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Design of Pure Sine Wave Inverter with Automatic Transfer Switch for Hybrid Solar Power Plant

Hanifah Nur Kumala Ningrum[a], Basuki Winarno[a], Andhika Dharma Saputra[a], Rakhmad Gusta Putra[a]

[a]Politeknik Negeri Madiun, Madiun, Indonesia

A B S T R A C T

DC inverters are used to control the speed and torque of electric motors, which are widely used in industries and household appliances, curently DC inverter was integrated to electronic vechile. An inverter is an electronic device that converts direct current (DC) into alternating current (AC). The output of an inverter is an AC voltage in the form of a square wave, modified sine wave, and pure sine wave. In this research, an inverter with pure sine waveform with 220 VAC rms and 50 Hz frequency. An Automatic Transfer Switch (ATS) is needed to automatically divert electrical power from the Solar Inverter into the AC main source and vice versa. This ATS works when the battery capacity from a solar battery is decreased, the power source is switched to the AC main source , and diverted to a solar inverter when the battery capacity is under 50%. In this research, 184 watts of load is tested on performing the pure sine wave inverter. The ATS works properly to divert the source and needs a 5-second time delay when diverting the AC main source to a solar inverter, and a 1-second time delay when diverting from a solar inverter to an AC main source.

Keywords: Pure Sine Wave Inverter, Automatic Transfer Switch

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1. Introduction

As time goes by, humans are trying to find other ways to develop environmentally friendly power plants. One of them is by utilizing renewable energy, such as solar light energy (solar). Solar energy can be used to supply solar cells. Then the solar cell output will go to the inverter which can then be used for the load. To convert DC voltage to AC, you need a device called an inverter. [1-2]

An inverter is an electronic circuit that changes electrical voltage from direct current (DC) to alternating current (AC). One commonly used inverter configuration is the H-Bridge circuit. The H-Bridge circuit works by setting a combination of switches that are activated. One commonly used switch is the Metal Oxide Semiconductor Field Effect Transistor (MOSFET). The advantage of MOSFETs as switching components is that the switching speed is fast and does not cause current disturbances [3-4].

The Off-Grid system in PV makes it possible to store the electrical power produced by PLTS in batteries for use when the electricity grid is down or if the PLTS is not generating electricity [5]. These off-grid systems cannot be expected to power all applied electrical loads, as the cost and size of the batteries would be prohibitive. To overcome the automatic transfer of electricity sources, it is necessary to create equipment that works automatically, so that when the electricity goes out/experiences interference, the electricity operator does not need to operate the transfer of the electricity source manually. For this reason, it is necessary to design equipment and a control system that can work automatically to take over the electricity supply from the inverter power source to PLN or vice versa [6-7]. This automatic control system is usually called Automatic Transfer Switch (ATS). Automatic Transfer Switch is a series of controls for Power Inverter switches with PLN that work automatically [8]. This tool is useful for turning on and connecting the AC Main Source to the load automatically when the inverter goes out. When the inverter comes back on, this tool will automatically move the power source from the AC main Source to the inverter to turn on the load. From these various backgrounds, the author intends to make an inverter using an Automatic Transfer Switch for PV and AC main source. The input voltage which was originally 12VDC will be changed to 220 VAC so that it can be used for daily life. The settings for the load output use the Automatic Transfer Switch to transfer the inverter voltage to the AC main source automatically[9-10].

From these various backgrounds, the author intends to make an inverter using an Automatic Transfer Switch for PV and PLN hybrid generators. The input voltage which was originally 12VDC will be changed to 220 VAC so that it can be used for household loads. The settings for the load

* *Corresponding author.*
E-mail address: hanifah_nkn@pnm.ac.id.

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output use the Automatic Transfer Switch to transfer the inverter voltage to the AC main source automatically.

2. Methods

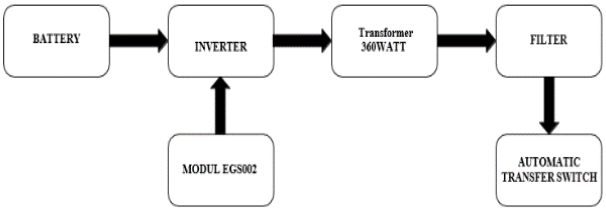

Figure 1. Block diagram of the Research

The image above is an inverter working diagram created by the author. The way the block diagram works is as follows. The battery input is the source to the inverter circuit. The EGS002 module is used to turn on the signal for switching the Mosfet in the inverter circuit. The output from the inverter circuit goes to the UPS transformer to increase the voltage to 220V. After the voltage is increased, a filter is applied to minimize the ripples in the AC signal produced by the inverter. The voltage produced by the Inverter goes to the Automatic Transfer Switch (ATS).

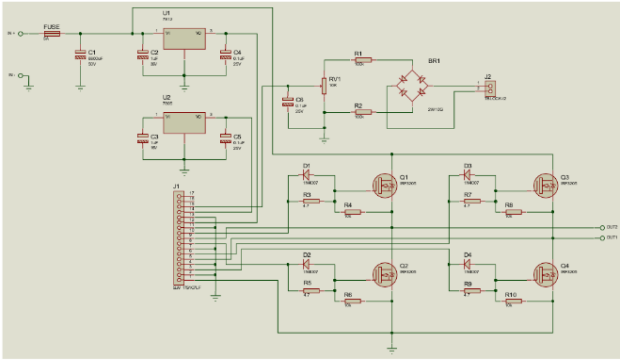

Figure 2. Design of the Inverter circuits

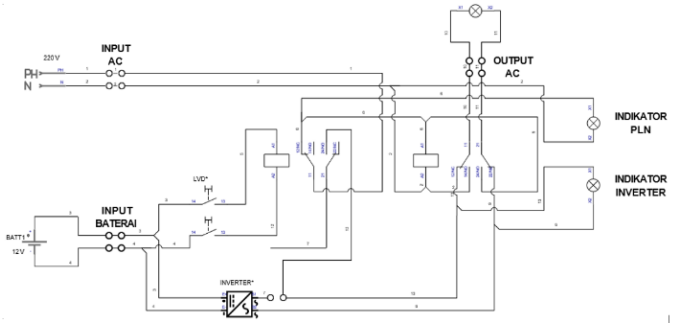

Figure 3. Design of Automatic Transfer Switch

The first stage of this research is to carry out simulations and design the components of the Inverter and ATS. Next is the process of making, assembling, and testing the tool. The process of making and assembling the tools will explain the materials used, the manufacturing time, and details of the tools made. Meanwhile, at the tool testing stage, we will discuss the tool test data and analyze each circuit in the inverter, check the SPWM signal, provide filter capacitors, measure the direct output voltage and output from the transformer, measure the output power without load and with a predetermined load. Checking the ATS is testing the delay when changing the solar panel voltage to PLN voltage, checking the MCB, Relay, LVD, Inverter and Transformer connections up to the output.

3. Result

The device assembly in this research begins with an inverter circuit on the PCB, which has been adapted to the circuit simulation, and continues with the automatic transfer switch assembly on the panel box. The ATS assembly is adjusted to the previous design using components that has been simulated on the software Proteus.

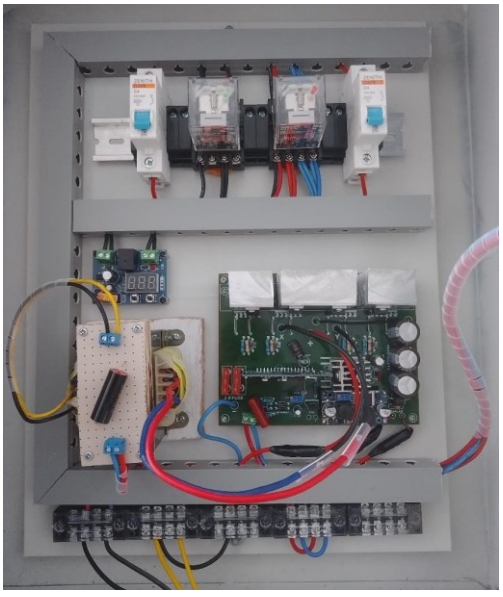

Figure 4. Assembling the inverter and ATS on panel box

3.1 No-Load Test for Inverter Output

This output testing stage is carried out to determine the signal and output voltage produced by the inverter which has been made without using a load.

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Figure 6. Output Signal Sinusoidal Pulse Width Modulation

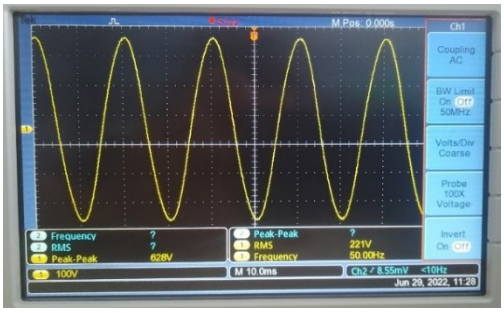

Figure 7. Sinusoidal waveform from inverter output (with passive filter and transformer)

3.2 With Load Test Inverter Output

This output testing stage is carried out to determine the signal and output voltage produced by the inverter which has been made using a load. The inverter output results in a load of 1 incandescent lamp with a power of 150 watts. Obtained an output voltage of 184V on the inverter voltage indicator (figure 8). And Inverter signal test results using a load of a bulb lamp and 1 notebook charger with a total power of 184 watts. Obtained Peak to Peak value of 436Volt. RMS is 167 Volts. Frequency of 49.90Hz. The value 100V is the Voltage/Div (figure 9).

Figure 8. Result of output inverter with bulb load

Figure 9. Result of ouput inverter with bulp and notebook charger

3.2 Automatic Transfer Switch Test Result

The ATS (Automatic Transfer Switch) testing stage is carried out to determine the delay that occurs when changing the voltage supply from AC main source to the inverter and vice versa.

Table 1. Delay testing on automatic transfer switch

Test	Result
AC main source to inverter	5 seconds delay
Inverter to AC main source	1 second delay

4. Conclution

In testing all components, namely ATS (Automatic Transfer Switch) and Inverter. In this case it can be concluded that:

1. The inverter output can produce a 220Vac voltage with a pure sine signal after passing through a transformer and filtered by a passive filter.
2. In ATS (Automatic Transfer Switch) it can be concluded that changing the input supply from the battery to the PLN can take 1 second so that the load will continue to run or work. On the other hand, changing the PLN to the inverter takes 5 seconds.
3. Both components have worked according to the expected results.

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