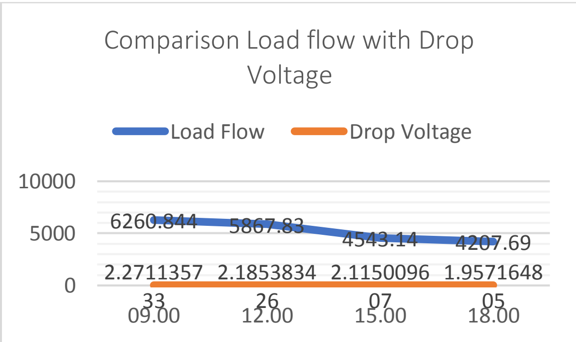

Fig 7. Comparison graph of load flow with voltage drop

Based on graphic data, it shows that the load value at 09.00 experienced a load capacity usage reaching 6260.84 VA and was also accompanied by a decrease in load capacity at 12.00 with a voltage drop that fell to 2.18% from 2.27%. You can see a decrease in the data load from 09.00 to 18.00 accompanied by a decrease in voltage drop and the voltage profile automatically increases, meaning that the system can still be said to be in a stable condition with results like that.

4. CONCLUSIONS

From the results of calculations and analysis of the voltage profile and voltage drop in the GKB 2 at Universitas Muhammadiyah Semarang, a conclusion can be drawn that:

1. The quality of the voltage and electric current is in good condition with a voltage above 220 in accordance with the standard limits permitted by PLN.
2. The power factor is in good condition where the power factor value is still above the limit permitted by PLN, namely 0.85.
3. The voltage drop is still below the PUIL 2011 tolerance limit, namely <4%. So the quality of the voltage profile at GKB 2 Universitas Muhammadiyah Semarang is still said to be in good condition.
4. The ratio of the load to the voltage drop value is good, on the basis that when the load value increases, the voltage drop value also increases, then the condition is said to be in good condition.

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