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HYBRID INVERTER SYSTEM USING PULSE WIDTH MODULATION

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ABSTRACT

This work on the hybrid Inverter System using pulse width modulation is basically a Width Modulated (WM), Metal Oxide Semiconductor Field Effect Transistor (MOSFET) based Inverter which works on the principle of Pulse Width Modulation. The inverter uses the integrated (IC) and a pair of some MOSFETs to drive the load. The design and implementation starts with the power supply. Component selection was made with the aid of electronics data book, which made the design and calculations very easy. One main feature of this hybrid inverter is the monitoring section, and the battery-charging section connected to the inverter circuit. The inverter converts DC supply of the battery into AC power supply required by most electrical appliances/equipment when the AC main is not available and when the AC main is available. The AC main supply goes to the AC mains Sensor, the Relays and Battery charging section of the inverter.

Key Words: Hybrid, Inverter, Pulse width modulation, Transistor, Integrated circuit

1.0 Introduction

The problem of erratic power supply in Nigeria has affected the socio-economic growth of the country. Electricity is one of the greatest inventions due to its very vital role in socio-economic and technological development. Electricity can be transmitted in two ways namely; alternating current (AC) or direct current (DC). Direct current has a limited use and it depends on alternating current (AC), and the direct current cannot travel far because of its higher loss tendency and difficulty in transformations. Alternating current is safer for long distance transmission [3]. Direct current is preferred over alternating current because of its probability hence the introduction of a hybrid inverter that is mobile alternating current source from portable direct current battery. An inverter is a power electronic device that converts direct current (DC) to alternating (AC), the converted alternating current can be at any required voltage frequency with the use of appropriate transformer, switching and control circuit.

This work is aimed at the design of a hybrid inverter. As Rectifier converts AC to DC, Inverter is the name given to DC to AC conversion. Hybrid inverters are a new piece of solar technology that combines the benefits of a traditional solar inverter with the flexibility of a battery inverter into a single device. Inverter could be designed

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to use a renewable energy source such as solar energy to power a system and serve as a substitute when electric power from a utility source is not available, i.e. it is designed to provide uninterruptible alternating current (220 volts) power supply to the load connected to its output socket. The switching is done by the sensor, relay and battery charging section of the inverter automatically to enhance efficiency and productivity of the users[1]. Modern inverters are less bulky, and more efficient with the use of Integrated Circuits technology and solid state devices [7]. There are different types of inverter which include:

a) Square Wave Inverter: The output wave form of the voltage for this inverter is a square wave as shown in figure 1. This type of inverter is least used among all other types of inverter because all appliances are designed for sine wave supply.

If we supply square wave to sine wave based appliance, it may get damaged or losses are very high. The cost of this inverter is very low but the application is very rare. It can be used in simple tools with a universal motor.

(b) Sine Wave Inverter: The output wave form of the voltage is a sine wave and it gives us a very similar output to the utility supply. This is the major advantage of this inverter because all the appliances we are using are designed for the sine wave. So, this is the perfect output and gives guarantee that equipment will work properly. This type of inverters is more expensive but widely used in residential and commercial applications [2].

(c) Modified Sine Wave: The construction of this type of inverter is complex than simple square wave inverter but easier compared to the pure sine wave inverter.

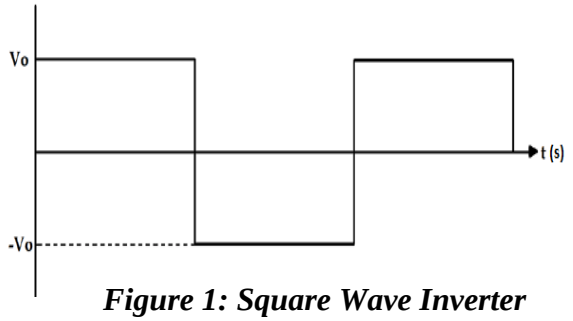

Figure 1: Square Wave Inverter

The output of this inverter is neither pure sine wave nor the square wave as could be seen in figure 2. The output of such inverter is the sum of two square waves. The output wave form is not exactly sine wave but it resembles the shape of a sine wave [6].

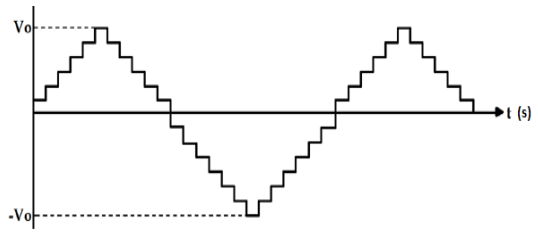

Figure 2: Modified Sine Waved Inverter

There are different types of inverter based on their sources which include the following:

a) Current Source Inverter *(CSI)*: In Current source inverter, the input is a current source. This type of inverters is used in the medium voltage industrial application, where high-quality current wave forms are compulsory.

b) Voltage Source Inverter (VSI): In Voltage Source Inverter (VSI), the input is a voltage source. This type of inverter is used in all applications because it is more efficient and has higher reliability and faster dynamic response. Voltage Source Inverter (VSI) is capable of running motors without de-rating. Inverter is categorized according to the type of load:

In terms of phases, the inverter has two types viz single phase inverter and three phase inverter. Single-Phase Inverters are popularly used in residential and commercial areas.

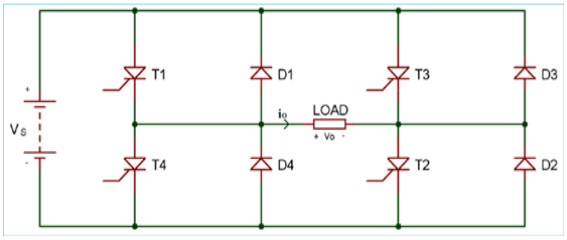

Figure 3: Single Phase Full- Bridge

a) **Single Phase Full-Bridge Inverter**: In this type of inverter, four thyristors and four diodes are used. The circuit diagram of single-phase full bridge is as shown in below figure 3.

b) **Three Phase Bridge Inverter**: In case of industrial load, three phase ac supply is used and for this, we have to use a three-phase inverter. In this type of inverter, six thyristors and six diodes are needed and they are connected as shown in below figure 4.

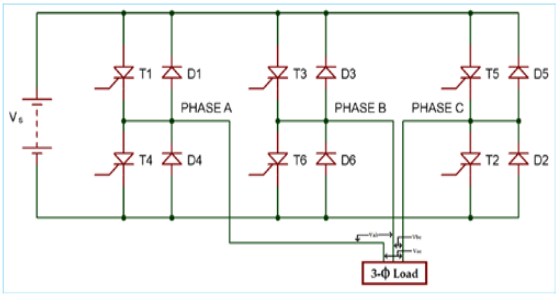

Figure 4: Three Phase Bridge Inverter

2.0 Material and Methods

The materials used for this work include:

(i) bipolar transistor, (ii) thyristors and (iii) Metal-Oxide Semiconductor Field Effect (MOSFET) (iv) Deep Cycle Battery: (v) Battery Balancer: (vi) Flexible Cable: (vii) Battery Lug; (viii) AC Circuit Breaker (ix) DC Circuit Breaker (x) Battery Rack:

In designing an inverter the first step should be to analyze the load which is to be powered. When an inverter is connected to power a load that is beyond its recommended capacity, it may lead to damage, failure or reduction of the life span of the inverter. After the design and construction, the installation is a very sensitive aspect for proper working durability of the inverter. The cable size and type, type of battery, and battery connections if the batteries are more than one, the distance between the inverter and the load must be considered.

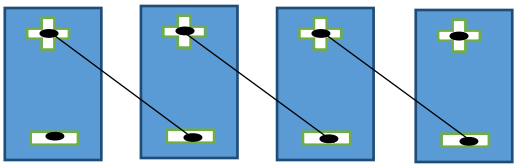

Figure 5: Diagram of series connection of batteries

The positive and negative of both ends of the battery bank (first and fourth) will be connected to the positive and negative of the inverter battery terminal. A 50A DC circuit breaker is connected along the battery to inverter cable for battery isolation if need arises. A 30A AC circuit breaker is connected between the AC input and inverter for AC input isolation.

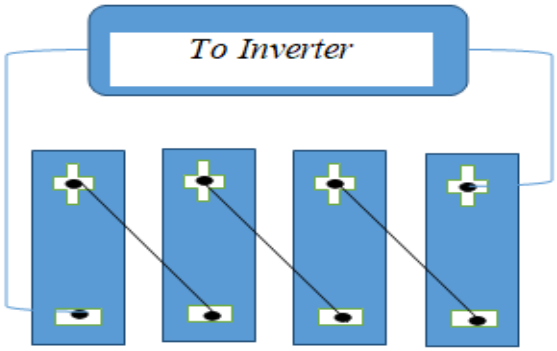

Figure 6: Diagram of four batteries series arrangement as connected to inverter

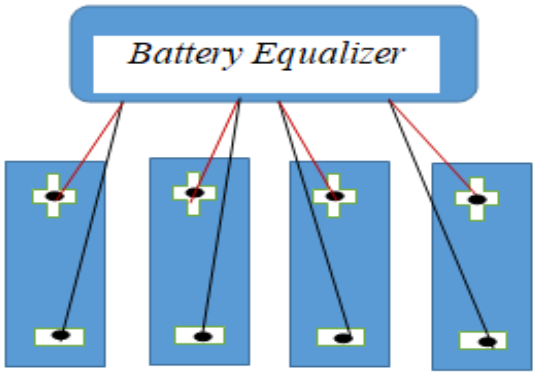

Figure 7: Battery Equalizer

The representation below is the block diagram of the complete inverter installation process.

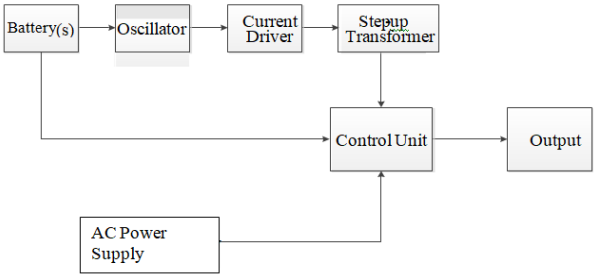

Figure 8: Block Diagram of the inverter

For the control unit, the ATMega8 microcontroller serves as the central processing device, it monitors inputs such as voltage level of battery, Power Distribution Company input current/voltage level, etc. This unit has five (5) relays connected to it via a current driver IC, ULN2003 which can drive up to 500mA current. The ULN2003 drives the relays according to decision taken by the microcontroller.

At the oscillator unit, the DC energy from the battery is converted to AC energy of a specified frequency. It is an electronic source of alternating current or voltage having sine, square, saw tooth or pulse width. In particular, this design is a Pulse Width Modulated, MOSFET based Inverter. The oscillator used in this design was Pulse Width Modulation regulator control (SG3524) which was modified to sine wave using BC557 transistors. MOSFETs are metallic oxide semi-conductors in which the gate is completely insulated from the channel by a thin layer of silicon oxide. This permits operation with gate source or gate channel voltage above and below zero. A step-up center tapped transformer is used and it will step up 48V AC from the output of the inverter unit to the desired 220V AC.

3.0 Results

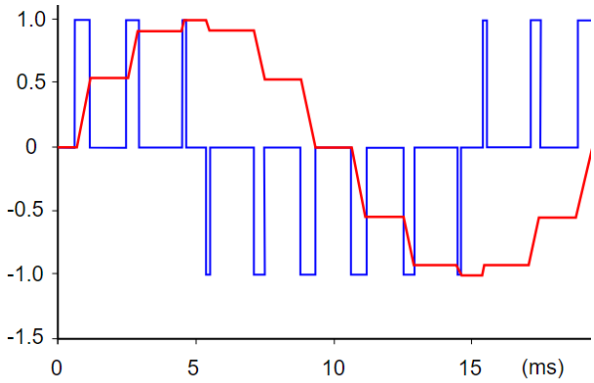

Figure 9: The output of a pulse width modulated hybrid inverter

The pulse width modulated inverter produces an output in form of a pulse width modulated output. The input was extracted from the modified sine wave form. It could follow the modulation as could be seen. At peak voltage of 1V with varying periods (t). The output varies in width as the time changes**.**

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