International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 08 Issue: 05 | May - 2024 SJIF Rating: 8.448 ISSN: 2582-3930

DESIGN OF PHOTOVOLTAIC POWER INVERTER

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ABSTRACT

Our attention has shifted to renewable energy sources due to the increased demand for energy and the ongoing depletion of fossil fuels. These sources are not only a sustainable and limitless supply of energy in the future, but they are also environmentally benign. The first type of renewable energy is solar energy. The design of the solar inverter, which is needed to drive AC loads and is mostly utilized for consumable purposes, is the main topic of this essay. The developed inverter has a 100W power output, a 12V input voltage, a 220 V output, and a 50Hz square wave output.

Keywords – *Square wave, Battery Maintenance, Photovoltaic cell, etc.*

1. INTRODUCTION

Solar inverters have become increasingly popular in recent years, as evidenced by the growing number of individuals utilizing them. The surge in their usage highlights the rising necessity for solar inverters in the current era. Essentially, a solar inverter functions similarly to a conventional electric inverter, but it harnesses the power of the Sun, specifically solar energy. By leveraging solar power, these devices play a crucial role in converting direct current into alternating current. Direct current flows in a singular direction within a circuit and is instrumental in delivering electricity in the absence of a traditional power supply. This type of power is typically employed in small electronic devices such as mobile phones, MP3 players, and iPods, where energy is stored in batteries. Conversely, alternating current oscillates back and forth within a circuit and is commonly used to power household appliances. The primary function of a solar inverter is to facilitate the operation of DC-powered devices on AC power, enabling users to take advantage of alternating current.

The decision to opt for a solar inverter over a standard electric inverter is justified by the utilization of solar energy, a readily available, clean, and environmentally friendly power source derived from the Sun. Often referred to as photovoltaic solar inverters, these devices have the potential to yield substantial cost savings for consumers. While small-scale grid systems comprise only two components – panels and inverters – off-grid systems are more intricate, incorporating batteries that store excess energy for use during periods without sunlight, such as nighttime. Rooftop solar panels and batteries work in tandem to capture sunlight and convert it into electricity.

Excess electricity is stored in the batteries to power appliances when sunlight is not accessible, ensuring continuous functionality. The integration of solar inverters into residential and commercial settings exemplifies a shift towards sustainable energy practices and the adoption of renewable power sources. As technology advances, solar inverters are poised to play an increasingly pivotal role in meeting the energy needs of diverse consumer segments.

The necessity of operating AC Loads using solar energy necessitates the development of Solar Power Inverter. Given that the majority of contemporary conveniences rely on 220 volts AC, the Power Inverter serves as the core component of the Solar Energy System. Not only does it change the low voltage of 12 volts DC to the 220 volts AC required to power most appliances, but it can also replenish the batteries when linked to the utility grid, as is the case with a completely independent stand-alone solar power system. These inverters are specially crafted to extract energy from a battery, regulate the battery's charge through an integrated charger, and transmit surplus energy to the utility grid.

An inverter stands as an electronic apparatus that alters direct current (DC) into alternating current (AC); the converted AC can be adjusted to any desired voltage and frequency through the utilization of suitable transformers, switching mechanisms, and control circuits. Solid-state inverters, devoid of mechanical components, find application across a broad spectrum, ranging from minor switching power supplies in computers to extensive electric utility high-voltage direct current systems that transport substantial power volumes. Inverters are widely employed to furnish AC power from DC origins like solar panels or batteries.

2. BLOCK DIAGRAM

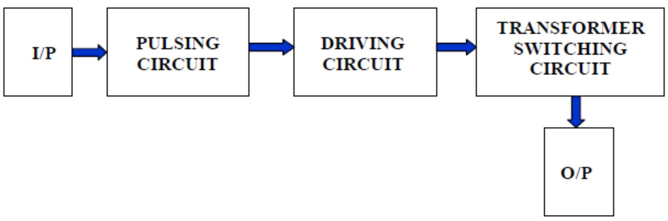

Fig.No. 2.1 : Block diagram of Proposed System

3. METHODOLOGY

The three components of the inverter circuit are as follows:

- SECTION A is the pulsing circuit;
- SECTION B is the driving circuit; and
- SECTION C is the transformer switching circuit.

3.1 SECTION A (PULSING CIRCUIT)

An integrated circuit (chip) called the 555 Timer IC is utilized in many oscillator, pulse-generating, and timer applications.

In this circuit configuration, the 555 timer functions as a monostable multivibrator, a commonly utilized electronic circuit for generating a single pulse of a specific duration. Within the provided schematic, the control (CTRL) reference voltage necessary for the timer's operation is sourced from capacitor C2, which plays a crucial role in determining the timing characteristics of the circuit. Capacitor C1, on the other hand, is responsible for defining the triggering voltage required to initiate the timing process within the monostable multivibrator. It is essential to understand the distinct functions of each component in this circuit to comprehend the overall operation and functionality of the 555 timer when utilized as a monostable multivibrator.

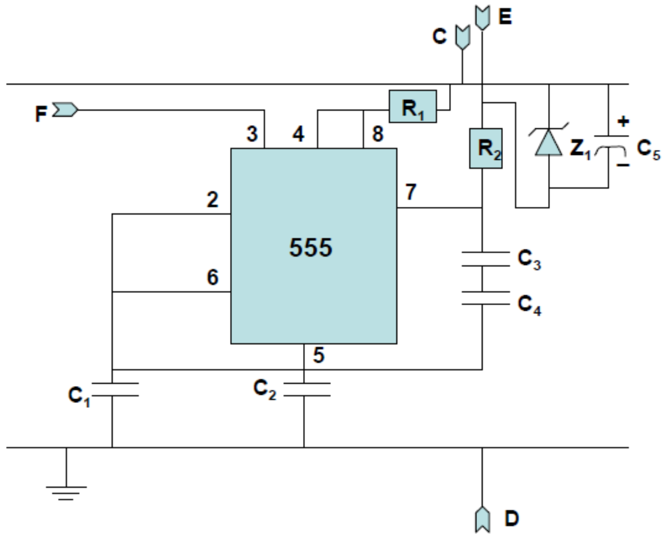

Fig.No. 3.1 : Pulsing Circuit of Proposed System

The third pin, denoted as pin number 3, establishes a direct electrical connection to the positive voltage supply terminal, commonly referred to as +Vcc, within the electronic circuit. This connection serves to provide a source of power to the specific component or module associated with pin 3, ensuring its proper functionality and operation in the overall system.

The reset pin, also known as pin number 4, along with pin number 8, are specifically designated for the purpose of providing the necessary drive signal to activate the transistor Q2 within the driving circuit, thereby enabling the proper functionality and control of the circuit.

The pulse produced by the 555 timer is supplied to the drive circuit by the paths C, D, E, and F. Since pin number 7 is the discharge pin, a zener diode (Z1) and a capacitor (C5) are employed to maintain the voltage.

A monostable multivibrator, sometimes known as a one-shot multivibrator, is a circuit that generates pulses. The C network, which is externally linked to the 555 timer, controls how long each pulse lasts. When the circuit is in a stable or standby condition, its output is either logic-low or roughly zero. Applying an external trigger pulse causes the output to become pushed high (» VCC). The external RC network attached to the timer determines how long the output stays high. The output automatically returns to its logic-low stable condition at the conclusion of the time interval. Up until another trigger pulse is applied, the output remains low. The cycle then starts over. The term "monostable" refers to a circuit that has just one stable state, which is output low.

Figure 2.3 555 displays the internal diagram for a 555 timer functioning as a monostable multivibrator.

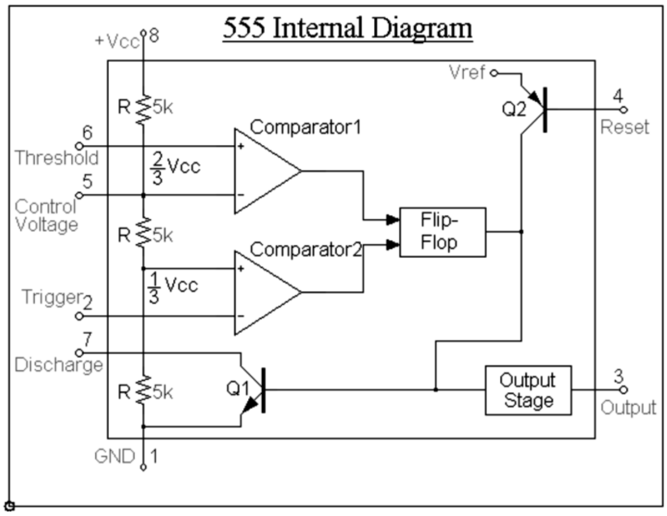

Fig.No. 3.2 : The Multivibrator's Internal Diagram

- **DESCRIPTION OF THE 555TIMER**

Supply voltage (V_{CC})	4.5 to 15 V
Supply current (V_{CC} = +5 V)	3 to 6 mA
Supply current (V_{CC} = +15 V)	10 to 15 mA
Output current (maximum)	200 mA
Maximum Power dissipation	600 mW
Power Consumption (minimum operating)	30 mW@5V, 225 mW@15V
Operating Temperature	0 to 70 °C

PIN	NAME	PURPOSE
1	GND	Ground, low level (0 V)
2	TRIG	OUT rises, and interval starts, when this input falls below 1/3 V_{CC}
3	OUT	This output is driven to $+V_{CC}$ or GND.
4	RESET	A timing interval may be interrupted by driving this input to GND
5	CTRL	"Control" access to the internal voltage divider (by default, 2/3 V_{CC})
6	THR	The interval ends when the voltage at THR is greater than at CTRL.
7	DIS	Open collector output; may discharge a capacitor between intervals.
8	V+,VCC	Positive supply voltage is usually between 3 and 15 V.

3.2 SECTION B (DRIVING CIRCUIT)

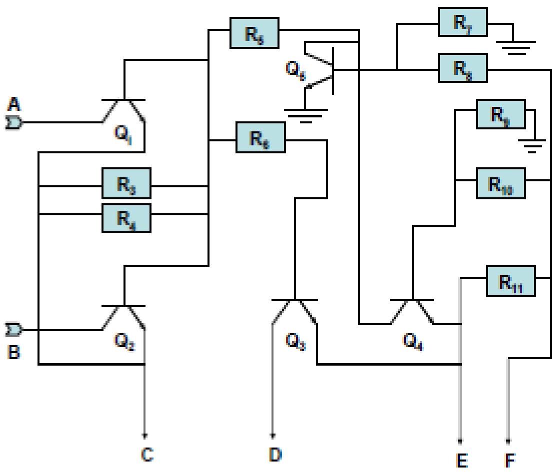

Fig.No. 3.3 : Inverter's Driving Circuit

Since the voltage from the inverting transistors is insufficient to drive the transformer, which has a higher rating, this driver circuit is essentially necessary. To improve heat dissipation, the power transistors are linked to the heat sink.

The circuit essentially comprises a pair of transistors, namely two SL100 (Q1 and Q2), which function to generate a square wave output. This square wave output is then subjected to the influence of an additional transistor, the 147B (Q5), which serves the purpose of inverting one of the square wave outputs, thereby resulting in the attainment of a full-wave square output. Furthermore, the resistances R11 and R7 are strategically employed in this circuit to establish the reference voltages for the transistors Q4 and Q5, respectively. Similarly, the resistances R9 and R10 are incorporated in the circuit to regulate the base current of transistor Q4, while R8 is dedicated to controlling the base current of transistor Q5. Subsequently, the aforementioned square wave is directed towards a pair of power transistors, namely Q6, Q7, Q8, and Q9, through the intermediary of two resistances, R12 and R13, thereby constituting the driver circuit for the transformer. Moreover, the inclusion of a diode (D1 and D2) in each pair of power transformers serves the crucial function of upholding the unidirectional flow of current within the circuit.

3.3 SECTION C (TRANSFORMER SWITCHING CIRCUIT)

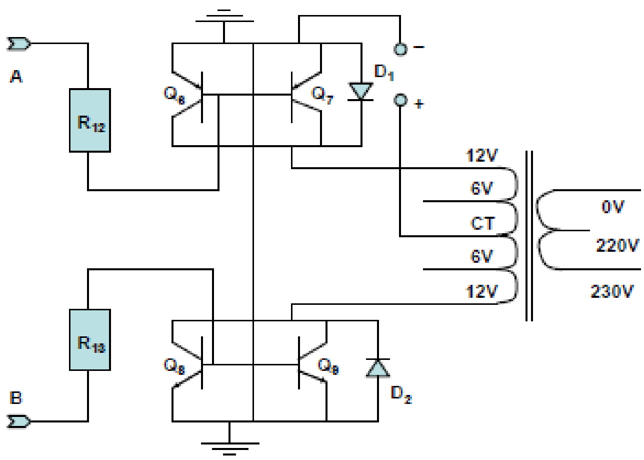

Fig.No. 3.4 : Inverter Transformer Switching Circuit

- In the transformer switching circuit, the driving circuit's (A and B) output is supplied.

- The power transistor pair (Q6-Q7 and Q8-Q9) then receives the output pulse via resistances (R12 and R13).
- In essence, the resistances control the power transistors' base current. The power transistors are grounded at the emitters.
- To keep the current flowing in a single direction, the diodes (D1 and D2) are connected to each pair of power transistors.
- Better heat dissipation is achieved by connecting the power transistors to the heat sink.
- Once the pulse passes through A, it reaches the upper part of the 12-0-12 transformer's main coil, producing an output voltage of 220 volts on the secondary side.
- The output voltage received has an alternating nature because the lower part of B generates an output voltage on the secondary side when the pulse is sent through it.

In order to obtain a 220v output, a transformer is essentially needed. A 12-0-12 charger type push pull connected transformer is essentially the transformer that is being utilized here.

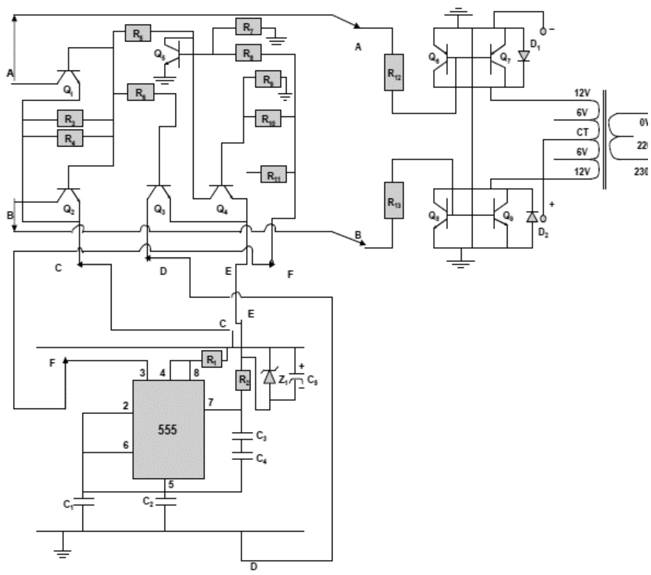

Fig.No. 3.5 : The circuit diagram for the Solar Inverter

3.4 The protective features of our project solar inverter

A. Overload Protection : The solar inverter will return to the protected state after 20 seconds if the load is reduced, or if the power consumption of the appliance or appliances exceeds the total power of the inverter.

B. Short Circuit Protection : The solar inverter will return to the protected mode if an appliance short circuits and won't stop working until the equipment is removed.

C. Thermal Protection : The solar inverter will go into protective mode if it becomes too hot and won't stop until it cools down by itself.

D. Reverse Polarity Protection : The voltage meter's hand will point in the opposite direction if the solar inverter is connected improperly, preventing any current from flowing through it.To that end, the positive terminal of the inverter is linked to a diode (IN5408).

4. ADVANTAGES

After thoroughly understanding what a solar inverter is and how beneficial it is to operate appliances both at home and in the workplace, we need to talk about the various benefits of the gadget.

- Greenhouse gas emissions and global warming have always been mitigated by solar energy.
- Solar energy usage also results in cost savings, since many individuals have begun utilizing solar-powered appliances.
- The process of converting direct current into batteries or alternate current is aided by a solar inverter. This is beneficial to those with minimal power usage.

- Because they are enormous in size, synchronous solar inverters benefit small homes and electricity businesses.
- Then there is this multipurpose solar inverter, which is the most effective and efficient of all. Because of its meticulous conversion of DC electricity to AC, it is ideal for commercial buildings.
- Because it is less expensive than generators, this inverter is cost-effective.
- In addition to solar inverters, solar cookers and heaters are among the various gadgets that harness solar power.
- The best option is to use solar inverters, which are superior to standard electric ones. Additionally, they don't require much money for upkeep.

5. DISADVANTAGES

- Initially, purchasing a solar inverter requires a substantial financial outlay.
- Only in conditions of high sunlight can it function well and generate direct current.
- The solar panels that gather sunlight take up a lot of room.
- Only when the Sun is strongly present can the gadget function as intended.
- When there is enough sunlight to fully charge their battery, solar inverters may function even in the absence of sunlight.

After considering a few of the drawbacks of solar inverters, we can conclude that even very beneficial devices eventually need to have adequate maintenance performed on them. In the case of solar devices, solar energy equipment is an absolute must. Thus, only get a solar device if you have an abundance of sun energy accessible.

6. RESULT & CONCLUSION

The output generated by the inverter primarily consists of a square wave pattern rather than a sine wave form. This distinctive square wave form offers certain advantages compared to the traditional sine wave configuration. Specifically, when it comes to illuminating a tube light, the square wave output eliminates the need for a choke, which in turn leads to cost savings due to the simplified setup and reduced components required in the circuit. This difference in wave patterns highlights the efficiency of square wave output in specific applications such as lighting, emphasizing the practical benefits of this waveform in modern electronic systems.

7. FUTURE SCOPE

The following next studies can make use of the model and controller for the PV inverter that have been developed:

- Currently, in the event that any abnormal situations arise, the PV inverter has to be unplugged from the grid. To enable the inverter to work in both grid-tied and islanding modes, a control system must be created and researched.
- Inverter shot through control approaches need additional research since increasing the shoot through duty ratio causes an increase in inductor current ripple.
- It will be interesting to look at further repetitive control and other grid current controllers, such as the resonant controller, for canceling harmonic currents.

- It is necessary to take into consideration how the partial shading condition affects MPPT performance.

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