BirEx JOURNAL
Budapest International Research in Exact Sciences
Medical, Biological, Argiculture, Engineering Science and other related areas
e-ISSN : 2655-7827
p-ISSN : 2655-7835
http://www.bircu-journal.com/index.php/birex

# Varistor in the Inverator Circuit Starting Energy Saver to Reduce Water Pump Electric Current

**Faisal Irsan Pasaribu[1], Noorly Evalina[2], Partaonan Harahap[3]**
[1,2,3]*Electrical Engineering Study Program, Faculty of Engineering, Universitas Muhammadiyah Sumatera Utara, Indonesia*
*faisalirsan@umsu.ac.id*

**Abstract:** *In general, the water pump is often used automatically, according to the use of the water faucet when it is opened. This automatic water pump system often triggers a surge in electric current when the water pump is on or off. This surge in electric current will increase compared to the nominal electric current. With increased current capacity, sometimes we face problems with the quality of electrical power in the electrical system, and will also increase electricity bills. The purpose of this research is to improve the quality of power to save electricity, reduce electric current when the water pump is used, so as to reduce the cost of using electricity bills, especially for water pumps. The use of Varistors in the Inverator Starting Energy Saver circuit is very influential in protecting the load when there is a surge in current even though it is momentary or long, so that it can improve the quality of electrical power at the water pump load. The data is carried out on measuring current, voltage, cos phi and frequency when the water pump is used without using an inverator. After making these measurements the measurement data can be saved as a comparison for the measurement data, which uses the installation of an inverator starting energy saver which is connected in parallel with the power source and also connected to the water pump. By installing the inverter starting energy saver circuit to improve the quality of electric power. The use of a varistor in the inverator starting Energy saver circuit clearly produces a current of 1.274 A and the voltage is 216 V without using an inverator. Furthermore, when using the inverter circuit, it produces a current of 1.098 A and the voltage drops by 207.6 V. The decrease in the working voltage of the water pump is still within the standard 5%.*
**Keywords:** *varistor; flow surge; starting energy saver; inverator; power quality*

## I. Introduction

The water pump is one of the electric motor equipment that functions to suck water, either from the water source directly, or from water that has been accommodated. It is undeniable that the water pump requires electric power that works according to its use. Therefore, the use of this water pump needs to be minimized as much as possible so that the cost of using electricity according to needs can be saved. If we turn it on continuously or turn it on automatically according to the use of the water tap when it is opened, of course it will certainly waste electricity. The use of electrical energy for water pumps can be high along with the high demand for water for washing, bathing, cooking and so on. The use of electrical loads such as water pumps is widely used both in households, office buildings, and in industry so that it affects and causes a decrease in the supply system and power quality (Hakim, 2017).

The need for good quality electrical power and in terms of various electrical equipment used both in laboratories, lecture rooms, and other rooms that use electrical equipment, it is very necessary to have good quality electrical power in supporting all forms of lecture activities within the scope of faculty, Generally the distribution of electrical power is used to serve loads such as: electric motors, computers and other

***DOI:*** https://doi.org/10.33258/birex.v3i4.2632

electrical equipment in which these loads contain coils of inductor wire. Inductors are components that absorb electric power for the purposes of magnetization and electric power. is called reactive power (Pasaribu, 2018).

## II. Review of Literatures

### 2.1 Varistor

Varistors are electronic components made of semiconductor materials with two terminals that function to protect electrical or electronic circuits from excessive transient currents and voltages. The word varistor itself comes from two vocabularies, namely variable and resistor. Varistor is a type of VDR (Voltage Dependent Resistor) (Pillai et al., 2013). The resistance value depends on the voltage that passes through it. Then there will be several advantages when using a varistor, namely: The initial starting current of the water pump becomes stable; Small Kw/Kvar losses, ie 0.005 to 0.010; Simple installation/installation and maintenance, without requiring a large space; and As additional benefits for consumers, among others, reduced active power required, power losses and stable water pump flow (Yana et al., 2017).

Varistor Working Principle, when the applied voltage increases, the resistance can change from MΩ (megaohms) to mΩ (milliohms). When the voltage is low, the varistor operates in the leakage current region, showing a large resistance, and a small leakage current. When the voltage rises to the nonlinear region, the current changes in a relatively large range, and the voltage does not change much. It exhibits better voltage limiting characteristics; the voltage rises again, and the varistor enters the saturation region, showing a small linear resistance. Due to the large current, the varistor will overheat and burn out or even break for a long time. Under normal use, the varistor is in the leakage current area. When subjected to a surge, it enters the nonlinear region to release inrush current, and generally cannot enter the saturation region (Asri, 2019).

Characteristics of VDR (Voltage Dependent Resistor) VDR (Voltage Dependent Resistor) is also known as a varistor, which is a resistor with a non-linear variable resistance value depending on the voltage value given to the VDR (Voltage Dependent Resistor). The value of the VDR (Voltage Dependent Resistor) resistance will be high when the voltage applied to the VDR is below the threshold voltage (threshold) and the resistance will drop rapidly when the voltage applied to the VDR exceeds the threshold value (threshold).

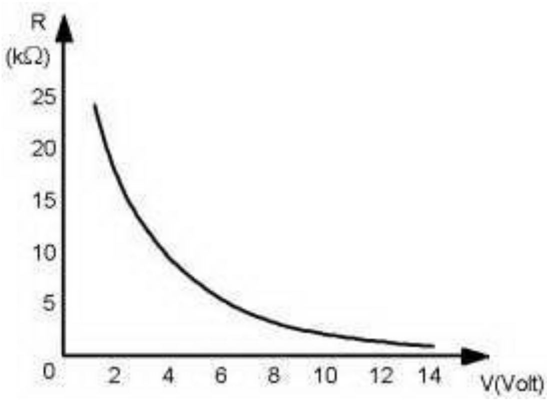



***Figure 1.*** *Characteristics of VDR (Voltage Dependent Resistor)*

From Figure 1 the characteristics of the VDR (Voltage Dependent Resistor) above, we can know that with the increase in the value of the voltage at the ends of the two VDRs (Voltage Dependent Resistor), the resistance of the VDR (Voltage Dependent Resistor) decreases. In practice VDR (Voltage Dependent Resistor) is used as a voltage stabilizer, or as a safety circuit against over voltage (Mumtaza & Supardi, 2019).

**2.2. Power**

Power is the energy expended to do work. In an electric power system, power is the amount of energy used to do work or work. Electrical power is usually expressed in units of Watt or Horsepower (HP), Horsepower is a unit of electrical power where 1HP is equivalent to 746 Watt or lbft/second. Watt is a unit of power. Wattmeter is a measuring instrument for measuring the power contained in an electronic component. One of the functions of knowing the power in an electrical circuit is its relation to efficiency and energy saving. Electrical power in the calculation can be grouped into two groups according to the electric power supply, namely DC electric power and AC electric power (Putri & Pasaribu, 2018).

Real power or active power is electrical power that is actually used, for example to generate heat, light or rotation in an electric motor. Real power generated by electrical loads that are purely resistive The amount of real power is proportional to the square of the electric current flowing in the resistive load and is expressed in Watts (Sitorus & Warman, 2013), (Pasaribu et al., 2020).

$P = V \times I \times \text{Cos}\ \varphi$……………………………..............…………………(1), (N Evalina, A Wicaksana, 2017)

So to find the value of active energy:

$W = P \times t$.........................................................................................(2)

Where : P = Active Power (*Watt*)
V = Voltage (*Volt)*
I = Current (*Ampere*)
Cos φ = Power factor
W = Active Energy (*Watt-Hour*)
t = Time (Jam)

Reactive power is expressed in units of VAR (Volt Ampere Reactive) is the electrical power produced by reactance loads. There are two types of reactance loads, namely inductive reactance and capacitive reactance. Inductive loads will absorb reactive power to produce a magnetic field. Examples of inductive electrical loads include transformers, single-phase and three-phase induction motors which are usually used to drive fans, water pumps, elevators, escalators, compressors, conveyors, and so on-other (Wahid, 2014). The relationship between the three electrical power units, namely active power/real power (W), reactive power (VAR) and apparent power (VA) can be seen in Figure 2 below:

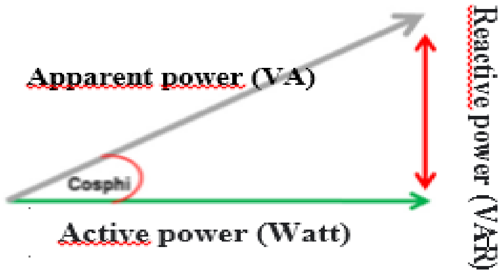



***Figure 2***. *Power Triangle Vector*

### 2.3. Flow Surge (Inrush Current)

The surge current is better known from the electrical language, namely the inrush current that first appears in the circuit, when the circuit is connected to a load. In an electrical circuit when the switch is closed there is a large current surge. The current surge that occurs is very short, on the scale of microseconds to milliseconds (Prasetyo, 2019). One way to reduce the impact of current surges and transient voltages on switching operations is to use a soft start (inverator). The working principle of the softstart is to reduce the inrush current at the time of initial loading so as to avoid the failure of the switch function as a circuit breaker (Asri, 2019).

The emergence of current surges when electronic devices are turned on is a phenomenon that occurs in electric power systems. This current is sudden and has a value several times the normal full load current. If there is no effort to reduce the current, then in the short term it will cause a decrease in the power quality of the electric power system. As for the long-term effect, it will shorten the working life of the electronic devices used, for example transformers and electric motors. This is because current surges can cause safety operation errors, which can reduce the power quality of the system (Zakky et al., 2013).

Wear spikes in electrical circuits can be considered as necessary or not necessary because at every start up of electrical equipment there must be a surge in current. However, current surges are considered dangerous for systems and electronic devices if the peak value of this current occurs is very large.

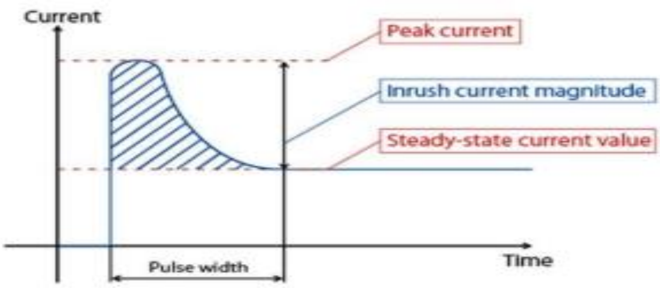



***Figure 3.*** *Inrush Current*

One way to reduce the impact of transient inrush currents on switching operations is to use an Inverator Circuit. The soft start circuit functions to drain the voltage to the load with large power slowly. In essence, the working principle of this soft start is to reduce current surges at the time of initial loading to avoid a malfunction of the switch as a circuit breaker. The use of soft start to reduce transient current surges has an effect in decreasing the initial electric power, so that it can reduce the cost of using electrical energy(Nugroho, 2012).

## 2.4. Electrical Load Properties

In an electrical circuit there is always a source and a load. When the power source is DC, then the nature of the load is purely resistive, because the frequency of the DC source is zero. The inductive reactance (XL) will be zero which means that the inductor will be short circuited. The capacitive reactance (XC) will be infinity which means that the capacitive will be open circuit (Pasaribu, 2018), (Putri & Pasaribu, 2018). So the DC source will result in an inductive load and the capacitive load will have no effect on the circuit. If the AC power source the load is divided into 3 as follows:

### a. Resistive Load

A resistive load which is a pure resistor, for example: incandescent lamp, heater. This load only absorbs active power and does not absorb reactive power at all. The electric voltage on the pure resistance is in phase with the electric current that precedes it.. And vectorically the relationship between the current and the voltage can be described as in Figure 4.

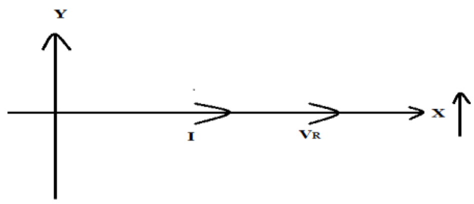



***Figure 4.*** *Current And Voltage at Resistive Load*

### b. Inductive Load

An inductive load is a load that contains a coil of wire wrapped around a core, usually an iron core, for example: electric motors, inductors and transformers. At an inductive load the current i lags 90° with respect to the voltage VL, and is vectorically depicted in Figure 5.

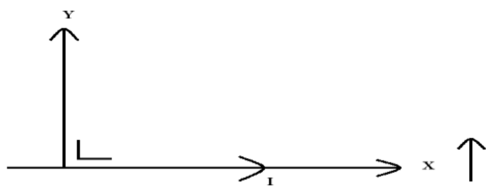



***Figure 5.*** *Current, Voltage at Inductive Load*

### c. Capacitive Load

A capacitive load is a load that contains a series of capacitors. This load has a power factor between 0-1 "leading". This load absorbs active power (kW) and produces reactive power (kVAR). The current i leads the voltage by 90° with respect to $V_C$.

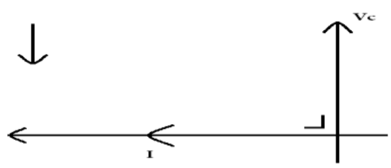



***Figure 6.*** *Current, Voltage at Capacitive Load*

## 2.5 Inverator Starting Energy Saver

Inverator is a tool for boosting electrical power surges, this tool does not violate the provisions of PLN because it does not interfere or change anything on the PLN meter. The electrical power capacity installed on the home network will limit the use of electrical power that can be distributed to the load. If there is excess power then the power grid will be cut off. If you want a higher power capacity, the capacity of the electricity network must be increased, even though the use of electricity when it exceeds the installed power capacity only operates for a short time. An alternative emergency backup that can be done to overcome the load that exceeds the installed power capacity is to add Inverator device for overload surges.

***Figure 7.*** *Inverator Device*

Inverators are also defined as electronic equipment that is used to regulate or smooth out surges in star currents or inrush currents from electrical loads. In general, electrical loads that have these characteristics are electric motors, but this also happens to other electrical equipment that has capacitors/elcos and diodes or rectifier circuits, such as a power supply on a PC. An electric power booster is an electronic device that is used as a medium for distributing electrical energy and increasing the use of electrical energy. In accordance with the working principle of an electric generator, this unit is capable of producing a strong current and alternating voltage (AC) which works through the principle of activation of AC electric voltage (Zakky et al., 2013).

This tool is a tool with a modification of the use of electronic circuits with new technology that is used for the ultimate goal of saving the use of electrical energy. Through the electromagnetic induction system, the excess electrons will increase the electric potential. The electric potential with a high difference will also increase the induced electric current and will increase the output power of the electric power booster. Electrical power boosters can be used to save on electrical energy needs in households, industries, or public places. The installation of this tool can be placed on the electricity network after the installation of the PLN kwh-meter and before the use of the electrical load installation (Pasaribu et al., 2020). The beginning of the use of an industrial workshop for agricultural tools and machinery had usage problems. The problem with the application of the power booster is that there is a decrease in the output voltage produced by the device. The voltage drop will be very detrimental if it continues to be applied to electronic equipment without using an adapter. The effect of using electrical energy with unstable voltage is damage to electronic equipment.

The working principle of this Inverator is to temporarily delay the consumption of electricity when the electrical equipment is first turned on. When the electrical equipment is turned on or the power switch is pressed, at that time a large electric current draws to fill the vacancy of the electric charge in the electrolytic capacitor (elco) contained in the power supply of electrical equipment after the rectifier or diode circuit. The flow of electricity that is sucked in when it exceeds the electrical load installed in this meter will result in the MCB of the meter tripping (Morales et al., 2013). With the inverator, the current flows slowly for a fraction of a second so that there is no large current draw for the first time.

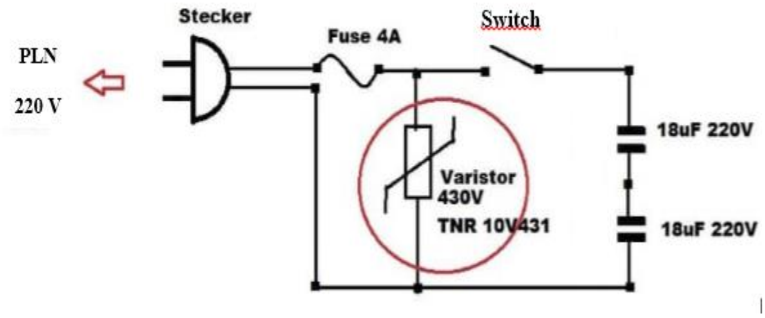



***Figure 8.*** *Simple Inverator Circuit Using Varistor*

## III. Research Methods

The research was conducted at the Electrical Engineering Laboratory, Faculty of Engineering, Universitas Muhammadiyah Sumatera Utara, and at Street Gelatik 12 No. 399 Perumnas Mandala.

There are 4 ingredients as the main components in the completion of this research, namely:

1) Inverator Starting Energy Saver, used as a 10% - 40% electrical energy saving device which issuitable for use for electric motor loadssuch as Water Pumps.
2) Power Meter (Morales et al., 2013), Power meter is a measuring instrument that canread voltage, current, frequency, powerfactor, active power and KVARH electricity consumption (Pasaribu et al., 2020),(Handajadi, 2014),
3) Waterpump PS 160 BIT model as themeasured load
4) Stop Contact, as a liaison between the Water Pump and the Inverator Circuit Starting Energy Saver.

Inverator Starting Energy Saver Inverators are several Varistors and Capacitors and other circuits that will reduce inrush currents and Energy Savers on electric motor loads, especially the use of Water Pumps. In general, electrical loads that have inrush current characteristics are electric motors, but this also happens to other electrical equipment that has capacitors/elcos and diodes or rectifier circuits, such as power supplies on PCs. An electric power booster is an electronic device that is used as a medium for distributing electrical energy and increasing the use of electrical energy. In accordance with the working principle of an electric generator, this unit is capable of producing a strong current and alternating voltage (AC) which works through the principle of activation of AC electric voltage (Zhou et al., 2016).

The process of testing and data collection will becarried out every 30 minutes when the Water Pumpisused. Data recording and observation is carried out starting from data on voltage, current, frequency, Pf, active power and apparent power generated before and after using the Inverator Starting Energy Saver circuit. The design and installation of the test equipment is shown in Figure 9. Below:

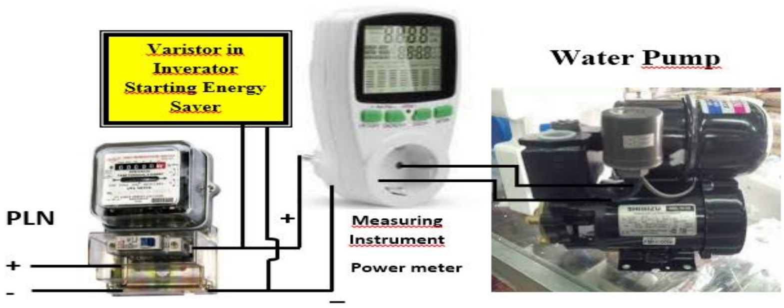



***Figure 9.*** *Tool Design*

Knowing the current, voltage and frequency of the water pump used is very important, especially if we want to install an inverter starting Energy Saver to reduce the use of electric current in the water pump. From the data, the value on the nameplate on the water pump used is not absolute because the electric voltage from the PLN source is not constant at 220 Volts.

## IV. Discussion

### Measurements Result

#### a. Live Load Data Not using Inverator starting Energy Saver

Measurements and direct observations were carried out for 30 minutes to meet the 800-liter water needs. The results of these measurements and direct observations without using the Inverator starting Energy Saver, where the measuring instrument used is the power meter. From the measurement results, the data on the results of voltage, current, power factor and power can be tabled in table 1 below:

**Table 1.** Load Measurement before using the Inverator Starting Energy Saver

| Load | T | Voltage | Current | Power factor | Load Power |
|---|---|---|---|---|---|
| Water Pump PS 160 BIT | 30 minute | 216 V | 1,274 A | 0,98 | 272W |

#### b. Live Load Data Already Using Inverator Start Energy Saver

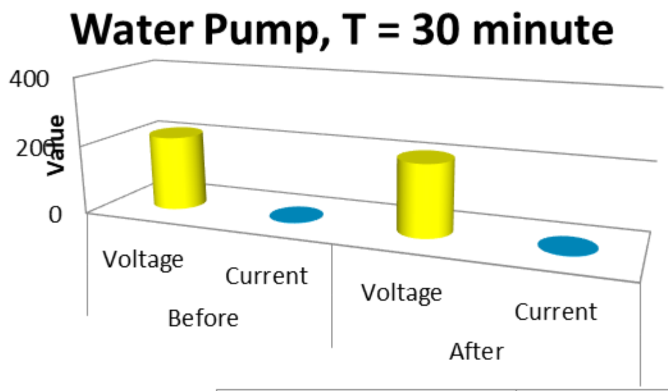
Based on the purpose of this study to produce efficiency in the use of electrical energy, direct measurements and observations were carried out for 30 minutes to meet 800 liters of water needs. The results of measurements and direct observations are using the Inverator starting Energy Saver, where the measuring instrument used is the power meter. From the measurement results, the data on the results of voltage, current, power factor and power can be tabled in table 2 below:

**Table 2.** Measurement of Load after using Inverator Starting Energy Saver

| Load | T | Voltage | Current | Power factor | Load Power |
|---|---|---|---|---|---|
| Water Pump PS 160 BIT | 30 minute | 207,6 V | 1,098 A | 0,98 | 223,9 W |

From the measurement results when using the Inverator Starting Energy Saver, there is a decrease in voltage and current as well as the power generated at the water pump. This is due to the large enough resistance in the inverter circuit, so that the inverter output voltage drops. This voltage drop also affects the current decrease due to resistance through obstacles in the inverter circuit. From the results of the voltage using the Inverator Starting Energy Saver, it is still allowed because it is not up to 10%, which is 9.4%.

From the results of voltage and current measurements before and after using the starting energy saver inverter circuit, the results can be seen in the following graph of Figure 10:




| | Before | | After | |
|---|---|---|---|---|
| | Voltage | Current | Voltage | Current |
| Water Pump T = 30 minute | 216 | 1,274 | 207,6 | 1,098 |

***Figure 10.*** *Voltage and Current Graph Before and Before Using the Inverator*

## V. Conclusions

Based on the purpose of this study, designing an inverter starting energy saver as an effort to improve power quality to save electricity, reduce current and voltage rises when a water pump is used. This improvement is also expected to be able to reduce the cost of using electricity bills, especially in the use of water pumps. Where the expected results and also able to reduce the use of electrical power through voltage and electric current in the use of water pumps. To be able to improve the quality of electric power, water pump measurements have been carried out before using the inverter starting energy saver circuit. After making these measurements, through the use of the inverter starting energy saver circuit, by carrying out these steps by installing and using the inverter starting energy saver circuit, it is clear that the current measuring value is 1.274 A and for the voltage is 216 V before using the inverter circuit. Furthermore, when using the inverter circuit, it produces a current of 1.098 A and the voltage drops to 207.6 V. The decrease in the working voltage of the water pump is still within the standard 5%.

## References


Asri, N. (2019). *Pemodelan Dan Analisa Lonjakan Arus Saat Starting Motor Induksi Tiga Fasa Menggunakan Solid-State Soft Start Switching*. University Of Muhammadiyah Malang.

Hakim, M. F. (2017). Analisis Kebutuhan Capacitor Bank Beserta Implementasinya Untuk Memperbaiki Faktor Daya Listrik Di Politeknik Kota Malang. *Jurnal Eltek*, *12*(1), 105–118.

Handajadi, W. (2014). Peningkatan Kualitas Daya Listrik Dalam Pemakaian Luminer Menggunakan Lampu Hemat Energi (LHE). *Jurnal Teknologi*, *7*(2), 134–140.

Morales, A., Robe, X., & Maun, J. C. (2013). Assessment Of Wind Power Quality : Implementation Of IEC61400-21 Procedures. *Department Of Electrical Engineering. CP 165/52 Université Libre De Bruxelles*, 1–7.

Mumtaza, F. I. A. Z., & Supardi, Z. A. I. (2019). Analisis Penggunaan Soft Start Untuk Mengurangi Lonjakan Arus Awal Pemakaian Listrik. *Inovasi Fisika Indonesia*, *8*(3).

N Evalina, A Wicaksana, A. D. (2017). Perbaikan Faktor Daya Transformator Berbeban Pada Beban Dan Saluran Dengan Menggunakan Kapasitor. *Seminar Nasional 1*

*UISU*, *1*, 26–33. Https://Scholar.Google.Com/Citations?View_Op=View_Citation&Hl=Id&User=7L-3dboaaaaj&Pagesize=80&Citation_For_View=7L-3dboaaaaj:Qjmakfhdy7sc

Nugroho, A. (2012). Desain Alat Pereduksi Arus Transien Akibat Starting Beban Pada Jaringan Listrik Skala Rumah Tangga 900VA. *Tugas Akhir Jurusan Teknik Elektro-Fakultas Teknik UM*.

Pasaribu, F. I. (2018). Implementasi Filter Rc Pada Reduksi Harmonisa Dalam Pengobatan Ceragem. *Jurnal Elektro Dan Telkomunikasi*, *4*(2), 62–66.

Pasaribu, F. I., Harahap, P., & Adam, M. (2020). Design Of Energy Storage Circuits For Efficiency Of Electric Power Usage In Computer Devices. *Budapest International Research In Exact Sciences (Birex) Journal*, *2*(3), 368–375.

Pillai, S. C., Kelly, J. M., Ramesh, R., & Mccormack, D. E. (2013). Advances In The Synthesis Of Zno Nanomaterials For Varistor Devices. *Journal Of Materials Chemistry C*, *1*(20), 3268–3281.

Prasetyo, F. A. (2019). *Rancang Bangun Soft Starting Pada Motor Induksi Satu Fasa Berbasis Sensor Arus Menggunakan Mikrokontroler Arduino Mega 2560*. Undip Vokasi.

Putri, M., & Pasaribu, F. I. (2018). Analisis Kualitas Daya Akibat Beban Reaktansi Induktif (XL) Di Industri. *JET (Journal Of Electrical Technology)*, *3*(2), 81–85.

Sitorus, R. J., & Warman, E. (2013). Studi Kualitas Listrik Dan Perbaikan Faktor Daya Pada Beban Listrik Rumah Tangga Menggunakan Kapasitor. *Singuda Ensikom*, *3*(2), 64–69.

Wahid, A. (2014). Analisis Kapasitas Dan Kebutuhan Daya Listrik Untuk Menghemat Penggunaan Energi Listrik Di Fakultas Teknik Universitas Tanjungpura. *Jurnal Teknik Elektro Universitas Tanjungpura*, *2*(1).

Yana, K. L., Dantes, K. R., & Wigraha, N. A. (2017). Rancang Bangun Mesin Pompa Air Dengan Sistem Recharging. *Jurnal Pendidikan Teknik Mesin Undiksha*, *5*(2).

Zakky, A., Ayatullah, R. I., Teknik, J., Institut, E., & Nasional, T. (2013). *Analisis Arus Transien Transformator Setelah Penyambungan Beban Gedung Serbaguna PT " X ." 1*(1), 1–10.

Zhou, B., Li, W., Chan, K. W., Cao, Y., Kuang, Y., Liu, X., & Wang, X. (2016). Smart Home Energy Management Systems: Concept, Configurations, And Scheduling Strategies. *Renewable And Sustainable Energy Reviews*, *61*, 30–40.