AIP Conference Proceedings

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Cite as: AIP Conference Proceedings **2499**, 030003 (2022); https://doi.org/10.1063/5.0105933
Published Online: 30 November 2022

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Design of a Single-phase Power Inverter with Voltage Controller Using IC SG3525

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Abstract. Currently, electrical energy from renewable energy sources such as wind energy, fuel cells, and solar cells has begun to be developed in Indonesia. However, the energy produced from this type of power plant is mostly still in direct voltage (DC). At the same time, the electrical load that must be served is electrical, primary energy consumption in the form of AC voltage. For that, we need an inverter that can convert DC voltage into AC voltage. The inverter is an electronic device capable of converting a DC voltage source into an AC voltage source with the desired magnitude and frequency. In general, current inverters are not equipped with AC output voltage control, so when the inverter load is large, it causes a voltage drop, so to overcome this, it is necessary to design an inverter that can control the output voltage through feedback so that the output voltage remains stable. In this research, the inverter is designed using IC SG3525 as an oscillator generator, IRFZ44 Mosfet driver as a power amplifier, and a step-up transformer to increase the 12V voltage to 220V. The test is done by observing the output waveform frequency and output voltage using an oscilloscope, observing the output voltage, current with a multimeter, and observing the feedback voltage to see the stability of the output voltage. The test results show that the designed inverter can produce square wave output with a maximum power of 100 Watts, an output voltage of 220V, and a frequency of 50Hz.

Keywords. Single-phase power inverter, Voltage controller, IC SG3525, square wave output voltage.

INTRODUCTION

Currently, the use of electrical energy from renewable energy sources such as wind energy, fuel cells, solar cells, and so on has begun to be developed in Indonesia [1]-[4]. However, the energy produced from this type of power plant is mostly still in direct voltage (DC) [5]. At the same time, the electrical load that must be served is electrical, primary energy consumption in the form of AC voltage [6]. For that, we need an inverter that can convert DC energy into AC energy [7]. An inverter is a piece of electronic equipment that can convert a direct voltage source into an alternating voltage source (AC) with the desired magnitude and frequency [8].

In general, current power inverters are not equipped with AC output voltage control, so when the inverter load is large, it causes a voltage drop, so to overcome this. It is necessary to design an inverter that can control the output voltage through feedback to remain stable. In this research, the inverter is designed using IC SG3525 as an oscillator generator, IRFZ44 Mosfet driver as a power amplifier, and a step-up transformer to increase the voltage from 12V to 220V. The test is done by observing the output waveform frequency and output voltage using an oscilloscope, observing the output voltage, current with a multimeter, and observing the feedback voltage to see the stability of

2021 2nd International Conference on Information Technology, Advanced Mechanical and Electrical Engineering (ICITAMEE)
AIP Conf. Proc. 2499, 030003-1–030003-6; https://doi.org/10.1063/5.0105933
Published by AIP Publishing. 978-0-7354-4286-3/$30.00

the output voltage. The test results show that the designed power inverter can produce a pure sine wave, producing a maximum power of 100 Watts, an output voltage of 220V, and a frequency of 50Hz.

This power inverter design research aims to design, test, and analyze power inverters based on IC3525. Testing the output voltage and its waveform is done using an oscilloscope. In this inverter design research, several benefits can be obtained. By making this tool, it is hoped that it can be a learning material to know more about the world of electronics, especially DC to AC conversion tools, or it can be called an inverter. This tool is expected to be useful for people who need an inverter with good and good quality. This inverter does not have a destructive impact on the long-term use of electrical equipment supplied by this inverter.

LITERATURE REVIEW

Guacci et al. [9] suggested a GaN e-FET-based three-phase two-thirds-PWM inverter. It is well established that gallium nitride dual-gate monolithic dual-gate mode e-FETs enable improved power inverter performance. This project involved the design and simulation of a power inverter. The results indicated that the efficiency of the 3.3 kW 3-bB CSI system could reach 98.4 percent while employing 2/3-PWM and a 2G MB GaN e-FET sample in the 3-power inverter experiment.

Sun et al. [10] proposed a decentralized generalized method for controlling the power factor angle droop of single-phase cascaded inverters. In comparison to other control systems, it has the advantage of allowing for smooth transitions between different modes. Additionally, the proposed inverter is suited for all sorts of loads in island mode and is capable of stable four quadrant inverter operation.

Power Inverter

A power Inverter or usually referred to as an Inverter, is an electronic device or device that can convert direct electric current (DC) to alternating electric current (AC) at the required voltage and frequency according to the circuit design. Sources of unidirectional DC power, the source of the Power Inverter, can be batteries, batteries, or solar cells. This inverter will be handy if applied and used in areas that have limited AC power supply. Because with the availability of this Power Inverter, people can use batteries or solar cells to supply household appliances such as TVs, fans, computers, or even refrigerators and washing machines which generally require an AC power supply with a voltage of 220V or 110V.

The Power Inverter can generate waveforms, sine waves, modified sine waves, and pulse width modulation waves. All of these output waves depend on the inverter circuit design that is made. However, nowadays, the most widely used waveforms are the sine waveform and the modified sine wave. The inverter can output the frequency of the electric current produced in general is around 50Hz or 60Hz with an output voltage of around 120V or 240V. The most commonly found electrical power output for consumer products is around 150 watts to 3000 watts.

In general, a Power Inverter that can convert DC electric current to AC electric current includes several parts, namely an oscillator circuit, a switch circuit, and a CT transformer, as shown in Figure 1.

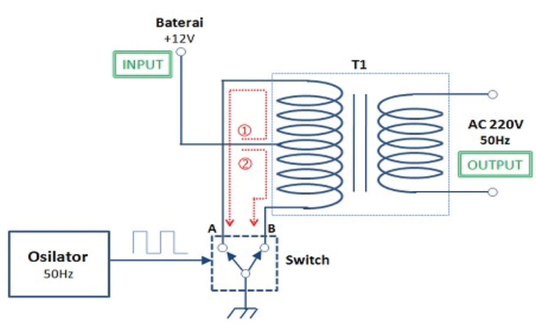

FIGURE 1. Basic structure of an inverter

A power source still in a DC electric current condition with a low voltage (e.g., 12V) is entered into the Center Tap (CT) of the Secondary Transformer. The two ends of the pins on the other Transformer, namely Pin A and Pin B, are connected through a switch (switch) with two directions to ground the network. If the switch is connected at point A, it will cause an electric current in line 1 to flow from the battery's positive terminal to the Center Tap

Primary Transformer, which then flows to point A of the Transformer to ground through the switch. When the switch is moved from point A to point B, the electric current flowing in line 1 will stop. Line 2 electric current will start flowing from the positive battery terminal to the Transformer Primary Tap Center to ground through switch point B. Points A, B, and Lines 1, 2 can be seen in the picture above,

The alternation of ON and OFF or A and B conditions on this switch is controlled by an oscillator circuit that functions as a 50Hz frequency generator. As a result, the electric current from point A to point B and point B to point A at a speed of 50 times per second was diverted. Thus, the DC electric current flowing in line 1 and line 2 also alternates 50 times per second so that it is equivalent to AC electric current with a frequency of 50Hz. At the same time, the primary components used as switches in the Switch Inverter circuit are generally MOSFETs or transistors. The secondary Transformer will produce an output in the form of a higher voltage (e.g., 120V or 240V) depending on the number of turns in the transformer secondary coil. Therefore, the turn ratio between the primary and secondary transformers used in the inverter is also significant to influence.

SG3525 Module

The SG3525A circuit module is an integrated circuit board with chips and other supporting components commonly used for designing circuits of all types of electrical power supplies. Examples of the use of SG3525A can be used in motor control circuits, DC-DC converter circuits, DC-AC converter circuits, and Lamp Dimmer circuits. This IC has several useful features for an electric power supply assembly, such as the Soft Star feature when the device is turned on. In addition, this IC serves to control the PWM signal needed for the circuit. Figure 2 shows the SG3525 module and its pin connection. The basic specifications of the SG3525A chip are:

a) The minimum voltage for IC SG3525 is 8 VDC and a maximum of 35 VDC.

b) Has an internal reference voltage set to 5.1 V + with an accuracy of ±1%.

c) Oscillator that can be changed in value from 100 Hz to a maximum of 500 kHz.

FIGURE 2. SG3525 module and its pin connection

METHODS

In Figure 3, it can be explained that the 12 Volt battery is the main power source in the power inverter test. The 12 Volt battery in the form of a DC voltage with a frequency of 0 is converted into a 12 Volt square wave AC with a frequency of 50 Hz by the SG3525 oscillator IC. The 12 Volt AC voltage is then amplified with the IRFZ44 MOSFET. The 12 Volt AC voltage which has been amplified by the MOSFET is then increased from 12 Volts to 220 Volts AC using a step up transformer. To maintain the stability of the output voltage to remain at 220 V, feedback is installed on IC 3525, which aims to control the output voltage to be stable by adjusting the size of the PWM. The next stage is the overall circuit design using the Proteus application software. This software is used because it can make a schematic clearly and there are very complete components for all types of components needed in the design of this inverter. In addition, this professional proteus software also has a simulation feature that can be used for virtual simulations, making it easier for users to design a tool.

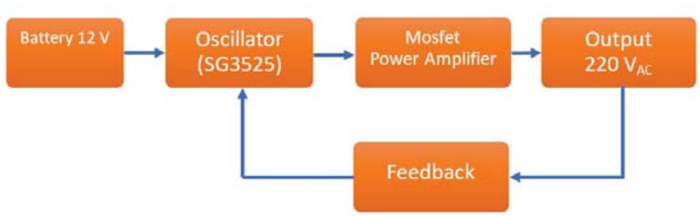

FIGURE 3. Composition of designed power inverter

RESULTS AND DISCUSSION

Testing the Output Signal of IC SG3525

SG3525 is an IC that is manufactured in a factory, so the possibility of manufacturing defects is very likely. This test aims to see the output of the IC SG3525. Testing IC SG3525 requires a DC power supply that has 12V power. Then to see if the IC SG3525 is working normally, it can be seen from the results of the output waves on the output legs A and B. To see the waves, a digital oscilloscope is needed.

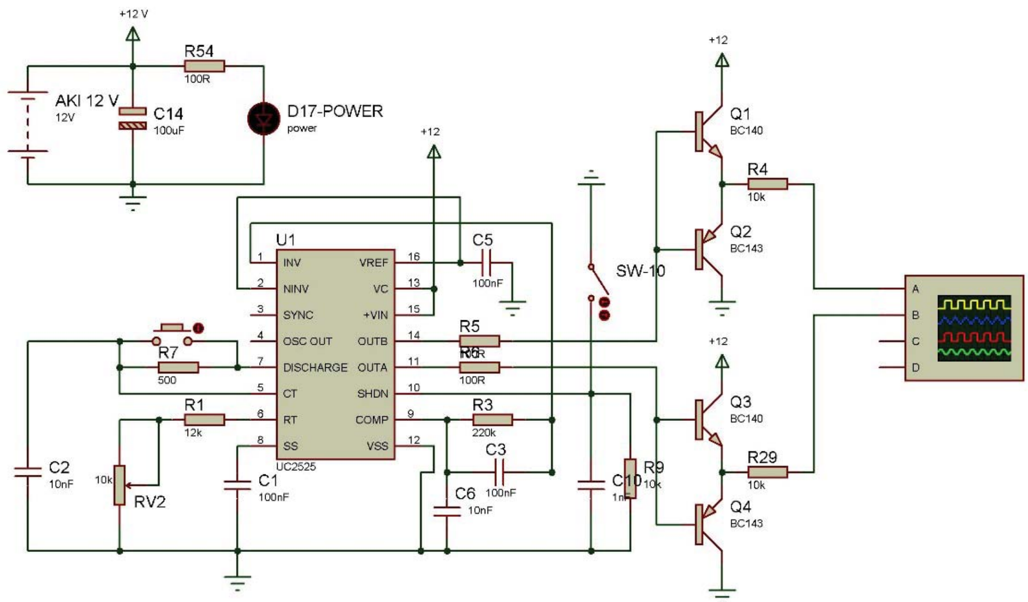

FIGURE 4. Test scheme of the IC SG3525 module

The tools needed for this test are a 12-15 V DC power supply and a digital oscilloscope. In Figure 4, it can be seen that in order to carry out the test, it is necessary to follow the scheme of installing the image. The steps that must be carried out are:

a. Connect pin out A and out B with the oscilloscope

b. Observing with an oscilloscope the waves that come out from pin Test 1 to Pin Test 4.

c. The test runs every 3 seconds and turns off because the VFB pin is grounded.

The result of testing the output voltage of the IC SG3525 module is shown in Figure 5. The figure shows that the output voltage is still in the form of a square that is not yet in the form of a pure sine wave.

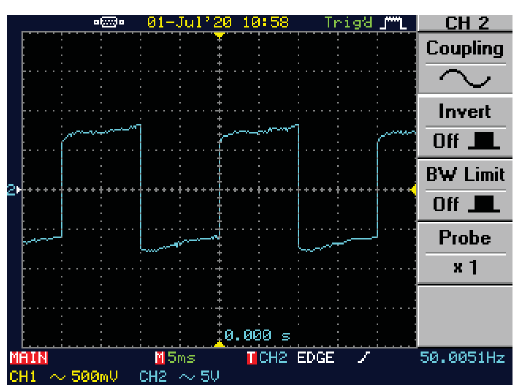

FIGURE 5. Result of output voltage of the IC SG3525 module

Testing the Feedback Voltage of the IC SG3525 Module

The SG3525 module is equipped with a feedback feature that functions to control the AC output voltage. On the SG3525, the Voltage Feedback input is on pin 1. The function of this feature is that when the inverter input drops the voltage, the SG3525 will continue to stabilize the AC output voltage by setting its PWM to always remain at 220 Volts. The feedback circuit is assembled using 4 diodes with a bridge rectifier model, 2 100k resistors and a 10k trimpot. This trimpot is used to set the desired inverter output voltage. This test requires 2 voltmeters installed at the AC output of the transformer and at the DC feedback input pin 1 SG3525. Figure 6 shows the test scheme of feedback voltage testing of the IC SG3525 module.

The tools needed for this test are one DC power supply and two digital multimeters. The test steps are:

a. Attaching an analog voltmeter to the output
b. Install a digital voltmeter on the feedback voltage.
c. Rotate the trimpot RV1 to see the effect of the feedback voltage on the output voltage.
d. Observe the magnitude of the feedback voltage and output voltage.

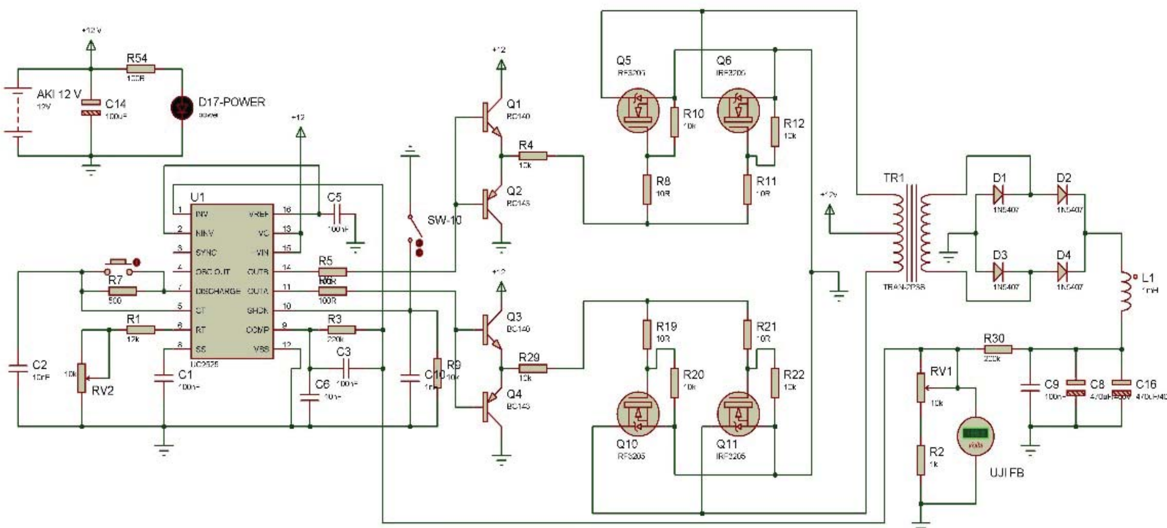

FIGURE 6. Test scheme of feedback voltage testing of the IC SG3525 module

TABLE 1. Results of measuring the feedback voltage

No.	Input DC Voltage (volts)	Output AC Voltage (volts)	Feedback Voltage (volts)
1	13.5	55	3.01
2	13.5	100	3.03
3	13.5	150	3.06
4	13.5	200	3.08
5	13.5	220	3.09
6	13.5	242	3.10

Table 1 contains the results of a feedback voltage test connected to the SG3525 module's pin 1. The test begins by determining the output voltage, which is 55 volts AC, and the feedback pin voltage, which is 3.01 volts DC. Then, with the output voltage set to 100 volts AC, a feedback voltage of 3.03 volts DC is generated. The test is carried out in stages, with the output voltage being monitored. The most recent test was conducted at 242 volts AC, resulting in 3.10 volts DC feedback. After testing and collecting voltage data, it is clear that the higher the AC output voltage from the power inverter, the higher the feedback voltage that reaches the ICSG3525 module.

CONCLUSION

Based on the results of the design and data analysis, it can be stated that the design of a single-phase pure sine inverter using the integrated circuit SG3525 was effective, as evidenced by the inverter's performance at various input voltages, specifically 12-15 volts DC. The output voltage is around 215–220 Volts AC, which is stable at 50Hz. The inverter is capable of operating with a variety of different electrical loads, including resistive, inductive, and capacitive loads. The feedback voltage is proportional to the output voltage.

After conducting study, the authors discovered various points that can be used as proposals for future research, specifically that it is hoped that it can be continued as an inverter with pure sine output. Additionally, to boost the inverter's power capability, a high-power Mosfet must be included. Additionally, it is recommended to employ high-quality and proven primary and supporting components because they have a significant impact on the tool's performance.

ACKNOWLEDGMENTS

The authors express their deepest gratitude to the Directorate of Research and Community Service, Directorate General of Higher Education, Ministry of Education, Culture, Research, and Technology of the Republic of Indonesia, and Universitas Muhammadiyah Yogyakarta.

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