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Current and Voltage Analysis of the Influence of Capacitors on Electrical Loads

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Abstract: Currently, electricity utilization is increasing along with the increasing demand for new tides. Electricity usage increases with demand. When installing power capacitors in the electrical network, it is the installation of capacitors in parallel in an electrical installation in the hope of increasing the efficiency of the power factor. This study aims to determine the effect of capacitors on current and voltage. The method used is an experimental method with the aim of knowing the effect of a treatment. The research design carried out by designing power capacitors, determining the load point of installing power capacitors with 2 electrical loads, namely freezers and fans. Next after the installation of the power capacitor is the measurement of the electrical parameters studied. The results of this study show that the addition of power capacitors has an influence on electrical loads. The average voltage and current values in the fan are 210.6 V and 0.97 A, while in the freezer it is 209.5 and 1.105 A.

Keywords: Capacitor; Current; Elevtric Load; Voltage

Introduction

Electricity is a source of energy that can transfer energy into another electronic form. This electric power is needed by various levels of citizens. Electricity is a series of physical phenomena related to the flow of electric charge (Parker et al., 2019). Electricity causes various consequences, such as lightning, electromagnetic induction, static electricity, and electric current. Without realizing it, electricity has become a primary need for human life, without electricity electronic equipment that is commonly used cannot function or be used properly (Izadi et al., 2017).

Electric power is one of the needs that cannot be separated from the lives of citizens in this era of globalization (Denholm et al., 2021). Electricity consumption increases along with the increasing demand for new tides. Residents use electricity ranging from recharging cellphone batteries, ironing, watching TV, washing, and cooking. For the industrial sector and business actors, electricity has become a vital need for the smooth running of their business, such as shopping. Often in order to save expenditure items, the business actor makes various efforts to squeeze the number. Among the efforts tried include buying low-power electronic equipment, turning off flattening at night, or buying energy-saving equipment. Meanwhile, the need for electricity for the place has been quite large with the presence of coolers and freezers, plus efforts to save by turning off inefficiently. After that, with the diversity of tariff circles for electricity consumers about electricity tariffs provided by industry (Persero) PT. The State Electricity Industry became 8 circles and the removal of subsidized fuel for those 900 VA and above made the price per unit of PLN energy (kWh) considered quite expensive for most of the business actors. For electricity for B-1 / TR businesses with an energy limit of 2.200 VA, the tariff per kWh is IDR 1.100.00. Installing capacitors is one alternative to explore saving on electricity, namely by installing energy capacitors (energy savers). The installation of energy capacitors in the electrical network is the installation of capacitors in parallel in an electrical installation in the hope of increasing the efficiency of energy aspects (Agrawal et al., 2019). Low power factor

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is a very undesirable thing insofar as it causes an increase in current, which causes an increase in active energy exhaustion in all elements of the power system from the power plant center to the electricity user. In order to justify a very favorable situation for the supply of electric power systems from a method point of view as well as a cheap angle, it means to have a power factor as close as possible to number one. Increasing the load will result in a decrease in rotation caused by slippage when the motor is operating (Kayal & Chanda, 2016).

Where the capacitor is a passive electronic component that has the ability to put a temporary electric charge and release it back when needed. This component consists of 2 conductors separated by an insulator or dielectric. This insulator can be in the form of air, paper, mica, plastic, ceramics, or other materials that have the expertise to withstand electric current. Capacitors have 2 stops, they are positive stop and negative stop. When a capacitor is connected to a source of electric voltage, until the electric charge is to be placed between 2 conductors separated by a dielectric. The electric charge stored in the capacitor is measured in units of Coulomb (C) and its capacity is measured in units of Farad (F). The load that generally exists in the distribution system is inductively resistive so that there is a resistive current and inductive current flowing through the load. The amount of inductive current at the inductive load is compensated by the capacitive current in the capacitor bank because the capacitive current is passed through by the installed capacitor. After installing the capacitor bank, the total current drawn by the inductive load decreases. In other words, we can say that there is only resistive current in the network. Consuming low current will result in revision of the voltage profile and power loss (Hoq & Taylor, 2021).

The use of energy capacitors in electrical networks is the installation of capacitors in parallel in an electrical installation in the hope of increasing the efficiency of energy aspects (Hadiningrum et al., 2020). Low power factor is a very undesirable thing insofar as it causes an increase in current, which causes an increase in active energy exhaustion in all elements of the power system from the power plant center to the electricity user. In order to justify a very favorable situation for the supply of electric power systems from a method point of view as well as a cheap angle, it means to have a power factor as close as possible to number one.

To maximize the utilization of existing electrical energy from PLN, the existence of reactive energy must be made to a minimum (Berutu et al., 2021). In contrast, PLN as an electricity service provider calculates the energy used by electrical equipment per unit of time accumulated at the end of the month. For universal citizens who are less mastery, this matter can be a gap for sellers who market energy savers (energy capacitors). Sellers report energy savers with the brand "Power Plus" can save up to 40%. If energy capacitors are installed in a household installation, the result will not be very significant in lowering the total current in the network. This can be intertwined because the pure resistive current value does not change so that the measured energy value at kWh m does not change. The purpose of this research is to recognize the effect of capacitor accumulation on voltage and current acting on electrical loads in a place. It is hoped that with this research, residents recognize the efficacy of mastering the use of energy capacitors that match the energy load capacity in their own homes and are more aware of the true influence of capacitors installed both on a household scale and on a business scale.

Method

The materials to be used in this study are Power Capacitors, Elco capacitors, Cables, connectors, IN 4007 Diodes, Plugs, 3 mm LEDs, Black paralon pipe caps, Voltage sources. Measuring Instrument, Multitester (Heles U-78; 10-50-250-1,000V; sensitivity 9kΩ/v), Digital tester (Clamp Meter; 0-750 VAC; 50-500 Hz), Electronic Energy Meter (Dem1499; 230 V; 16 A/3680 W; 50/60 Hz), Power saver (Powerplus; 100-250VAC; 50 Hz). The research procedure determines the installation load point, assembles the equipment one by one, turns on the installed load by turning on the ON button, Observe and record the measurement results on the multitester, digital meter, ampere meter, and cosphi meter, repeat the experiment once again, and record the results of all experiments for further analysis, perform the same steps at each change of capacitor variations.

The quantitative research method is a scientific method because it has fulfilled scientific principles, namely empirical, objective, measurable, rational, and systematic. While discriptive research is research intended to investigate circumstances, conditions or other things that have been mentioned, the results of which are presented in the form of research reports. Descriptive analysis is a statistic used to analyze data by describing or describing the data that has been collected as it is without intending to make conclusions that are generally applicable.

Result and Discussion

Research related to the quality of electrical loads with the addition of power capacitors produces data in the form of numbers in tables and graphic images which include voltage and current measurements,

measurements are carried out on 2 load objects. Data retrieval by measurement using measuring instruments aims to take voltage and current data. Variations in data retrieval are carried out by ignoring voltage instability from PLN. Measurements are carried out at maximum load and are carried out in the stage before power factor improvement and the stage after power factor improvement (Dani & Hasanuddin, 2018). The measured electrical quality measurement data includes voltage and current using a digital Wattmeter. As a reference in this study, it was also measured before the addition of capacitors which were varied according to the initial plan of the study. The results of the study are shown in Table 1.

Table 1. Capacitor Measurement Data

Electrical Load	Capacitor Values (μF)	Voltage (V)	current (A)
Fan	0	211	0,23
	6	211	0.51
	12	211	0.23
	18	211	1.24
	24	211	1.68
	30	209	1.98
Average		210.6	0.97
Freezer	0	208	1.21
	6	209	0.95
	12	209	0.82
	18	209	1.1
	24	211	1.15
	30	211	1.40
Average		209.5	1.105

Test capacitors against voltage

Power capacitor tests on the amount of electric voltage show mixed results. In order to facilitate data analysis, data will be presented in the form of graphs shown in Figure 1.

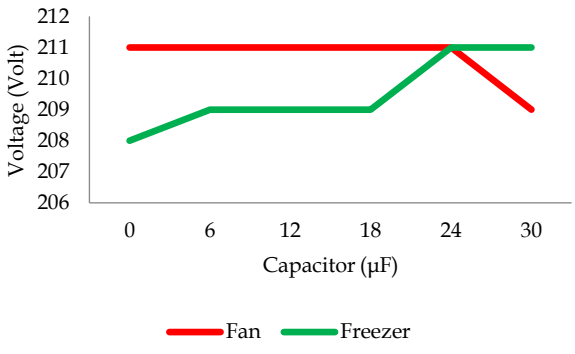

Figure 1. Variation of capacitors to voltage

In the freezer load, the measurement results show that without the addition of capacitors (0 µF) the voltage is 211 V. While with the addition of capacitors ranging from 6 µF – 30 µF changes in the form of increases. The increase is found in 24 and 30 µF capacitors, which is 211 V.

The power capacitor test on the amount of voltage at the fan load shows that the variation in the value of the paired capacitor from 0 µF – 30 µF makes the voltage vary as well, as seen in figure 1 the lowest decrease occurs in the variation of a 30 µF capacitor of 209 V compared to without the installation of a capacitor of 211 V. Overall of the three electrical loads installed with power capacitors produce an influence in the form of an increase and decrease in electric voltage.

Test capacitors against current

Power capacitor tests on the amount of electric current show varying results. In order to facilitate data analysis, data will be presented in the form of graphs shown in Figure 2.

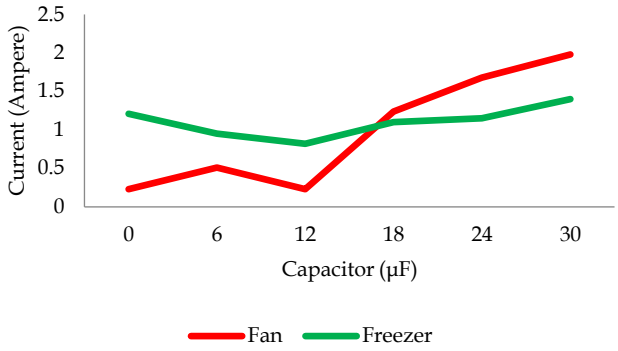

Figure 2. Variation of capacitors against current

In freezer load, according to Figure 2 shows that the value of electric current decreased by 0.82 A in the 6 µF capacitor variation, compared to before the addition of the capacitor the current power was 0.95 A, then followed by the 12 µF capacitor variation where the electric current fell at the lowest point by 0.82 A. In the addition of capacitors with variations of 18 µF and 24 µF the freezer load electric current increased only by 1.1 A and 1.15 A compared to without added power capacitors. Another thing that happens to the addition of a power capacitor with a variation value of 30 µF increases the electric current to 1.40 A.

Measurements on the fan showed different results, in the installation of power capacitors with a variation value of 6 µF, the electric current flowing had increased by 0.51 A compared to before the installation of the power capacitor. Overall, the two electrical loads installed with power capacitors produce an effect in the form of an increase and decrease in electric current.

Power is the energy released to carry out business. In an electric power system, energy is the amount of

electrical power used to carry out business. In the electric power system, electrical energy can be categorized into 3 types, namely, Real energy / Active Energy (Apparent Power) which is symbolized by P with units of Watts, Reactive energy (reactive Power) which is symbolized by Q with units of Reactive Volt Amper, and Apparent energy which is symbolized by S with units of Volt Amper. In the problem of alternating electrical systems where voltage and current are sinusoidal, the multiplication between the two wants to create active energy units of volt-amperes (VA) which have 2 parts. The initial part is energy utilized by consumers, it can be movement in the motor, it can be heat in the heating element, etc.; This utilized energy is often said as active energy (real power) has a unit of watts (W) that flows from the source side to the load side with an average value of not zero. The second part is energy that is not utilized by consumers, but is only found in the network, this energy is often said to be reactive energy (reactive power) has a volt-ampere- reactive unit with an average value of zero (Musyahar, 2017). Active power, reactive power, complex power, and power factor are all part of the power triangle (Fahlevi et al., 2023).

The result of adding a power capacitor to the load results in a good increase in power factor. In freezer objects, the power factor has the best tendency to increase in the 12 µF capacitor variation then decrease in the next variation as the variation of capacitors added is greater. The use of capacitors causes the value of cosphi to be greater, so it is suitable to be installed on a residential single-phase induction kWh meter that has a lot of inductive load, on the other hand, if used in a housing that has a lot of capacitive load, the use of capacitors on a single-phase induction kWh meter will actually be detrimental (Noor et al., 2017).

To change the low power factor to a better power factor at the motor load is to add capacitors to the motor load that are installed in parallel (Barlian et al., 2020). The low value of the power factor and the value of voltage drop are influenced by the load being run, for example the load being run is a face inductive load will increase the value of reactive power (Ferdiansah et al., 2023). From the analysis that has been carried out, the addition of capacitors to the freezer load, and the fan load does not cause any effect. The effect here is seen from the change in the value of active power that does not exceed 5%. Because the digital wattmeter measuring instrument has a measurement tolerance of 5%, the measured value of active power that increases or decreases is reasonable. This is in line with previous research which stated that it should be noted that if the power factor improvement of an installation results in reduced kVA, that power factor improvement does not affect the load in kW of the grid.

Conclusion

The addition of power capacitors to the electrical load results in an influence on the current and power factor that works. In this case, the addition is installed in parallel close to the electrical load. The active power value of the electrical load will have no effect on the addition of power capacitors. While the current value will decrease accompanied by a good increase in power factor (close to number 1). The addition of power capacitors that are not right with the type of electrical load actually results in an increased current followed by a worse power factor value (away from number 1). Important is the initial measurement of the value of active power, current, and power factor at the electrical load to which the power capacitor will be installed.

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Author Contributions
Yusnidah: Conceptualized the research idea, designed methodology, validated, analyzed data, wrote, reviewed, and edited.

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Conflicts of Interest
The author declares no conflict of interest.

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