

ANALYSIS OF VOLTAGE DROP IN LOW VOLTAGE NETWORK DISTRIBUTION SYSTEM IN TANTUI UP SUBSTATION KTATNT013 AMBON

Sefnath J. Wattimena

Electrical Engineering Study Program, Politeknik Negeri Ambon
Email : ephynaulu@gmail.com

ABSTRACT

The Low Voltage Network Distribution System to the House Connection is the end of the electrical energy service to consumers. A good service portrait can be seen from the quality of the voltage. The nominal value of the voltage must comply with the standards contained in SPLN 1: 1995, namely +5%; -10%. This research uses quantitative analysis research method. The research stage starts from data collection, calculation, analysis, and solution offering. Substation KTATNT013 Department A whose network end is in Kampung Kolam experienced a measured voltage drop of up to 131V at the end house, which has exceeded the SPLN tolerance limit. As a result, some consumer electrical appliances cannot function properly. To overcome this problem, an improvement solution is offered as well as the calculation of voltage drop before and after. The solution in the form of conductor uprating and network reconfiguration reduced the voltage drop from 96.05V (42.40%) to 27.43V (12.11%), while the transformer insertion solution reduced the voltage drop to 14.26 V (6.29%) on the existing transformer Low Voltage Network and 8.3V (3.77%) on the inserted transformer.

Keywords: Low Voltage Network, House Connection, Voltage Drop

INTRODUCTION

In the low voltage network distribution system, the normal voltage according to SPLN. No.1; 1995 (220/380 Volts: +5%; -10%). In reality, there are still problems in the form of decreasing voltage values during the process of distributing electricity to customers and this is called a voltage drop or voltage drop. Because of this voltage drop, the voltage on the receiving side will be different from the sending side. So the voltage received by the customer does not meet the SPLN voltage criteria, which is below 198 Volts (less than the minimum tolerance limit). Equipment in customer buildings can only work at certain voltages and voltage tolerances. Therefore, if the voltage does not reach the normal limit, the equipment cannot work properly. According to the results of interviews with the Supervisor of Engineering / Distribution ULP Ambon Kota, the worst voltage drop in the scope of work of PT PLN ULP Ambon Kota occurs at the furthest customer buildings located in Kampung Kolam, where the voltage source is supplied from the KTATNT013 substation located in Gunung Malintang. Voltage drop is caused by the large number of loads connected to the end pole and causes unreliability in the existing distribution system.

Based on the background description that has been stated above, the problem can be formulated, namely how much is the percentage of voltage drop that occurs in the low voltage network distribution system in the Tantui Upper Substation KTATNT013 Department A of Ambon City and how to correct the most appropriate voltage drop in accordance with the actual field conditions in the low voltage network distribution system in the Tantui Upper Substation KTATNT013 Department A of Ambon City. The benefit of this research is to get a good quality voltage in accordance with SPLN and improve the quality and quality of PT PLN services so that residents' electronic equipment can work properly.

THEORETICAL FRAMEWORK

Electric Power System

The electric power system is divided into four major parts, namely Generation, Transmission System, Distribution System and Load (Consumer). Electricity is generated at the generation center and then sent to consumers or loads through transmission and distribution systems. (Soeprijanto, 2018). The generation system consists of one or more generating units that will convert mechanical energy into electrical energy and must be able to produce sufficient electrical power according to consumer needs. The transmission system functions to transfer electrical energy from generation units in various locations with long distances to the distribution system, while the distribution system functions to deliver electrical energy to consumers. (Saleh, 2018).

Electric power systems are said to be a collection / combination consisting of components or electrical devices such as generators, transformers, transmission lines, distribution lines and loads that are interconnected and are a unit so as to form a system.

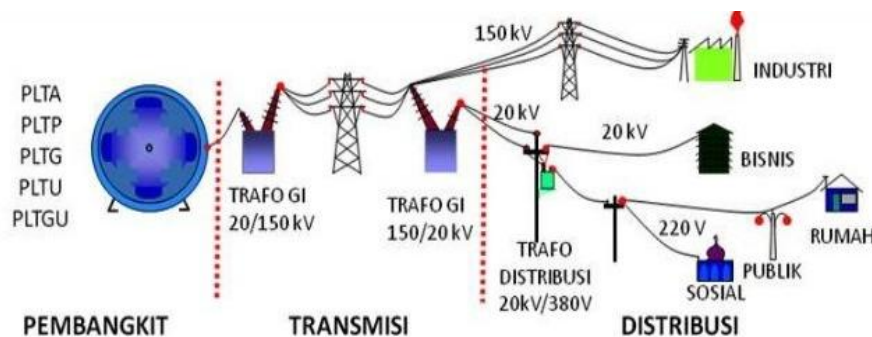


Image. Electric Power System (Wibowo, 2018)

In the world of electricity, technical problems often arise, where electric power is generally generated in certain places far from the collection of customers, while electric power users or electric power customers are scattered everywhere. then the delivery of electricity to the customer's place requires various technical handling. (Wibowo, 2018). Causes of losses in the power system: (1) Total loss from generation to end user = 14% of total generation power (3% transmission losses; 11% distribution losses), (2) Total loss in the distribution system (plant/building) = 2.5% to 7.5% of the total consumed, (3) 2 kinds of losses in the electrical system; losses as a result of electric current (); losses due to electrical equipment design (iron loss, stray loss, widage loss etc.), (4) Causes of losses in equipment; there are limits to the efficiency of equipment; inappropriate design or maintenance of equipment; lack of maintenance; low power factor.

Electric Power Distribution System

Distribution System is part of the electric power system. This distribution system is useful for channeling electricity from large power sources (Bulk Power Source) to consumers. So the function of electric power distribution is; 1) the division or distribution of electric power to several places (customers), and 2) is a sub-system of electric power that is directly related to the customer, because the power supply at load centers (customers) is served directly through the distribution net. Electric power generated by a large power plant with a voltage of 11 kV to 24 kV voltage is raised by the substation with a voltage boosting transformer to 70 kV, 154kV, 220kV or 500kV then channeled through the transmission line. From the transmission line, the voltage is lowered again to 20 kV with a voltage reducing transformer at the distribution substation, then with the voltage system the distribution of electricity is carried out by the primary distribution channel. From this primary distribution line, the distribution substations take the voltage to be lowered with a distribution transformer into a low voltage system, namely 220/380Volt. Furthermore, it is distributed by secondary distribution channels to consumers.

In general, the good and bad of the electric power distribution system is mainly in terms of the quality of power received by consumers. Good power quality, among others, includes: power capacity that meets and voltage that is always constant and nominal.

Voltage must always be kept constant, especially the voltage loss that occurs at the end of the line. Unstable voltage can damage devices that are sensitive to voltage changes (especially electronic devices). Likewise, a voltage that is too low will result in electrical equipment that cannot operate properly. One of the requirements for connecting electrical appliances, namely the source voltage must be the same as the voltage required by the electrical equipment. Too high a voltage will damage electrical appliances. (Suhadi & Wrahatnolo, 2008)

Voltage Drop

Voltage drop on the distribution line is the difference between the sending end voltage and the receiving end voltage. Voltage drop is caused by resistance and current. (Muammar and Lutfi, 2016). The main factors that cause voltage drop: (1) The amount of current flowing. The greater the current, the greater the voltage drop that occurs, (2) Impedance or resistance in the cable. The greater the resistance in a cable, the greater the voltage drop that will occur. Likewise with the length of the cable, the longer the cable, the greater the resistance in the cable so that the greater the voltage drop that occurs. (3) Cable diameter. The larger the diameter of the cable or wire, the smaller the inner resistance will be and vice versa, the smaller the diameter of the cable, the greater the resistance will be. (4) Power factor.

Power Quality.

Power Quality is the level of quality of the power grid and the level of efficiency of energy use. Power Quality has 3 main components, including Continuity, the degree to which electricity users can receive electricity all the time (free from interference), Voltage Level, how a system voltage can be maintained within the desired level and Efficiency, optimization of energy consumption. Power quality issues are important because, currently the quality of consumer-owned equipment is more sensitive, in utility systems there has been an increase in harmonic levels, consumers do not have and receive sufficient information regarding power quality issues and the failure of one component in the distribution system and installation can have certain consequences.

RESEARCH METHODS

The research method used is quantitative analysis which is used to analyze a phenomenon that is happening with data in the form of numbers. Primary data is obtained from direct measurements on the low voltage network distribution system in Department A KTATNT013 substation whose load is in Kampung Kolam Ambon City. Research Parameters Base Voltage (, Base voltage (in Volts) is measured at the secondary part of the transformer or voltage at PHBTR which is the base of the low voltage network at Substation KTATNT013 using a voltage meter. End Voltage (, End voltage (in Volts) is measured at the end of the low voltage network in department A of KTATNT013 substation using a voltage meter.

Line Current (I), The line current (in Amperes) is measured using a current meter which is the load current contained in the KTATNT013 substation A department. Transformer Capacity The load capacity (in kVA) of the transformer in Substation KTATNT013 found on the transformer name plate. Conductor Length (L) The length of the conductor (in km) which is the scope of this research is the length of the conductor in department A of the KTATNT013 substation measured using a location marker. Conductor Diameter (A) Conductor diameter (used in department A of KTATNT013 substation. Power Factor Power factor in Department A KTATNT013 substation measured at the base of the low voltage distribution network.

DISCUSSION AND RESULTS

The research location is in the Kampung Kolam area (Tantui Atas) Sirimau District, Ambon City, which is the working area of the Ambon City Customer Service Unit. Based on reports submitted to the Ambon Kota Customer Service Unit office, the community complained about voltage drops that caused some electrical equipment to malfunction.

After coordinating with PLN, it was found that the housing in Kampung Kolam is supplied with electricity from Substation KTATNT013 which is included in the Tantui Atas Substation with a transformer power of 200 kVA and has two majors, namely majors A and B. The substation is the work area of PT. The substation is the working area of PT PLN (Persero) ULP Ambon Kota.

Measurement Result(Afternoon)

a. Date: 30-04-2019

b. Time: 10.30 WIT

Table Results of Afternoon Load Measurement

Existing Daytime Measurement			
KTATNT013		Main	A Direction
Current (I)	R	121	83
	S	163	89
	T	151	95
Voltage (V)	R-N	229	229
	S-N	229	229
	T-N	228	228
	R-S	397	397
	S-T	395	395
	R-T	395	395
	The Final Pole End House		214 161
Power Factor	R	0,97	0,98
	S	0,97	0,98
	T	0,96	0,96

Measurement Result (Night)

a. Date: 02-05-2019

b. Time: 20.30 WIT

Table Night Load Measurement Results

Existing Daytime Measurement			
KTATNT013		Main	A Dirrection
Carrent (I)	R	198,9	103,7
	S	220,6	109,7
	T	226,1	115,4
Voltage (V)	R-N	227,3	227,3
	S-N	226,9	226,9
	T-N	225,3	225,3
	R-S	393,2	393,2
	S-T	393,1	393,1
	R-T	390,3	390,3
	The Final Pole End House		203 131
Power Factor	R	0,98	0,98
	S	0,97	0,98
	T	0,98	0,98

The conductor used

Low Voltage Network (JTR) Conductor

The conductor used for the JTR (Low Voltage Network) is the NFA2X-T 3 x 70 + 1 x 50 cable with the existing network length at the KTATNT013 substation. From the measurement results, it is found that the total length of the low voltage network conductor using the NFA2X-T 3 x 70 + 1 x 50 cable at the KTATNT013 substation in Department A is 525 m or 0.525 km. Whereas [in department B, the total length of the low voltage network conductor using the NFA2X-T 3 x 70 + 1 x 50 cable at Substation KTATNT013 Department B is 433 m or 0.433 m.

House Connection (SR) Conductor

The conductor used to become a house connection cable or SR is the NFA2X 2 x 10 0.6/1kV type cable.

Transformer substation KTATNT013

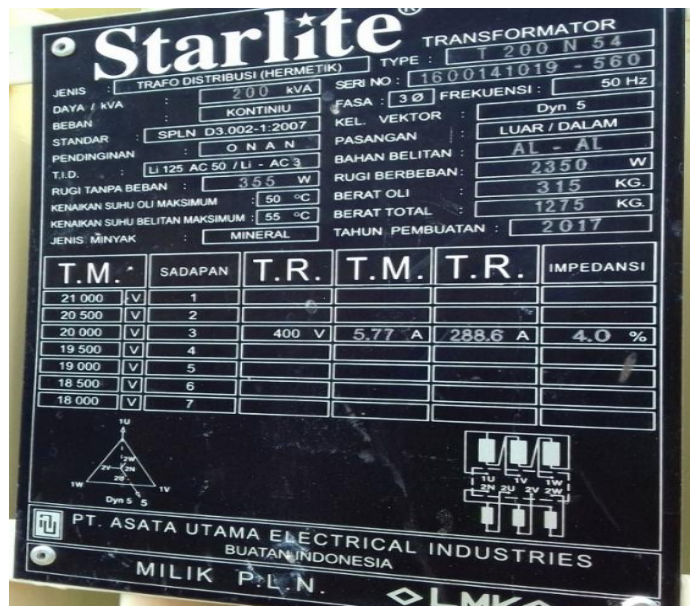


Figure Specification of substation transformer KTATNT013

Network Load

In JTR (Low Voltage Network) Department A, the largest connected load in Department A Substation KTATNT013 is the customer on pole 12 (final pole) which reaches 28500 VA.

Voltage Loss that Occurs

There is a voltage loss along the line that causes a voltage drop in a residential area called Kampung Kolam which is supplied by one final pole (Pole 12) where there are 36 customers. All PLN customers in Kampung Kolam receive electricity from only one TR pole which has exceeded the existing limit. According to the Distribution Network Construction Standard Book published by PLN, a maximum of five customer service connections (5 SLPs) can be connected to one JTR pole. In one SLP, a maximum series of seven house connections (7 SR) can be connected.

From observations and measurements, many SLPs have reached the maximum limit. And in SLP 4, the number of connected customers also exceeded seven and reached a dozen. And this is called SR-Deret. This is what causes the voltage drop in the Kampung Kolam settlement in Ambon City. The voltage in accordance with SPLN is SPLN.No.1 Voltage; 1995 (220/380 Volts: + 5%; - 10%) while if it is calculated on the SR (House Connection) line from the final pole to the end customer, the amount of voltage loss and the percentage of voltage drop based on the measurement results during the day is 32.91%, while at night 54.96%. with the lowest voltage calculated : 200.38 V, measured: 203 V.

House Connection

Houses that get a voltage drop are only houses in Kampung Kolam that get supply from the final pole of Department A KTATNT01 substation. So an improvement was tried in the form of replacing the existing SR (House Connection) cable in Kampung Kolam NFA2X 2 x 10 to 2 x 16.

Drop Voltage of JTR and SR

Based on the results of calculations using equation 2.6, the voltage loss in the network due to resistance and reactance between the five SLPs, namely SLP 1, SLP 2, SLP 3, SLP 4 and SLP 5 at the largest final pole is 69.93 Volts which has exceeded the tolerance limit of SPLN 1 of 1995, and this means that the worst voltage drop at Substation KTATNT013 Department A is: Calculated: 130 V, Measured: 131 V with voltage drop 73,88 %.

Voltage Drop Improvement with SR Uprating

Of the five SLPs, the home connection network is SLP 4 and calculations were made when uprating the conductor from 2x10 mm to 2x16 mm. With the calculation after this improvement, the worst total voltage drop at Substation KTATNT013 becomes: 69,61 V. Then the voltage received at the end house based on equation 2.5 is 156.89V and the percentage of voltage drop (Condition after SR cable replacement). Then the total voltage drop that occurs in the Low Voltage Network and Home Connection can reach 69.61V (%).

Voltage Drop Improvement with JTR Conductor Replacement and Network Reconfiguration

The second improvement experiment is to replace the existing JTR (Low Voltage Network) conductor in Department A from NFA2XT 3x70 to 3x95 and add two JTR poles with each 50m goal. Network reconfiguration improvement means rearranging the house connection and the Home Connection cable network in order to obtain the closest distance from the pole and reduce the series load on the Home Connection which causes a voltage drop. One of the solutions to overcome the SR row is to reconfigure the house connection and connect it to the new JTR pole (pole 13 and pole 14).

Voltage Drop Improvement with 50 kVA Transformer Insertion

Transformer Loading

Installed Power (Requirement): 28,500 VA or 28.5 kVA. Connected Customers: 36 Customers. The loading has reached warning status. And according to simaurits data, this transformer load continues to grow from 05/12/2016 to 12/03/2018 increasing up to 44%. Looking at the conditions in the Kampung Kolam area, this area is an area that will continue to grow in population because there is still a lot of vacant land. So the solution provided is to add one insert transformer with a capacity of 50 kVA.

Effect on Voltage

When the load of Kampung Kolam (Pole 12) which was originally supplied from KTATNT013 is moved to the KTATNT055 insert transformer, this also affects the voltage on network A KTATNT013 because the load is reduced. From the calculation that the voltage loss based on the resistance and reactance values is 14 Volts, which means that the voltage reaching the final pole (pole 11) is as follows $V_t = 212.24$ Volts. This results in the end pole in the distribution network in department A KTATNT013 substation getting a better voltage which is worth 212 volts, and the percentage of voltage drop (Condition after insert transformer).

CONCLUSION

The results showed that:

1. Measurement of peak load shows the voltage drop on the Low Voltage Network reached 23.5V (11.57%) and on the SR reached 70V (53.43%). While the calculation of the voltage drop that occurs at Substation KTATNT013 Department A on the Low Voltage Network reaches 26.12V (13.03%) and on the SR reaches 69.93V (53.76%).
2. There are two solutions offered, including solutions in the form of conductor uprating and network reconfiguration, which reduce the voltage drop from 96.05V (73.88%) to 27.43V (13.77%), while the transformer insertion solution reduces the voltage drop to 14.26 V (6.71%) on the existing transformer Low Voltage Network and 8.3V (3.92%) on the inserted transformer.

Suggestions

- a. To PT PLN (Persero). For the first solution, although the price is quite low, it cannot anticipate load growth in this area and in the future there will still be a voltage drop when this load growth occurs, not even just a voltage drop but can cause overload considering the transformer load is already quite high. So the author suggests taking the second solution even though the price is quite high, but it can anticipate the development of the load considering the need for power or the burden of electricity use will continue to grow over time.
- b. To students who want to do research with similar titles, it is better to use software to facilitate calculations and find out more specific results..

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