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# Designing a Pure Sine Wave Inverter 250 VA Based on EGS003

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ABSTRACT

The design of a pure sine wave inverter based on the EGS003 aims to improve the efficiency of electrical energy conversion. This inverter development method integrates PWM (Pulse Width Modulation) control with a pure sine wave reference signal. The use of PWM control allows precise adjustment of the pulse width of the output signal, according to the desired sine wave characteristics. Consequently, this inverter is capable of producing pure sine waves without significant harmonic distortion, enhancing the quality of the generated power and reducing energy losses due to harmonic distortion. This research involves the implementation of EGS003 technology, which is a dedicated PWM controller designed for inverter applications. The use of this controller enables the optimization of resource utilization and enhances energy conversion efficiency. Furthermore, the development of the EGS003-based inverter involves the analysis and design of control circuits in line with modern power electronics principles. This includes adjusting PWM control parameters to various load characteristics, allowing the inverter to operate optimally under different usage conditions. The design results demonstrate that the pure sine wave inverter based on EGS003 provides satisfactory performance in delivering output compliant with power quality standards. With the capability to generate pure sine waves without significant harmonic distortion, this inverter has broad application potential in power systems requiring high-quality power. Additionally, the use of PWM control technology in this inverter facilitates ease of operation adjustment and monitoring, enhancing the overall reliability and efficiency of the system.



## 1. Introduction

The world of electronics continues to evolve and advance, significantly easing and lightening human daily life. Many factors contribute to the ongoing development of electronic devices, resulting in a variety of shapes and uses, one of which is the inverter.

Electronic development is influenced by various factors, resulting in a variety of electronic devices. One such device is the inverter, which plays a role in converting DC voltage to AC voltage. This is crucial as a backup power source in vehicles or homes, providing emergency power during power outages. In its application, inverters can be used for various household appliances such as lights, TVs, computers, and fans, as well as tools such as drills and grinders. In remote areas, inverters also serve as a power supply for homes and various other electronic devices. Their presence is crucial, especially during power outages, providing AC power for lights and other needs at night.

Inverters serve as backup power providers in vehicles and homes, serving as emergency power when the household power is out. Why is it better to convert DC voltage to AC voltage? Because DC is more battery-intensive since all electrical equipment/components are taken from the battery, and converting DC voltage to AC serves as a form of utilizing renewable energy that can maintain electricity availability. An inverter can be defined as a device to convert DC voltage into AC voltage, where the output of the inverter allows us to change the frequency and voltage magnitude.

The output of an inverter can produce AC voltage with various waveforms, one of which is the sine wave. Pure Sine Wave or True Sine Wave is a type of inverter waveform that closely resembles, or even surpasses, the perfect sinusoidal wave found in conventional power grids. The technology used in these inverters is known as Pulse Width Modulation (PWM), which can convert DC voltage into AC with a waveform that closely resembles a sine wave overall.

EGS003 is a PWM (Pulse Width Modulation) controller widely used in inverter circuits. This controller is designed to precisely regulate the output voltage and frequency of the inverter, thus producing a pure sinusoidal waveform. The main advantage of EGS003 is its ability to control voltage and frequency with stability, as well as having advanced protection features to prevent damage to the inverter. With this capability, EGS003 has become one of the top choices for inverter designers who prioritize output quality and efficiency. Furthermore, the presence of EGS003 also simplifies the process of inverter design and development by providing an integrated controller with necessary features. Therefore, a deep understanding of EGS003 technology and performance is key to designing an efficient inverter.

This research is conducted due to the increasing demand for stable and high-quality power supply, especially in the context of household and small industrial applications. Pure Sine Wave-based inverters are desired solutions to ensure optimal performance of electronic devices, as they can produce nearly perfect sinusoidal waves. By utilizing the EGS003 controller, this research aims to design a 250VA inverter that is efficient, reliable, and economical, thus meeting the need for high-quality power supply in various everyday applications. Therefore, a device is designed to convert direct current to alternating current with a capacity of 250 VA using EGS003 PWM controller technology. This device aims to provide an alternative power source that can be used continuously and is suitable for household use as a backup power source up to 250 VA.

## 2. Methods

This research is conducted by designing a power optimization system on the harvester using the SSHI method connected to the piezoelectric harvester. In order for the system design to be carried out properly, sufficient information and collection of theories related to the process of designing this research system are needed.

### 2.1. Inverter

An inverter is a useful device for converting direct current (DC) electrical voltage into alternating current (AC) electrical voltage, also known as DC to AC voltage converter. With an inverter, users can provide AC power simply by using batteries, which often serve as low DC power sources such as batteries, solar panels, or fuel cells that need to be converted into AC current for wider use.

The use of AC power generated by inverters can help reduce noise in devices such as incandescent lamps and ensure smoother and quieter operation of inductive loads, such as motors, due to low levels of harmonic distortion. In the current market, there are two common types of inverters, namely modified sine wave inverters and pure sine wave inverters. Both types of inverters have different output characteristics and provide various levels of efficiency and distortion that can affect the performance of electronic devices in various ways.

The basic principle of inverter operation is by manipulating the DC current, chopping it, and then reversing it to produce a square wave. This wave is then filtered into the desired sine wave, simultaneously eliminating unwanted harmonics.

## 2.2. Car Battery

Batteries serve as the primary source in DC transmission because they direct the flow of current from one point to another in one direction. In alternating current (AC), which differs from DC, the voltage oscillates between two values at a certain frequency, and continuous changes in current and voltage facilitate the regulation of voltage increase or decrease. In situations of high-voltage transmission over long distances, a transformer is the only necessary component to regulate voltage increase or decrease.

## 2.3. EGS003

The EGS003 is a newly developed single-phase pure sine wave inverter driver board, which adopts the special EG8011 single-phase pure sine wave inverter chip as the control chip, and the drive chip adopts the high-voltage full-bridge driver chip EG2126. It is compatible pin-to-pin with the EGS002 and expands new functions based on the EGS002. The entire board consists only of the EG8011 and EG2126 ICs and several separate devices, making the driver board significantly smaller in size than the EGS002. The driver board integrates voltage, current, temperature protection functions, LED alarm function, LCD drive function, and fan control function.

The EG8011 is an enhanced pure sine wave inverter control chip, which adopts Complementary Metal Oxide Semiconductor (CMOS) technology and integrates functions such as Sinusoidal Pulse Width Modulation (SPWM) generator. The EG2126 is a cost-effective high-power MOS transistor and a special transistor gate driver chip or Insulated Gate Bipolar Transistor (IGBT).

## 2.4. Trafo

There are two ways to use a transformer to change alternating current voltage to higher or lower levels:

1. Step-Up Transformer: A step-up transformer is used to increase the voltage or level from low to higher levels. The secondary voltage component is turned into a higher output voltage by increasing the number of turns in its secondary coil, thus reducing the number of turns in the primary coil. This step-up transformer is used to connect a generator transformer to the grid in electrical voltage.
2. Step-Down Transformer: Step-down transformers reduce the level of AC voltage from high to low levels. In this type of transformer, the number of turns in the primary coil is greater than the number of turns in the secondary coil. Step-down transformers are used to convert high electrical voltage, such as that supplied by the national grid (e.g., 220V), into a voltage level suitable for household electronic equipment.

## 2.5. Oscilloscope

An oscilloscope is an electronic measuring device used to represent the shape of electrical signals in waveform form, allowing for visualization and analysis. When measuring a circuit with an oscilloscope, the signal being observed will be displayed moving from left to right repeatedly on the oscilloscope screen, enabling users to accurately inspect and analyze the waveform.

From this illustration, we can identify the frequency and amplitude of the voltage, as well as display waveform detection. Various functions of the oscilloscope measurement tool include:

- Measuring direct current or alternating current voltage and calculating frequency.
- Analyzing waveforms in electronic circuits.
- Observing voltage amplitude, frequency, and period of unknown signals.
- Determining phase difference between input and output signals.

These functions make the oscilloscope a versatile tool for electronic measurement and analysis in various applications, such as circuit debugging, signal analysis, and waveform characterization.

## 2.6. Pure Sine Wave

A pure sine wave is a waveform that closely resembles a sinusoidal wave and is even superior in that aspect. This waveform is suitable for use with all electronic devices. The technology used in inverters to produce pure sine waves is generally known as Pulse Width Modulation (PWM), which enables the conversion of voltage from DC to AC. The advantages of a pure sine wave include having output with very low harmonic distortion and providing clean power, similar to regular sinusoidal electricity, thereby not damaging electronic devices.

## 2.7. Inductor

Inductors have the property of storing energy in a magnetic field when an electric current flows through them. An inductor is an electronic component typically made of wire wound into a coil, often in a toroidal shape, which can induce voltage across the inductor. The main function of inductors is often applied in electronic circuits for various purposes, including filtering, coupling, and forming resonance in the circuit.

Inductance is the measure of an inductor's ability to produce a magnetic field and depends on the number of wire turns, measured in henries (H). Inductors are essential components in the world of electronics, and understanding how they work and how to utilize them can aid in designing and comprehending various types of circuits.

## 2.8. Flowchart of Data Collection

Data collection for the design of a pure sine wave inverter based on EGS003 is carried out as shown in the flowchart Fig. 1. The principle of operation of the inverter system is that when DC current is supplied from the car battery, the inverter will convert the current into AC using the EGS003 module. Then, the transformer steps up and steps down the voltage according to the requirements of the load. The step-up and step-down processes in the transformer protect the current that will flow to the load being connected. With step-down, the current can be observed on an oscilloscope in the form of a waveform graph. By displaying a sinusoidal waveform on the oscilloscope, potential damage to household electronic devices can be avoided. If the waveform displayed on the oscilloscope is square wave, it should be avoided as it can cause damage to electronic appliances.

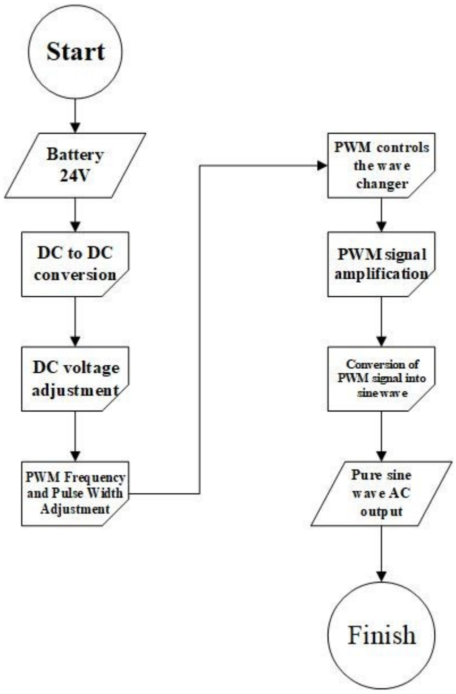


**Fig. 1.** Flowchart of data collection

## 3. Results and Discussion

Testing the load on the inverter serves several important purposes. One of them is to evaluate the performance of the inverter by ensuring that it can produce stable output and meet the requirements of the applied load. Additionally, testing helps identify the inverter's ability to handle various types of loads, ranging from resistive loads to inductive loads, and ensures that the inverter can maintain the quality of the generated power, such as stable voltage and frequency.

Load testing can also be used to determine the maximum capacity of the inverter and ensure that it can operate efficiently without overheating or failure when used under different load conditions. Therefore, load testing on the inverter is important to ensure its performance and reliability in everyday use with loads such as 5-watt incandescent bulbs, 27-watt LED bulbs, 30-watt LED bulbs, and 40-watt LED bulbs. Here are some loads used to test this device.

### 3.1. 5-watt Incandescent Bulb

In the incandescent bulb testing Fig. 2 using an oscilloscope, the purpose is to observe the electrical signal characteristics provided to the bulb. By using an oscilloscope, we can examine the characteristics of the electrical waveform flowing through the incandescent bulb and analyze how the bulb responds to the given voltage.

The oscilloscope is used to visually display a frequency of 50 Hz, as seen in Fig. 3. Therefore, the testing is conducted with the intention of verifying that the incandescent bulb operates according to the specified standards, as well as identifying any disturbances in the electrical signal that may affect the bulb's performance.

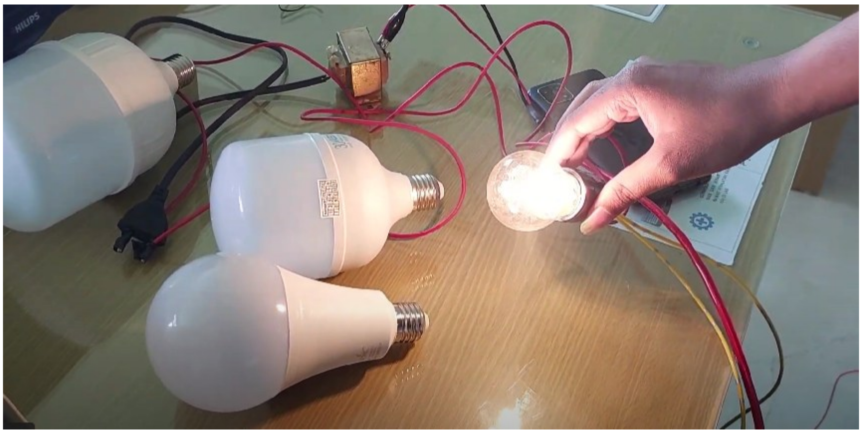

**Fig. 2.** Inverter testing using a 5-watt load

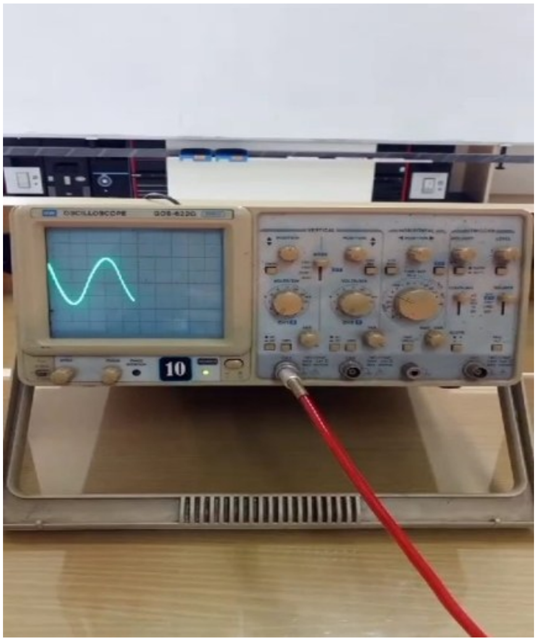


**Fig. 3.** Sinusoidal waveform in the testing of a 5-watt incandescent bulb load

### 3.2. 40-watt LED Bulb

The testing of the inverter with a 40-watt LED bulb in Fig. 4 using an oscilloscope aims to assess the electrical signal characteristics generated by the inverter and the response of the LED bulb to those signals. The oscilloscope is used to visually display a frequency of 50 Hz, as seen in Fig. 5.

Through testing and measuring voltage and waveform shape, we can determine the appropriate output from the inverter for loads such as 5-watt incandescent bulbs, 27-watt, 30-watt, and 40-watt LED bulbs that can accept AC voltage from the inverter. However, there is a difference in the sinusoidal waveform for the 27-watt, 30-watt, and 40-watt LED bulb loads, where the peak of the waveform is slightly imperfect. This is what is called Harmonic Distortion.

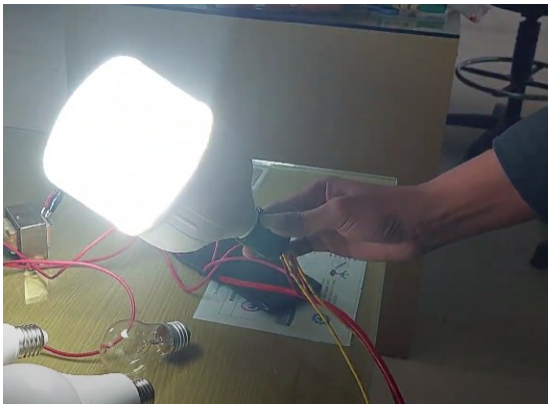

**Fig. 4.** Inverter testing using a 40-watt LED bulb

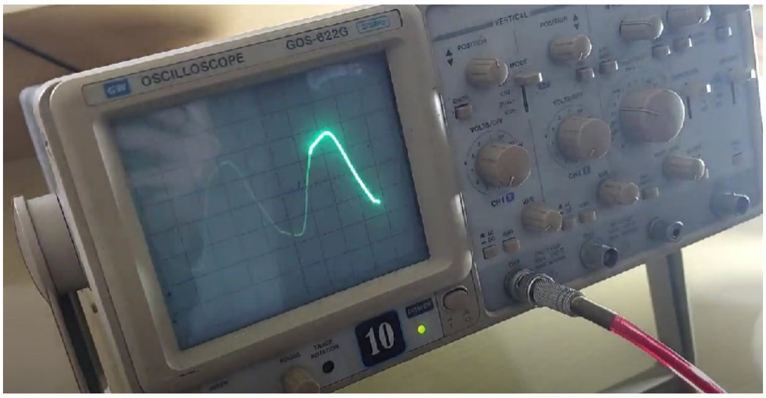


**Fig. 5.** Sinusoidal waveform in the testing of the 40-watt bulb load

Harmonic distortion refers to distortion in the waveform of electrical current or voltage, which can cause disturbances in the power distribution system. These disturbances occur when there is deviation from the ideal sinusoidal waveform, which can lead to instability in the flow of electricity and affect the performance of various electronic devices connected to the system. It is understood that the use of inverters may not pose problems for resistive loads. However, if non-linear loads are connected, they tend to heat up quickly and may cause damage to the connected electronic devices, especially if used for extended periods.

Testing the inverter with the load can be seen in Table 1 is important to ensure that the inverter meets the requirements and is reliable in its practical application, and makes a positive contribution to the overall performance of the power system. After testing by measuring tests in the form of current, voltage, and power at input and output conditions on the inverter using several different loads. Then a graph is made which aims to help clarify and communicate the results of the research to the reader. The following graphs are made from the results of testing the EGS003-based inverter on several.

**Table 1.** Inverter test results using load

| Load (W) | V input (VDC) | I input (A) | V output (VAC) | I output (A) | Frequency (Hz) | P output (w) |
|---|---|---|---|---|---|---|
| 5 | 24.51 | 1.29 | 222.5 | 0.035 | 50 | 4.4 |
| 27 | 24.50 | 2.49 | 222.1 | 0.104 | 50 | 26.2 |
| 30 | 24.50 | 2.60 | 222.1 | 0.110 | 50 | 29.7 |
| 40 | 24.49 | 3.17 | 222 | 0.142 | 50 | 39.2 |

A comparison graph such as Fig. 6 between current input and voltage input is a visual representation that illustrates the relationship between the electric current flowing through a circuit and the voltage applied to the circuit. In this graph, the voltage value is the independent variable represented on the x-axis, while the current value is the dependent variable represented on the y-axis. If the applied voltage increases, then the current flowing in the circuit will tend to increase as well, as long as the resistance in the circuit remains stable.

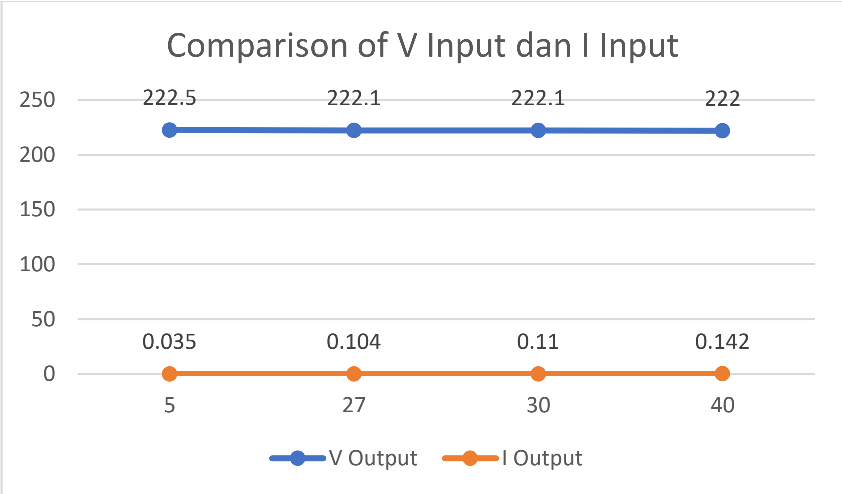


**Fig. 6.** Input voltage and input current graph

This phenomenon is in accordance with the principle of Ohm's law, which states that the current in a circuit is proportional to the applied voltage, with resistance as the multiplying factor. This graph has important significance in analyzing the operational characteristics of electrical circuits, interpreting power consumption, and determining crucial parameters such as resistance.

The comparison graph shown in Fig. 7 between the output voltage and output current illustrates the relationship between the value of the voltage outputted and the current flowing from an electronic system or device. In the graph, the x-axis depicts the output voltage value, while the y-axis depicts the output current value. As the output voltage increases, the output current also tends to increase, assuming that the load characteristics remain consistent. This response reflects how the system responds to variations in voltage and current, which has important relevance in analyzing the performance of an electronic system, evaluating its stability, as well as adjusting its operational parameters.

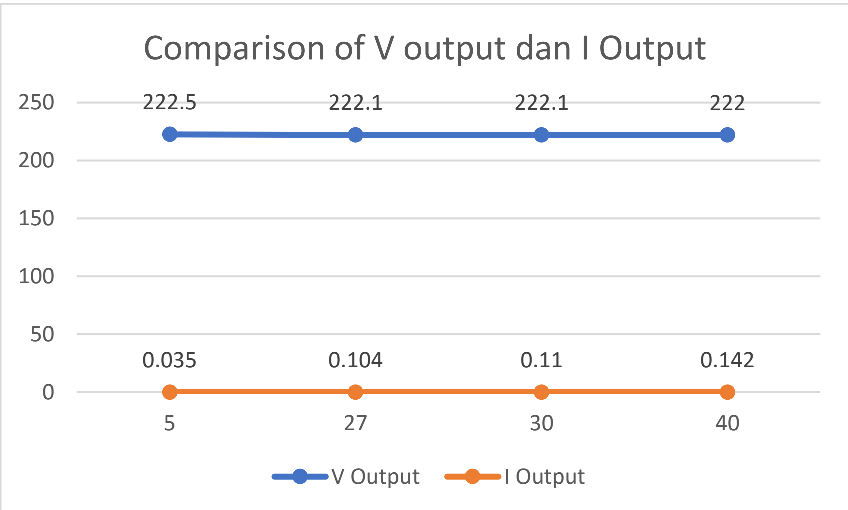


**Fig. 7.** Output voltage and output current graph

A power input to power output comparison graph illustrates the relationship between the power entering a system or device and the power leaving the system. In this graph, the x-axis represents the power input value, while the y-axis represents the power output value. If the power input increases, the power output also tends to increase, provided the efficiency of the system or device remains stable. This graph helps in understanding the energy efficiency of a system, evaluating performance, and identifying potential improvements in order to increase energy efficiency and overall performance.

The calculation to convert the output voltage and output current into power, a basic formula in electronics is used which is expressed as $P = V \times I$. In the formula, $P$ represents power, $V$ represents voltage, and $I$ is current. By multiplying the output voltage value with the output current value, we can calculate the amount of power produced by an electronic system or device when it is operating. For example, if the output voltage reaches 12 volts and the output current is 2 amperes, then the output power can be calculated using the formula, resulting in a value of 24 watts.

With inverter testing using loads made in the form of graphs aimed at visualizing data that shows performance comparisons in achieving research objectives. In Fig. 6 explains the incoming current and incoming voltage when testing the inverter using the load, in Fig. 7 explains the outgoing current and outgoing voltage when testing the inverter using the load, and the last graph in Fig. 8 explains the input power and output power when using the load.

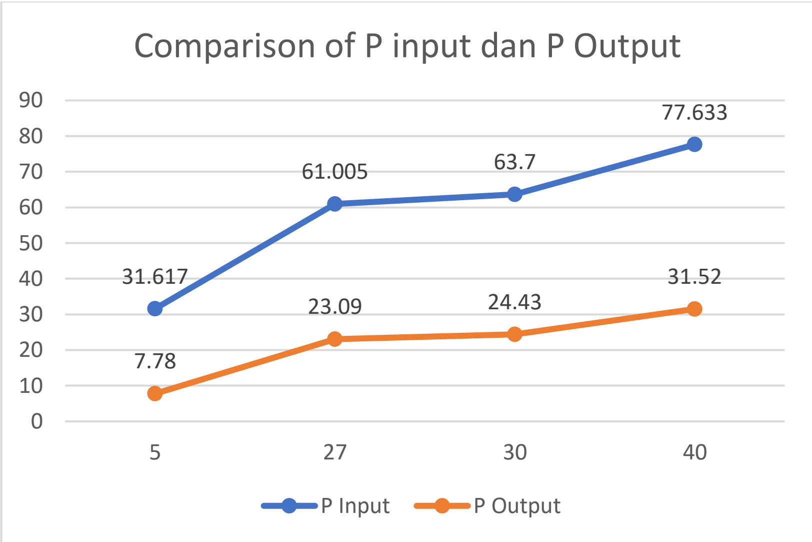


**Fig. 8.** Output voltage and output current

## 4. Conclusion

Based on the results of the research that has been done, several conclusions can be drawn, namely: The EGS003 module-based inverter design tool in this study can function properly. The tool made can produce a voltage of 200 watts. So that household electronic equipment under 200 watts can be used properly. With the EGS003 module applied to the inverter design running properly, where the EGS003 module is a sine wave driver so that it is more stable. That way electronic equipment in households does not experience damage when receiving the AC voltage generated by this EGS003-based inverter. With supporting components such as MCBs and inductors play an important role when the device is turned on, with the MCB as a short circuit protec that will damage the components in the inverter and also the inductor is paired on the transformer to filter the voltage entering the transformer. There is a difference in sine waves on both types of loads caused by the load of this led lamp there is harmonic distortion, which when seen the wave is unstable at the peak of the sine wave. In other words, non-linear type loads cannot be used for a long time because it will cause the transformer in the inverter to heat up quickly, and if used continuously, there will be damage to the load with this non-linear type. In contrast to non-linear type loads, resistive type incandescent lamps have no problem at all in their tests when tested on an oscilloscope. As long as this resistive load does not exceed the capacity of the output voltage generated by the inverter, there will be no problems as with non-linear load types.

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