CARITAS UNIVERSITY AMORJI-NIKE, EMENE, ENUGU STATE

Caritas Journal of Physical and Life Sciences

CJPLS, Volume 3, Issue 2 (2024)

Article History: Received: 15th October, 2024 Revised: 3rd December, 2024 Accepted: 14th December, 2024

DEVELOPMENT AND IMPLEMENTION OF MODIFIED SINEWAVE 3.5KVA INVERTER

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Abstract
The instability of Nigeria's power supply has driven research into alternative solutions within the power sector. This paper focuses on the design and construction of a 3.5 kVA single-phase modified sine wave inverter, capable of efficiently converting DC voltage to AC voltage at a reduced cost. The system allows for adjustable output voltage and frequency through an integrated oscillator circuit (SG3524N), transformers, and precise switching and control circuits. Key components, including MOSFETs, diodes, resistors, and deep-cycle batteries, work collectively to meet the functional requirements of a reliable inverter. Challenges encountered during design were addressed, resulting in an inverter that delivers a stable output current of up to 15.9A and a consistent 220V AC output from a 24V DC input during performance testing.

Keywords: ***Inverter, PWM control circuit, MOSFETs, Oscillator circuit(SG3524N), Deep-cycle batteries.***

Introduction

The need for reliable and stable electricity in Nigeria has become critical due to frequent power outages affecting both residential and commercial sectors. This project addresses this issue by designing and constructing a 3.5 kVA inverter to serve as a backup power solution for a typical 3-bedroom flat. Inverters convert DC power stored in batteries to AC power, making them an eco-friendly alternative to fuel-powered generators. This project explores inverter technology, focusing on efficient, sustainable, and stable power supply. The paper objectives include the design and construction of a 3.5 kVA inverter and testing its performance and cost-effectiveness. In this context, an inverter is a device that converts direct current (DC) to alternating current (AC), enabling continuous operation of electrical appliances during power failures.

Literature Review

Inverters have evolved significantly over the past century. Originally, AC-DC conversion was achieved using mechanical components such as rotary converters, which were inefficient and costly. Today, modern solid-state inverters employ advanced semiconductor devices, such as Bipolar Junction Transistors (BJTs) and Metal-Oxide-Semiconductor Field-Effect Transistors (MOSFETs), which are efficient, reliable, and compact.

Inverters are classified by their output characteristics (square wave, sine wave, modified sine wave) and by the source of their input (voltage or current). In this project, a modified sine wave inverter is employed due to its balance of efficiency and cost-effectiveness. Pulse Width Modulation (PWM) is the control technique used, which allows for efficient power regulation by controlling the inverter's switching frequency.

System Design

The system design centers on creating a modified sine wave inverter with a power rating of 3.5 kVA, suitable for supporting household appliances like lights, fans, and TVs. The inverter receives a DC input from a 12V battery, which it converts into a stable AC output of 220V at 50Hz, compatible with the national grid standard.

Key components and circuits include:

- **MOSFETs and BJTs**: These serve as the primary switching devices due to their high power-handling capabilities, efficiency, and fast switching rates.
- **PWM Control Circuit**: This regulates the switching devices to maintain a stable output frequency and voltage.
- **Transformer**: A center-tapped transformer is used to boost the low-voltage DC input to the required AC output.
- **Battery**: The inverter is powered by a deep-cycle battery, which provides a stable energy source even under heavy loads.

The design also considers the inverter’s energy efficiency, component durability, and environmental impact, ensuring that the inverter operates effectively with minimal energy loss and heat dissipation.

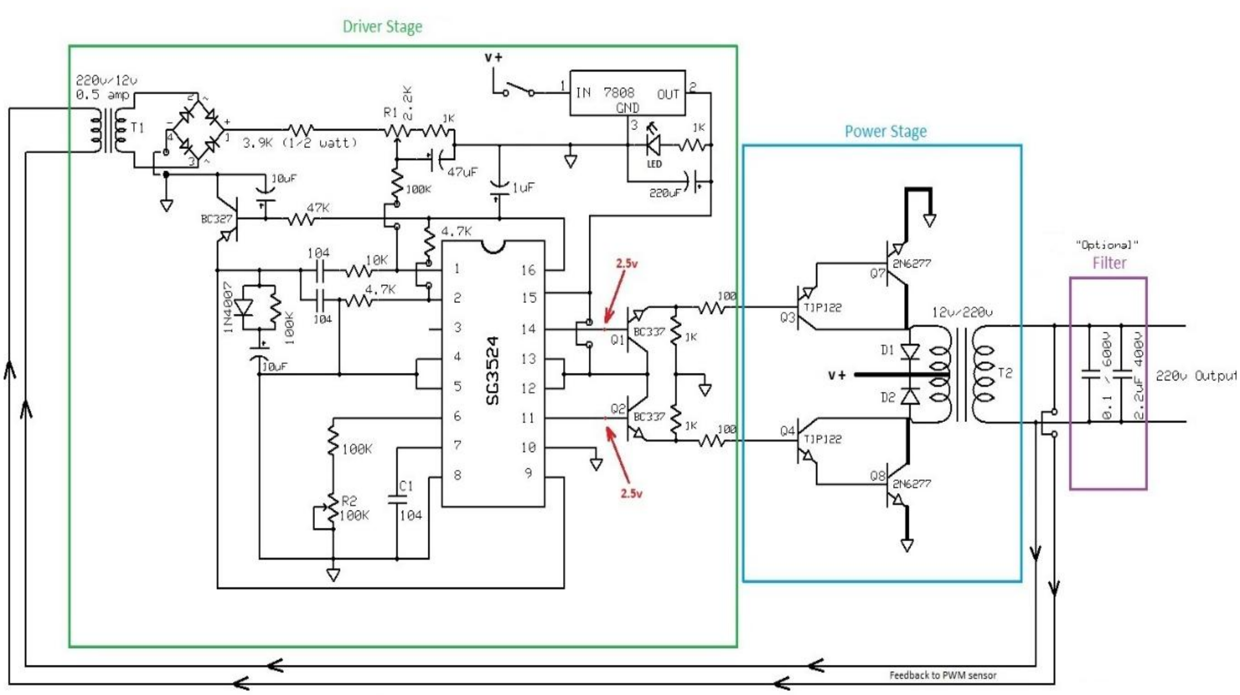

Fig 1.0: Circuit diagram of 3.5KVA Modified Sinewave Inverter. (EDAboard.com, 2103)

Methodology

The inverter operates through a two-step process:

1. **DC Boost Conversion**: The low DC input voltage is first converted to a higher DC voltage.
2. **AC Conversion with PWM**: The boosted DC voltage is converted to AC using a PWM technique, which controls the MOSFETs to produce a modified sine wave output.

This process is managed by several integrated circuits, sensors, and relays:

- **AC Mains Sensor**: Detects the presence of grid power and seamlessly switches to battery power when the grid is down.
- **Oscillator and Driver Circuit**: Generates a 50Hz PWM signal, driving the MOSFETs to achieve the AC output.
- **Battery Charger and Changeover Circuit**: Allows the inverter to switch between battery and grid power, ensuring consistent availability of AC power.

The inverter is designed to work with single-phase power, making it ideal for residential use, while maintaining a power output of 3.5 kVA. The paper also includes provisions for circuit protection, including fuses and relays, to safeguard against over-voltage and current spikes.

Testing and Results

VA	PRIMARY THEORETICAL	PRIMARY MEASURED	SECONDARY THEOREICAL	SECONDARY MEASURED
VOLTAGE	24V	24.4V	220V	218.1V
CURRENT	145.83A	146.23A	15.909A	16.1A

Table 1.0: Result for 3.5KVA Transformer Test

Table 4.1 in the full report presents the results, showing that the inverter meets the expected voltage and current outputs . The system's efficiency and reliability confirm its suitability for residential backup power.

Construction

The construction process involved designing and assembling the circuit on a printed circuit board (PCB). The project's casing was carefully selected to ensure durability, heat dissipation, and ease of handling. Metal was chosen as the primary casing material to improve thermal regulation and protect internal components.

Additional design considerations include:

- **Ventilation**: Airflow within the casing prevents overheating of components, extending the inverter's lifespan.

- **Portability**: Compact design minimizes the space required, making the inverter practical for home installation.
- **Component Arrangement**: Strategic component placement on the PCB reduces electrical noise and enhances stability.

Discussion

This project demonstrates that inverters can serve as a reliable backup power source, particularly in regions like Nigeria where power interruptions are frequent. The use of modern components, such as MOSFETs and BJTs, significantly enhances the inverter's efficiency and stability, making it a practical alternative to traditional generators.

Challenges during construction included managing MOSFET heat, which was mitigated with heat sinks, and controlling noise in the charging circuit, which was reduced with filter capacitors. These design enhancements ensure that the inverter can withstand extended periods of operation without compromising performance.

Conclusion

The 3.5 kVA inverter constructed in this project successfully meets the power demands of a typical 3-bedroom flat, providing a stable, efficient, and environmentally friendly alternative to fuel-powered generators. Its high efficiency (96.08%) and steady AC output (220V at 50Hz) make it a dependable backup solution, especially in regions with unreliable grid power.

The inverter offers significant advantages over generators, including reduced noise, zero emissions, and lower operational costs. This project underscores the inverter's role in residential power applications, with potential scalability for larger capacity demands.

Recommendations

For future work, the inverter's capacity could be scaled to 5 kVA, meeting higher power demands. Additionally, integrating solar charging capabilities would reduce dependence on the grid for battery charging, further enhancing the inverter's sustainability. Implementing more advanced MOSFET technologies could improve overall efficiency and stability, particularly under heavy load conditions.

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