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Design and Implementation of a 625va Pulse Width Modulated Inverter

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Abstract - *The inverter has overtime been accepted as a good alternative source of power supply due to its environmental compatibility. In this work, a 625VA Pulse Width-Modulated (PWM) Inverter at a frequency of 50Hz is designed and implemented. The circuit makes use of PWM controller that generates a PWM signal which is fed to the MOSFET Driver stage. The PWM controller, MOSFET driver stage and output stage which are the three main stages are active circuits which are powered by battery(s). The inverter was found to perform well when tested. The duration at which the inverter discharges under load condition depends on the total power of load connected to its output terminal and the power rating of the battery connected to its input terminal. At a load of 350watt and a battery capacity of 100AH, the inverter duration was found to be 2 hours 18 minutes.*

Key Words: Inverter, Pulse Width Modulation, MOSFETs, Batteries, DC, AC

1. INTRODUCTION

The role electricity plays in our everyday lives cannot be overemphasized. Virtually all activities of man both professional and domestic, revolves around electricity. Electronic communication systems, medicine, agriculture, education, as well as various house hold appliances that makes life comfortable all depends on electricity in its various forms. Therefore when there is a problem with power supply, the economy and the people by extension are adversely affected. Hence, there is always a need for alternative power supply. An inverter is an alternative source of power which is environmental friendly, with low maintenance cost and which can be readily available.

An inverter is an electronic device or circuitry that changes direct current (DC) to alternating current (AC). The input voltage, output voltage and frequency, and overall power handling depends on the design of the specific device or circuitry. The inverter itself does not generate any power; the power is generated from a DC source like a battery. Usually, when we talk about the inverter, it is generally with an arrangement of inverter circuit and a battery. It can also be combined with other sources like wind or solar energy. Basically, an inverter is used to supply uninterrupted 220V AC to the load connected to its output socket. It provides constant AC supply at its output socket, even when the AC mains supply is not available [1]

Any device that works on DC supply can be used during the mains power breakdown by connecting them to batteries. But batteries have a fixed life and running power consuming equipment using the battery could be very expensive. [2]. Hence, rechargeable batteries can be used in this type of situation to reduce the cost. An inverter is used to power device that does not have the facility to connect to a DC power source or device that requires AC power source for its operation.

Formerly, Pulse Width Modulation (PWM) techniques were used in voltage and current source Inverter alone but with the availability of self-commuted devices, such as power transistor, Metal Oxide Semiconductor Field Effect Transistor (MOSFET), Insulated Gate Bipolar Transistor (IGBT) *etc.* pulse width modulated DC to AC converter is now common in many applications. The steady state and active performance of Inverters, AC to DC converters, and DC and AC drives are significantly dependent on the pulse width modulation techniques. [3]

Pulse Width Modulation (PWM) of a signal or power source involves the modulation of its duty cycle, to either convey information over a communication channel or control the amount of power sent to load.[3]

2. REVIEW OF RELATED WORKS

This section reviews a few related work that has been done on inverters, inverter design and construction.

The inverter is one of the most important components in an independent energy system. An inverter converts direct current to alternating current, and also changes the voltage. In other words, we can say that it is a power adapter. It allows a battery-based system to run conventional home appliances like television, fan, computer, *etc*. through conventional home wiring. We can use direct current directly, but for a modern lifestyle, we need an inverter for the vast majority of equipment. It provides power supply when there is cut in the utility power supply. It plays very important role in areas where there is regular cuts in power supply. It works on the basic principal of charging and discharging of battery. [4]

Chaniago *et al.* (2008), gave a brief idea about choosing an inverter. they discussed different parameters like where it is to be used, what type of loads (appliances) you will be powering, the maximum power the inverter will need to handle, the quality of the power critical, size and weight of inverter, *etc.*[5].

Osuwa and Peter (2014), in their paper, described the production of solid state inverters which provides environmental friendly alternative for uninterruptible power supply for the working of different gadgets and for sustainable economy. The study was anchored on the design and construction of 1 KVA inverter for provision of power using locally sourced 80 Ah 12 volts deep cycle battery. The construction was divided into four units namely, oscillator units, MOSFETs assembly unit, Transformer unit and battery charger monitor unit. In building the inverter for the conversion of DC to AC at a normal frequency of 50 Hz, Due consideration is given to the switching speed of the oscillator used to make sure that the MOSFETs in their two channels operate in their saturation and cut off states when appropriately driven by oscillator outputs in a way to complement each other. [6]

Omitola, *et al*. (2014), opined that in the modern society, electricity has great control over the most daily activities for instance in domestic and industrial utilization of electric power for operations. Electricity can be generated from public supply to users in different ways including the use of water, wind or steam energy to drive the turbine as well as more recently the use of gas Generators, solar energy and nuclear energy are as well source of electricity. They designed and constructed a 1000Watts (1KW) 220 Volts Inverter at a frequency of 50Hz. This device was constructed with locally sourced components and materials of regulated standards. The basic principle of its operation is a simple conversion of 12V DC from a battery using integrated circuits and semiconductors at a frequency of 50Hz, to a 220V AC across the windings of a transformer.

Mburu (2014), designed a microcontroller based pure sine wave inverter using Pulse Width Modulation (PWM) switching scheme to supply AC utilities with emergency power. It involves generating of unipolar modulating signals from a Programmable Interface Computer (PIC16F887A) and using them to modulate a 12V dc MOSFET based full H-Bridge. The focus of the work was designing an inexpensive, versatile and efficient pure sine wave inverter that gives a 240V, 600W pure sine wave output. [7]

In a standard Inverter without the PWM technology, the output voltage changes according to the power consumption of the load. The PWM technology corrects the output voltage according to the value of the load by changing the Width of the switching frequency in the oscillator section. As a result of this, the AC voltage from the Inverter changes depending on the width of the switching pulse. To achieve this effect, the PWM Inverter has a PWM controller IC which takes a part of output through a feedback loop. The PWM controller in the Inverter will make corrections in the pulse width of the switching pulse based on the feedback voltage. This will cancel the changes in the output voltage and the Inverter will give a steady output voltage irrespective of the load characteristics. [7]

3. Design and Implementation

The methodology involved in this work ensured that the inverter elements for this project were designed and selected to withstand the inverter rated value of 625va at maximum load. The basic block diagram of a Pulse-width-Modulated (PWM) inverter is shown in fig.1. A PWM controller generates a PWM signal which is fed to the MOSFET Driver stage. The PWM controller, MOSFET driver stage and output stage are active circuits which are powered by a battery. The battery charger unit could be an appropriate mains charger circuit or an alternative source charger controller which replenishes the battery.

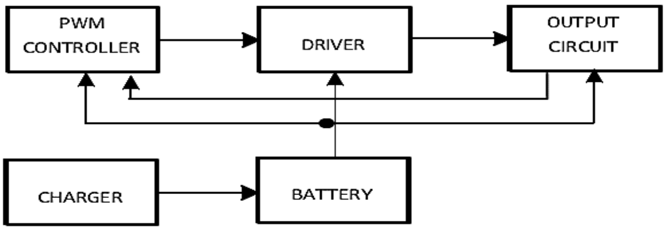

Fig -1: Basic Block Diagram of a Pulse-Width-Modulated (PWM) Inverter

3.1 Oscillator section

In this section, 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. This particular design is a Pulse Width Modulated (PWM), MOSFET based Inverter.

The required 50Hz signal is generated by the PWM controller IC (SG3524). This versatile PWM controller can be used in a variety of isolated and non-isolated switching power supplies such as inverters. This IC has internal circuits for the entire operation of the pulse width modulation. The Oscillator circuit to generate the switching frequency is also incorporated in the IC. [8] By supplying a constant 12Volt DC through a voltage regulator to the IC SG3524 PWM, the frequency of the oscillating signal was determined by connecting a variable resistor in series with a resistor and both connected in parallel with a capacitor to form the RC time constant network.

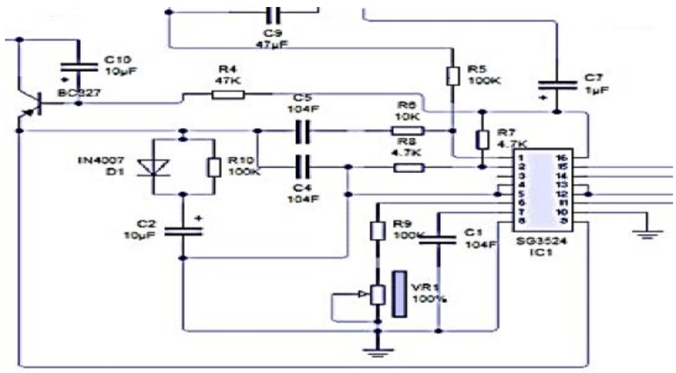

Fig -2: A Circuit of the Oscillator Section

3.2 MOSFET Driver Section

The MOSFET stage is shown in fig. 3. It conducts the load current through the centre-tapped step up transformer. The MOSFET used in the design is IRF150, N-Channel. Fixed resistors of 10kΩ were connected between the gate and source to aid fast switching by discharging any residual charge at the gate. A total of four MOSFETs were used for the design of the MOSFET driver. Two for each half of the full period.

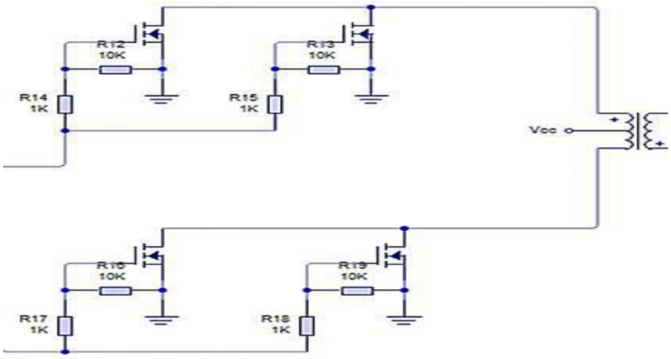

Fig -2: A Circuit of the MOSFET Driver Section

This configuration consists of an array of MOSFETs connected in parallel. The MOSFET used in this design has its path number as IRF150 and the following data sheet parameters:

- Current rating = 38A
- Voltage rating = 100V
- Power factor (pF) = 0.8
- Power rating = 150W

The required number of MOSFETs per channel for a 625VA Inverter is thus obtained:
P = VA cosθ
Where cosθ = pF; and P = actual or real power of the Inverter.
Therefore;
P = 625 x 0.8 = 500W
The Total number of MOSFET is given by:
Number of MOSFETSs = Actual Power of the design/ Power rating of the MOSFET:
That is; 500/150 = 3.3333
Hence, 4 MOSFETs were used; with 2 on each parallel channel, boosting the current to drive the transformer.

3.3 Output Feedback Section

The voltage feedback section is made up of a step-down transformer, a bridge rectifier arrangement of four diodes and resistor divider network. These serve to sample the output dc of the battery to the PWM IC that will in turn affect the pulse width modulation of drive pulses. The circuit is shown in Fig.4

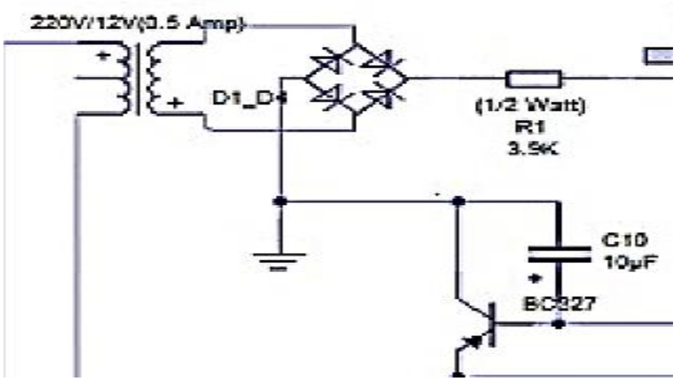

Fig -4: Output Feedback Section

3.4 Structure and mode of operation

A complete circuit diagram of the PWM inverter circuit is shown in Fig 5. IC (SG3524) is the pulse-width modulator IC and its function is to generate the 50Hz alternating pulses from pin 14 and 11, needed to drive the MOSFET banks of the four (4) MOSFETs. R9 and C1 determine the frequency of oscillation. Resistors R4 and R7 set the reference voltage for pulse width modulation control, through pin 2 of the IC. This reference is constantly compared with the voltage at pin 1 from the feedback loop to determine the trend of the pulse-width variation but it works in inverse relation, so as to balance the change in output voltage. When the output voltage tends to increase, the pulse width reduces and vice versa to keep the output voltage constant within a tolerance range.
The MOSFET banks made of the four MOSFETs make up the power drivers. The alternating pulse output from IC is fed to the MOSFET banks. The MOSFETs switch the DC voltage at the primary of centre-tapped transformer, which is serving as the step-up transformer to create the alternating voltage effect and flux change needed for transformation by the transformer. The transformer then would step up the now converted 12V DC to 220V AC. Transformer, bridge rectifier D1-D4, R1 and R5 make up the feedback network. The output voltage is rectified to DC. Resistor R5 helps to appropriately adjust the error voltage for effective control. When the output voltage increases, the auxiliary winding output voltage increases and this causes increase in output from R5. This change is detected by IC through pin1 and the consequence is that the pulse-width of the pulses generated is gradually reduced in proportion to the change. This is so that the output voltage that was initially high would begin to drop to the nominal value and vice versa.

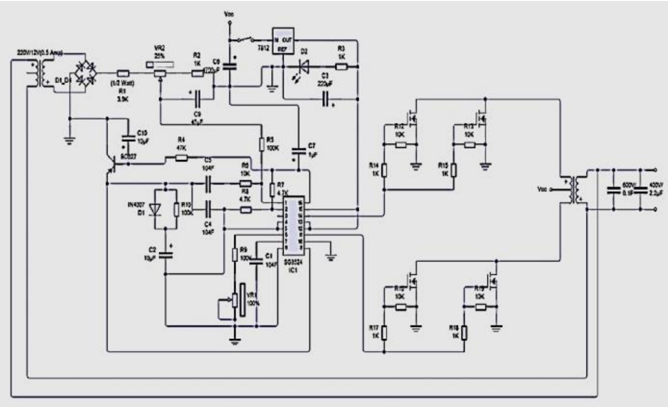

Fig -5: Circuit Diagram of the PWM Inverter Circuit

4. CONSTRUCTION AND TESTING

The construction of the inverter is all about soldering and coupling of the active circuit. The soldering was done on a Vero board with a 60 watts soldering iron, the components were properly arranged by following the designed circuit diagram of the project. In order to conform to the requirement of this project, temporary construction of the prototype was done on bread board before finally transferring it onto the Vero-board for permanent soldering. The circuit was constructed, tested and put to use under proper load conditions. In other to achieve accuracy in the design, some necessary adjustments were made to some of the components used. The complete unit was housed in a metallic blue casing. Battery terminals for positive and negative, power switch, handle and output meter were fixed in their allotted slots and connected to their respective points on the circuit. The casing was earthed and each stages carefully arranged inside and connected together.

While constructing, all components used were tested to ascertain their conformity with the required standard of the objective of this project. The output voltage of the inverter was filtered by a 2.2µF/400V capacitor connected across the output terminals to remove the unwanted harmonics so as to get as smooth as possible sine waveform output voltage. The duration at which the inverter discharges under load condition depends on the total power of load connected to its output terminal and the power rating of the battery connected to its input terminal. Bearing in mind that total load must not exceed 500watts.

Table -1: Performance Analysis of the Inverter

Battery Rating (V)/(AH)	Total Load(W)	Duration (Hrs)
12.0/100	150	5.2
12.0/100	350	2.3

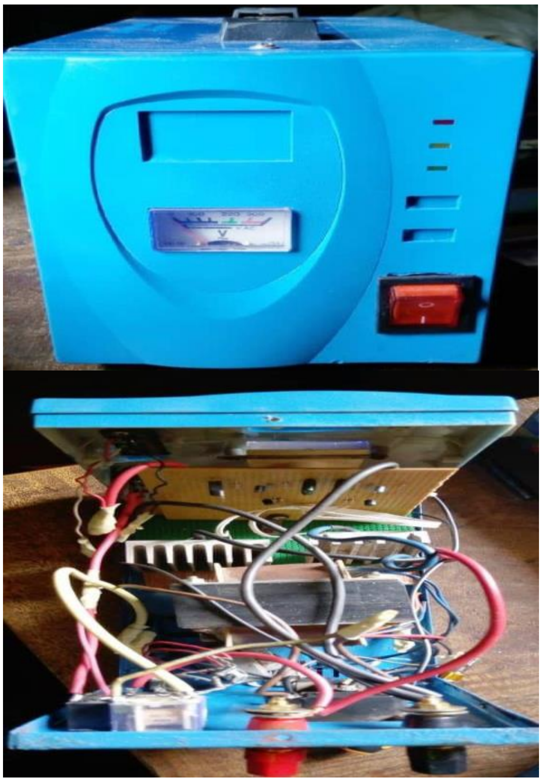

Fig -6: Completed Inverter

4. CONCLUSIONS

The erratic power supply in the country calls for an alternative power supply to be used as an emergency. This inverter has met the objective and purpose for which it was designed. It can be used in homes, offices and industries to serve as an alternative power supply because of the following advantages: Low maintenance cost, no moving parts, no noise pollution, Easy installation and no environmental pollution. The performance of the project after test met design specification. The general operation of the design and performance depends on the user who is prone to human error such as overloading the system, making wrong battery connection or using wrong battery voltage.

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REFERENCES

[1] O. O. Omitola, S. O. Olatinwo and T. R. Oyedare, " Design and Construction of 1KW (1000VA) Power Inverter," *Innovative Systems Design and Engineering* vol.6 no. 2 pp.1 – 13, 2014

[2] D. Suleiman, "Design and Construction of a 500Watts Inverter," B.Tech Thesis, LAUTECH, Ogbomoso, Nigeria. 2000

[3] C. Anene., 'Design and Implementation of a 5 kVA Inverter', *Journal of Electrical and Electronics Engineering* 2016

[4] N. Narendra, T. Shubham, N. Gaurav, D. Akshay and T. Ashish, "Design of Automatic Electricity Inverter," *International Journal of Advanced Research in Computer and Communication Engineering*, vol. 6 no. 2 pp. 478 – 480, 2017

[5] K. Chaniago, J. Selvaraj and N. Rahim, "Implementation of Single-Phase Grid Connected Inverter Using TMS320F2812," *3rd IEEE Conference on Industrial Electronics and Application*, 2008 p. 1498-1502.

[6] J. C. Osuwa and C. F. Peter, " Construction and Implementation of 1 KVA Inverter," *IOSR Journal of Applied Physics, vol. 6 no. 6 pp. 56 – 58, 2014*

[7] M.B. Mburu, "A Pure Sine Wave Inverter for House Backup," B.Sc. Thesis, University of Nairobi, Kenya. April, 2014

[8] http://www.maxim IC SG 3524 Pulse Width Modulation

[9] A. K. Theraja and B. L. Theraja, "A text book of Electrical Technology," *22nd Ed, S. Chan and Co. Ltd*, Delphi., 1997