DC TO AC CONVERTER PROTOTYPE USING SOLAR PANEL

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Abstract

The purpose of this research was to design a DC to AC converter using solar power source. The device was equipped with pump and water filter. DC to AC converter can be used to drain river water. The streamed water was filtered so that the cloudy and smelly river water became hygienic. The hygienic water can be used by the community of the banks of the river for daily needs. The method used in this research was research and development with 5 steps of development. The steps consisted of potential problems, data collection, product design, design validation and product testing. The results of the research prototype DC to AC converter using solar panels can be realized by combining sub-systems including two monocrystalline 150 WP Solar Panels, 30 Ampere Solar Charger Controller, DC to AC Converter, 220 V AC Water Pump, 10 Inch Water Filter Housing with Media Sponge Cartridge and Media Carbon Active. The result of this research was to produce a DC 12 V to AC 220 V converter with a pure sine output waveform. The DC to AC converter can turn on water pump with a capacity of 125 watts that was equipped with a water filter to purify water.

Keywords : DC to AC Converter , Monocrystalline Solar Panel, Solar Charger Controller.

Introduction

The survey conducted by the Directorate of Drinking Water Development, Directorate General of Human Settlements in 2006 showed that every Indonesian consumes an average of 144 liters of water (0.144 m3) daily [1]. From these data, at least the water needs of about 144 liters per day for each person. If there is a shortage of water, river water will be an alternative solution to meet household water needs. Several rivers in certain areas are widely used for bathing, washing, and defecation activities, so that the quality of river water becomes polluted. Therefore, it is necessary to separate water from the river for the community, so that the water that has been separated from the river can be used for daily needs. The separation of water from the river will also prevent residents from directly washing, bathing, etc. in the river so that the quality of river water is not polluted. Rivers in some areas are far from the PLN electricity source so that the use of solar power through solar panels will be an alternative energy to generate electricity, especially if the river is located in the tropical area. .

There are many new applications for DC-AC converters in th distributed energy field generation systems such as solar power systems, fuel cell power systems combined with supercapacitors or battery energy storage. With all the switching cells, the recommended converter is also equipped with a modern high-current low-power MOSFET, and it increases efficiency over conventional isolated DC-AC converters (Hans Ertl, et., al, 2002: 1048-1057). The converter is also used to switch the minimum power and is able to increase the dc voltage with a low input to a high level dc-ac output voltage with no output filter. The converter control is a system with loop regulator that becomes a dc input source as two voltage regulator loops to produce the desired output voltage, and produces an automatic battery charge/discharge to balance the power flow (Saeed Danyali, et., al, 2014: 775-788). The design of the new voltage source inverter is called a boost inverter or boost dc-ac converter by producing an ac output voltage greater than the input dc one that depends on the instantaneous duty cycle to optimize the dynamics of the boost inverter with the priority of mode control over the classical control scheme is resistance. for variations in plant parameters (Ramon O. C, et., al. 1999: 134-141). With the help of the embedded DC-DC converter, the storage battery voltage can be varied over a wide range. To minimize the power ratings and power losses of the embedded DC-DC converter, a simple PWM strategy based on zero-sequence injection operator is proposed. By adopting the proposed PWM strategy, the smaller ratio of the total power needs to be processed by the embedded DC-DC converter while most of the power is only processed by the three-phase DC-AC stage in a single conversion stage. As a result, a quasi-one-stage power conversion is achieved to improve the overall conversion efficiency of the DC-AC power system (Jiangfeng Wang, et., al, 2020: 1-12). The DC-AC converter design with solar panels may save costs in processing several tools to be more useful in fulfilling the needs of people living in the area.

Based on some studies on the basis of the problem of unmet water needs, especially from people in remote areas and far from PLN electricity sources, researchers will design a prototype DC to AC converter using solar panels as a power source that will be controlled by a solar charger. controller and electricity are stored in the battery. The designed DC to AC converter will have a pure sine output waveform and a 220 V AC voltage for running the water pump. The system that will be made by researchers, both

solar panels, solar charger controllers, batteries, inverters and water pumps will be packaged into one tool design. The system will also be equipped with 10-inch water filter housing with sponge cartridge media and active carbon media that are installed together with the tool, so that water drawn from the river using an AC water pump will be filtered first using a filter housing with sponge cartridge media and active carbon media. , then the water produced becomes clear and may help people who have lack clear water, especially for people who live in remote areas.

Literature Review

DC to AC Converter

DC to AC converter is usually called inverters. Inverter or Power inverter is an electronic device that can convert a direct current source DC (Direct Current) into alternating current AC (Alternating Current). Inverters are used in many applications, for instance used in conditions where only low DC current is available such as that generated by batteries (Accu) or solar panels and that was required to supply electronic equipment with AC input. In the market today, there are two types of differences in the AC voltage generated by inverters generally, namely the output wave in the form of a modified sine wave and the output wave in the form of a pure sine wave. The modified sine signal is the inverter output in the form of a square wave or modified square wave with the shape follows a sine wave pattern. This modified sine type is easier to manufacture than an inverter with a pure sine output. The pure sine inverter produces an output wave that is identical to the wave generated by the power supply operator (Elliot, 2014).

Prototype is potential system version that gives developers and potential users an idea of how the system will function in its finished form (Darmawan, 2013). Oscillator is an electronic circuit to produce an output signal without an input signal. The oscillator produces a periodic waveform only with a DC voltage input. The oscillator output can be sinusoidal and nonsinusoidal depending on the type of oscillator (Asad, 2012).

(*Pulse Width Modulation*) Bipolar Generator

. In a switching bipolar PWM inverter, the PWM signal is generated by comparing a sinusoidal wave (reference wave) with a triangular signal (carrier signal). The output signal carries the value of the sine frequency ($f$sine). On the other hand, the triangular signal frequency ($f$tri) is also the switching frequency (Michel & Percy, 2009).

Full Bridge Converter

In this study, researchers used a full-bridge converter or H-bridge inverter circuit configuration. Full-bridge converter is a circuit to convert DC voltage to AC. The configuration of the full-bridge circuit consists of 2 pairs of switches, namely (S1,S2) and (S3,S4) which work alternately. The DC voltage is converted into AC voltage by opening the specified switch sequentially so that it reverses the polarity of the load quickly [10]. The full-bridge converter circuit configuration can be seen in Figure 1.

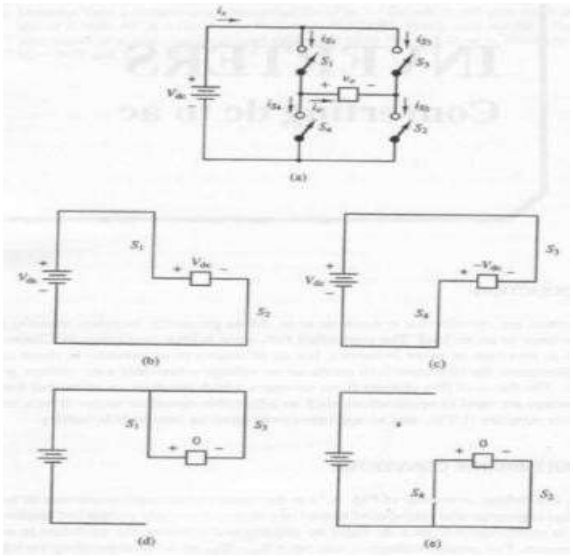


Figure 1. (a) Full-bridge converter (b) S1 and S2 closed (c) S3 and S4 closed. (d) S1 **and** S3 closed. (e) S2 and S4 closed

Low Pass Filter

The low pass filter is to eliminate all unfavorable harmonics from the output signal. By designing a filter, the output voltage and current must be pure AC sinusoidal with the operating frequency (Clayton, 2010). The figures related to low pass filters can be shown in Figure 2 and Figure 3.

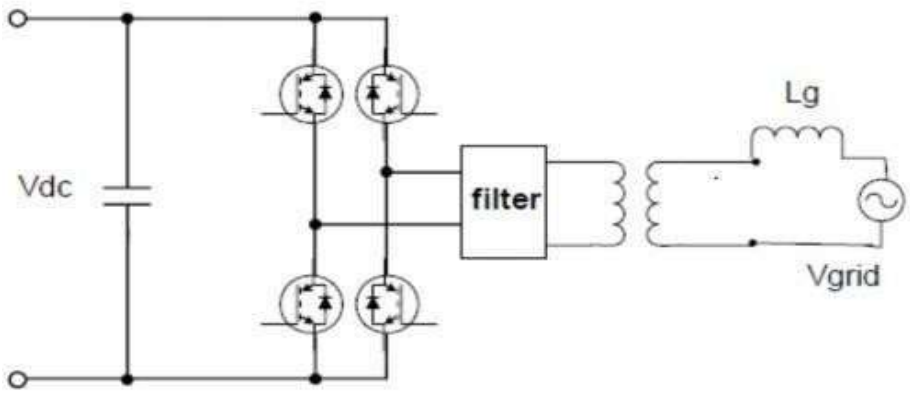


Figure 2. Harmonic filter block diagram

The output of the inverter before the filter applied is not sinusoidal, after the low pass filter the output becomes sinusoidal. Low pass filter is used to select the required frequency, and eliminate high frequencies that are higher than the cut-off frequency [11].

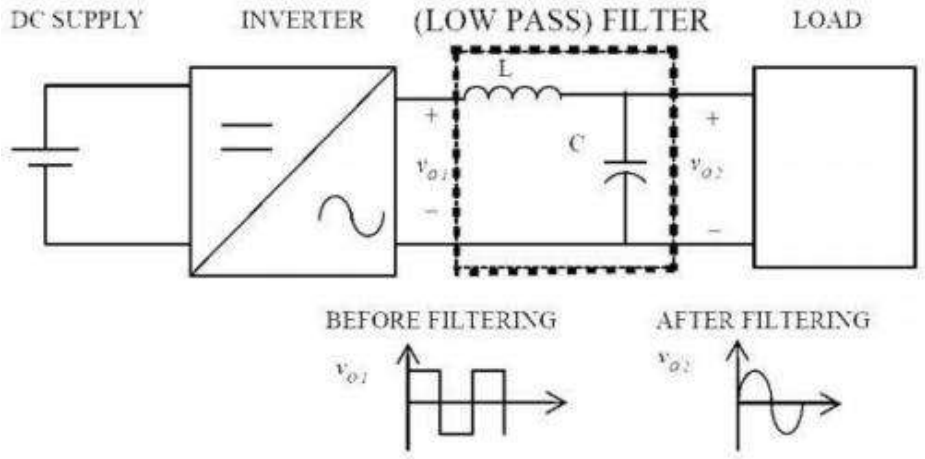


Figure 3. Block Diagram LC Filter

Solar Panel

A solar panel is a total consisting of solar cells that convert sunlight energy into electrical energy. Solar panels are often referred as photovoltaic (PV). Photovoltaic (PV) is semi-conductors-based technology in a solid state that converts sunlight energy directly into electrical energy without any rotating parts, it does not cause noise, and it does not emit exhaust gases. The amount of electrical energy produced by the photovoltaic module depends on the available solar power and depends on the direction of the solar module towards the sun. The things that affect the performance of photovoltaics are the climatological conditions in question including temperature and solar radiation (Firman, 2017: 98-102).

Research Methodology

The method used to make DC to AC converter prototype using solar panels is a research and development method to produce certain products and test the effectiveness of these products so that they can function in the wider community. This study used five steps namely potential problems, data or information collection, product design, design validation and product testing (Sugiyono, 2009).

Potential and Problems

The research started from the potential and problems with the need of clear water in the community became decrease, but there is river that can be used as an alternative sourceusing the river flow, the sun is very hot and the river is far from PLN electricity.

Data Collection

Collecting data from various information as material for planning the design of the DC to AC converter prototype using solar panels.

Product Design

The design of DC to AC prototype converter using solar panels produced in this study was designed with the help of solar panels as a tool to produces DC electricity, a solar charger controller as a controller for DC voltage regulators and the current generated from solar panels before being stored in the battery. The battery was used as a DC electricity store, the DC to AC converter is used to convert 12 volt DC electricity into 220 volt AC power, the AC water pump was used to draw water from the river, the filter housing with clear sponge media and carbon cartridge media was used as a water filler. to be a clear water.

Design Validation

Design validation is a simulation result of product design in simulation software to assess the dc to ac converter prototype using solar panels. The designs designed by the researchers are shown in Figure 4, Figure 5, and Figure 6.

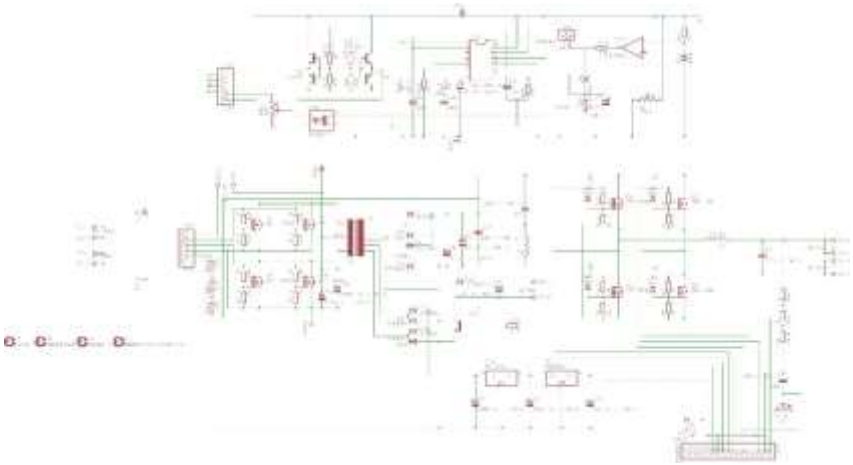


Figure 4. Schematic Design of DC 12 V to AC 220 V Converter Circuit Design

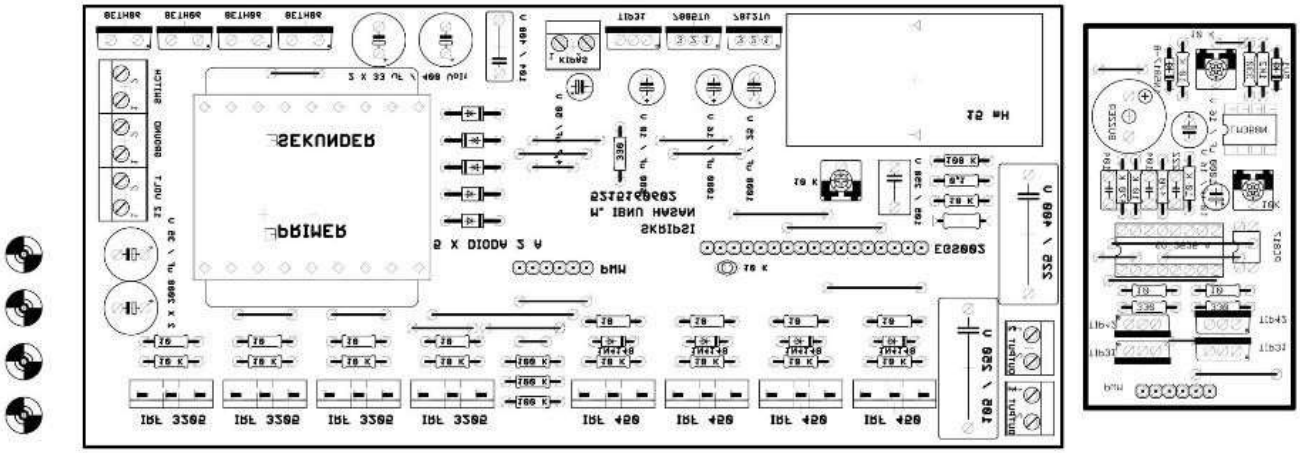


Figure 5. DC 12 V to AC 220 V Converter Circuit Layout Design

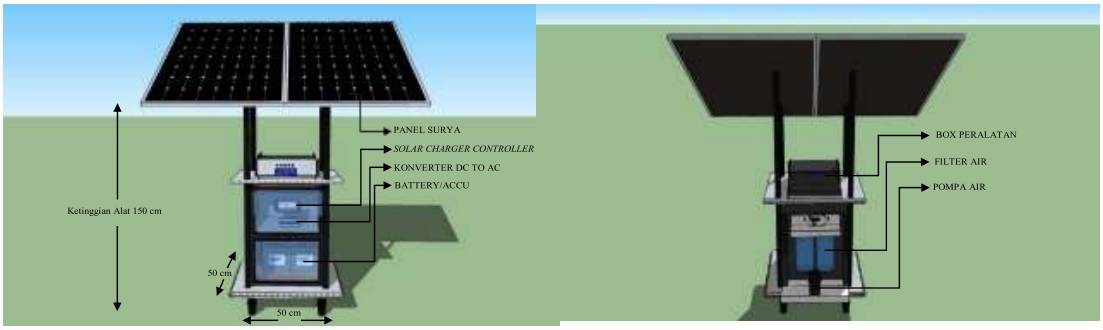
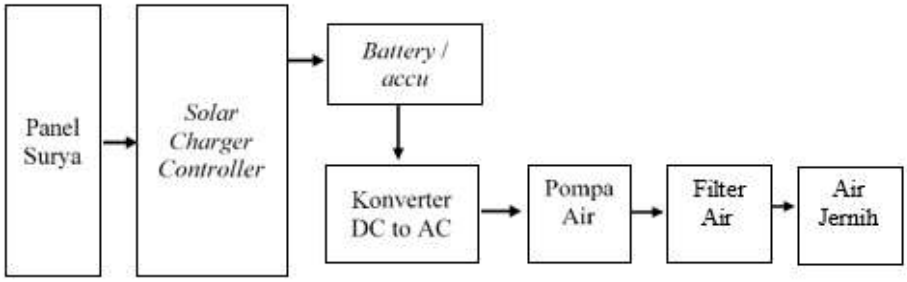


Figure 6. Overall Tool Design

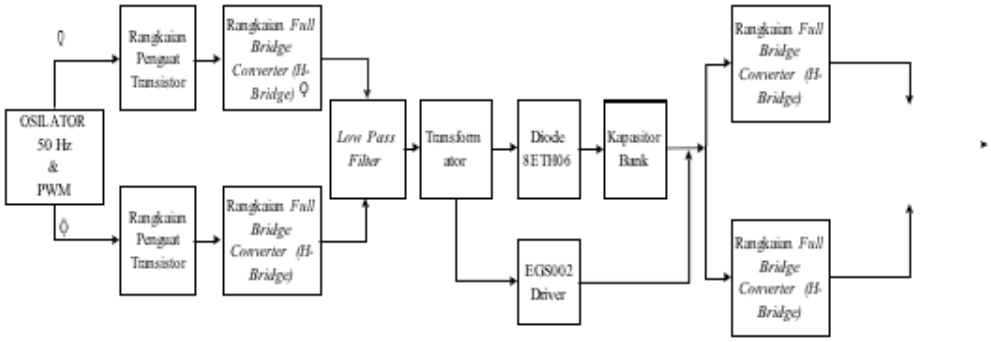
Product Test

Product trials include assembling a prototype dc to ac converter using solar panels as a whole, measuring and testing the resistance of an inverter made to drive an ac water pump, and testing a water filter to purify water taken from the river.

Overall Tool Block Diagram

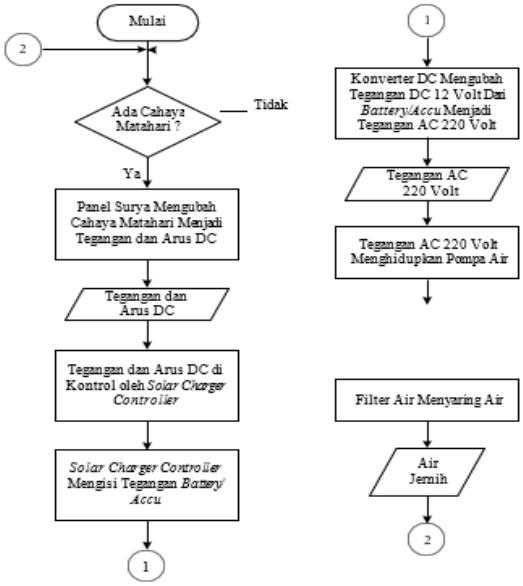


Gambar 7. Diagram Blok Alat Keseluruhan



Gambar 8. Diagram Blok Konverter DC to AC

Tool *Flowchart*



Gambar 9. *Flowchart* Alat

Results

The results of Design of a DC to AC Converter Prototype Using Solar Panels were carried out to find out how much the success value was in the experiment. The test was carried out with several tests, namely by testing the battery/accu, testing of two pieces of 150 wp solar panels, testing of the solar charger controller, testing the output waveform of the dc to ac converter, testing the water pump and testing the water filter. The results of the realization of the designs made by researchers are shown in Figure 10 and Figure 11.

Figure 10. Results of DC 12 V to AC 220 V Converter Design

Figure 11. Results of Overall Tool Design

Tool working principle

The design of the prototype DC to AC converter works by using power source generated from monocrystalline solar panels. Design of the prototype DC to AC converter using a solar charger controller as a voltage and current controller as well as an interface. On the solar charger controller there was an LCD that can display the DC voltage and current generated from the solar panel. DC electricity generated from solar panels and after going through the solar charger controller will be stored in the battery/accu and used to activate the DC to AC converter/inverter. The inverter made will be used to activate the water pump. Design of prototype DC to AC converter using solar panels equipped with a 10-inch water filter housing with sponge cartridge media and active carbon media installed with the tool. The filter housing is used to purify water drawn from the river by a water pump using the first medium, namely a sponge cartridge which functions to filter solid sediment particles in the water such as sand, mud, moss, crust, rust. Then the second medium is active carbon which functions to neutralize odors and chlorine content. Furthermore, the water produced becomes clear that may help people who have lack clear water, especially for people in remote areas.

Results

The first test was carried out on the battery (battery) to determine the magnitude of the voltage on the battery (battery). Furthermore, testing the battery (battery) is also to determine the condition of the battery (battery) that is in good condition or not. To get the voltage value from the battery (accu) a digital multieter is used, so that the measurement data contained in Table 3.1 are obtained.

Tabel 3.1 Hasil Pengujian *Battery/Accu*

No.	Tegangan Standar dari datasheet (Volt)	Tegangan *Battery/Accu* Ketika Diukur	Tampilan	Hasil Pengujian (Baik atau Tidak)
Accu 1	12-14 Volt	12.88 Volt		Baik
Accu 2	12-14 Volt	12.95 Volt		Baik

The second test was carried out on 2 pieces of monocrystalline 150 WP solar panels in parallel to determine the magnitude of the photovoltaic voltage, photovoltaic current, battery voltage, battery current (accu). To obtain the voltage value can be done the direct measurement and the current value can be seen on the LCD display of the solar charger controller. The following is the voltage and current measurement data for both photovoltaic and battery as shown in Table 3.2.

Table 3.2 The Results of Two pieces *Monocrystalline* 150 WP solar panel

No.	Waktu Pengukuran	Tegangan PV (Volt)	Arus PV (Ampere)	Tegangan *Battery* (Volt)	Arus *Battery* (Ampere)	Keterangan (Cuaca)
1	10.00	18.29 V	2.3 A	14.2 V	2.3 A	Cerah
2	10.30	19.29 V	2.3 A	14.22 V	2.3 A	Cerah
3	11.00	17.44 V	2.2 A	14.18 V	2.2 A	Berawan
4	11.30	19.45 V	4.2 A	14.19 V	4.2 A	Cerah
5	12.00	19.73 V	5 A	13.81 V	5 A	Cerah
6	12.30	20.48 V	7.1 A	13.84 V	7.1 A	Cerah
7	13.00	20.53 V	7.7 A	13.80 V	7.7 A	Cerah
8	13.30	20.55 V	13.7 A	13.84 V	13.7 A	Cerah
9	14.00	21.03 V	17.1 A	13.82 V	17.1 A	Cerah
10	14.30	20.73 V	13.1 A	13.84 V	13.1 A	Cerah
Rata-Rata		19.75 V	7.47 A	14 V	7.47 A	-

Subsequent testing on the solar charger controller was carried out to determine the function. The test was performed by observing the voltage display listed in the Solar Charger Controller and then measuring the output voltage. The results of the solar charger controller test can be seen in Table 3.3.

Tabel 3.4 Hasil Pengujian Konverter DC 12 V to AC 220 V

No.	Tegangan Input (Volt)	Bentuk Gelombang Output	Hasil Pengujian
1.	12 Volt		Bentuk gelombang sinus murni namun masih terdapat sedikit ripple

Subsequent testing on the water pump was carried out to determine the proper function of water pump. . The test was done by activating the pump using an inverter and a voltage source from the battery. The results of the water pump test can be seen in Table 3.5.

Tabel 3.5 Hasil Pengujian Pompa Air

No	Kriteria		Hasil
-	a Daya Pompa (Watt)	Arus Beban yang Terlihat pada Tampilan LCD SCC saat Pompa Aktif	Pengujian
1.	Daya 125 Watt Tegangan *Battery* = 14.2 V Arus = 125 : 14.2 = 8.8 A		Pompa Bekerja Baik

The next test on the water filter was carried out to determine the ability of filter housing with sponge cartridge media and active carbon in purifiying water. The test was carried out by taking samples of river water drawn by the pump and comparing samples of river water with filtered water. The test results of the water filter can be seen in Table 3.6.

Tabel 3.6 Hasil Pengujian Filter Air

No.	Kondisi Sample Air Sungai	Kondisi Air yang Sudah Melewati Filter Air	Hasil Pengujian
1.	Keruh Kehijauan	Jernih	
			Baik

Discussion

Indonesia is a country with a tropical climate and has two seasons, summer and rainy season. In summer, bright sunlight is very beneficial for human life. The sunlight is high and abundant, bringing benefits and positive impacts for Indonesia. The advantages gained by Indonesia's tropical climate conditions can be found in various sectors of life. One of the advantages of sunlight is as a source of DC panel power that can be converted into AC power. This AC power can be used for household needs such as household appliances, refrigerators, street lighting and water suction devices to become filters to make it hygienic. The design of the DC to DC buck boost converter is used as a powerful PID controller for a four quadrant DC to AC switch mode inverter. Total harmonic distortion (THD) for the output at voltage against sudden load changes is the design of this controller (Ramon Caceres, et., al, 2000: 180-185).

The results of voltage testing on each battery (accu) obtained a different voltage value between battery (accu) 1 and battery/accu 2. In battery (accu) 1 the voltage measured on a digital multimeter was 12.88 Volts while on battery (accu)) 2 the measured voltage on a digital multimeter was 12.95 Volts. The measured voltage was still within the normal limits of the battery/accu, so the two batteries are in good condition. Voltage testing on monocrystalline solar panels, the maximum voltage was 21.03 volts and the minimum voltage was 18.29 volts. The interval of 30 minutes starting from 10.00 to 14.30 of the solar panel test showed that the voltage generated varies every 30 minutes. It is because the absorption of solar panels from the sun increases when the weather is sunny. However, there is one time when the sun weather conditions were covered by clouds, namely at 11.00 WIB which causes the absorption of solar panels to decrease. Control methods designed to reduce voltage deviations in DC

links can be implemented without additional sensors found in solar converter applications (B. Wittig, et., al).

During solar charger controller test, it appears that there were no problems with the LCD in the solar charger controller display section. All voltage and current data can be displayed properly through this solar charger controller and when voltage measurements were taken, the measured voltage value was not much different from the voltage listed on the LCD in the solar charger controller display section. So that the solar charger controller can be said as a good condition. From DC to AC converter (inverter) test using an oscilloscope, it can be observed that the waveform was pure sine but there was still ripple, it is because the number of turns in the core was less dense and less added. It can also add a capacitor to eliminate the ripple. The most important thing is when the researchers tested this DC to AC converter with a load of 135 watts, the waveform remained stable and did not fall apart. The amplitude of the output wave is too large so that the oscilloscope cannot accommodate the whole wave, and it looks like the wave that was cut off a little. The increase in frequency occurs from 3 GHz, when observed with the unmagnetized case which usually has a GHz range in the application of a DC magnetic field. The frequency of radiation depends on both the density of the plasma and the strength of the dc magnetic field namely the plasma frequency and the cyclotron frequency. The frequency of the emitted radiation corresponds to the theoretical value (T. Higashiguchi, et., al, 2000: 4542-4545).

To test the water pump, the power of 125 watts was used and its current load requirement was 10.6 A seen in the measurement results on the solar charger controller. In testing the water filter, researchers used a filter housing with sponge cartridge media and active carbon media to purify the water drawn by the water pump. The results of the comparison of water from the river with filtered water was different. The results of the filtered water was clear so it can be said that the filter housing with sponge cartridge media and active carbon media can function properly. The results of the design of the converter were also carried out to control and form the output impedance of the boost converter to reduce ripple at the battery input. Second, the proposed controller achieves good dynamic performance online and load transients. Fast voltage recovery with small undershoot/overshoot cans was achieved on transients using the proposed controller. The proposed technique was validated using the hardware of a 1-kW two-stage converter (Aditya R. Gautam, et., al, 2018: 3125-3135). The input current generated by the Y-source converter was lower and smaller compared to the conventional Y-source structure with the results in a larger voltage gain (Rouzbeh Reza Ahrabi and Mohamad Reza Banaei, 2014: 801-808). The realization can be further reduced to only 9 IGBT (Ultra Rare Matrix Converter, USMC) if the phase shift of the voltage and current bases at the input and at the output is limited to ±/6. The dependence of the voltage and current transfer ratio of the system on the operating parameters was analyzed and the spatial vector modulation scheme as described in combination with the zero current switching procedure (J.W. Kolar, M. Baumann and F. Schafmeister, H. Ertl, 2002: 1-16).

Application of Results

The design of DC to AC converter using solar panels can be applied at remote areas with lack clean water even though the river flow is quite heavy, for street lighting in areas with the of shortage of electrical energy such as home lighting, power sources for refrigerators and televisions. With the use of this tool, it will save electricity because the source of electricity comes from nature, then this tool will certainly be able to overcome people with lack clean water in their households. Design of DC to AC prototype converter using solar panels equipped with a water filter so that the water produced through this intermediary tool will be clear and can be used directly by the community especially in remote areas that is far from PLN electricity sources.

Conclusion

Based on the results of research on the design of dc to ac converter prototype using solar panels, there are some conclusions : the system had functioned to convert sunlight into DC voltage electricity stored in the battery/accu. The DC to AC converter can convert 12 volt DC voltage from the battery/accu to 220 volt AC voltage. The DC to AC converter can produce a pure sine output waveform. The design of the prototype DC to AC converter using solar panels had functioned to run the inductive load of the water pump through a DC power source generated from the solar panel and had been converted into AC voltage. The water filter installed in the system had functioned to filter water into clear water.

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