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RESEARCH ARTICLE

SIMULATION OF INVERTER CIRCUIT USING MULTISM AND PROTEUS

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ABSTRACT

An inverter is an electrical device that converts direct current (DC) to alternating current (AC). The converted AC can be at any required voltage and frequency with the use of appropriate transformers, switching and control circuits. An inverter is essentially the opposite of a rectifier. In this project work, a 500W power inverter system was designed, simulated and constructed. The values of the various components were determined before the simulations were embarked upon using electronic workbench: Multisim® and proteus® software respectively. The inverter circuit in this project work is based on the operation of the IC CD4047. 12V AC is stepped up to 230V AC by using a step up transformer. The assembled composite unit worked well. The oscilloscope measurement tallied with the set frequency of 50Hz and the square wave oscillator output. The inverter system is capable of providing power to the appropriate load for up to eight hours; depending on the state of the 12V batteries

KEYWORDS: Inverter, electricity generation, Multisim, square wave, Proteus

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INTRODUCTION

Due to today's total dependence on electricity and because of frequent electrical power outage, back up power is becoming a necessity. Emergency back-up power system can provide electrical power to critical loads or the whole house during power outages.

Emergency power systems are types of systems, which may include lighting generator and other apparatus, to provide back up resources in a crisis or when regular systems fail.



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They find uses in a wide variety of setting from residential homes to hospitals, scientific laboratories and computerized systems. Emergency power system can rely on generators or uninterruptible power supplies. All type of electronic devices requires power supply from electric power sources for their operation. This source can be either generator or a battery. In our society today, the need for power supply can not be over emphasize, because the provision of good and services could be completely cut off without electricity power supply. For one to fully enjoy the betterment of living in this new dispensation there should be an adequate stable source of power supply (Tharaja, 2007).

In the world today there are currently two forms of electrical transmission, Direct Current (DC) and Alternating Current (AC), each with its own advantages and disadvantages. DC power is simply the application of a steady constant voltage across a circuit resulting in a constant current. A battery is the most common source of DC transmission as current flows from one end of a circuit to the other (Dongyuan, 2015). Most digital circuitry today is run off of DC power as it carries the ability to provide either a constant high or constant low voltage, enabling digital logic to process code executions. Historically, electricity was first commercially transmitted by Thomas Edison, and was a DC power line. However, this electricity was low voltage, due to the inability to step up DC voltage at the time, and thus it was not capable of transmitting power over long distances (Paul, 2015).

Electrical transmission has therefore been mainly based upon AC power, supplying most Nigerian homes with a 220 volt AC source. It should be noted that since 1954 there have been many high voltage DC transmission systems implemented around the globe with the advent of DC/DC converters, allowing the easy stepping up and down of DC voltages.

Over the years electricity has been generated through energy conversion from one place to another. Some of these energy sources are; Solar, Thermal, Wind and Electric generators etc. These sources have proved to be quite reliable and efficient but, over the years due to inadequate sources of energy to run the engines or a fault in the system as a result of poor maintenance, they have failed the users at one time or the other (Tharaja, 2007). As such the need for a reliable standby power supply is essential which brought into existence an alternative means called **inverter**.

Inverters are electronic circuits that convert DC to AC. We can easily say that inverters transfer power from a dc source to an ac load. The objective is to create an ac voltage when only a DC voltage source is available. A variable output voltage can be obtained by varying the input DC voltage and maintaining the gain of the inverter constant. On the other hand, if the DC voltage is fixed & not controllable, a variable output voltage can be obtained by varying the gain of the inverter, which is normally accomplished by pulse width-modulation (PWM) control within the inverter (Harry, 2008). The inverter gain can be defined as the ratio of the ac output voltage to dc input voltage.

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This paper presents the design and construction of 500VA square wave power inverter system using MULTISIM and PROTEUS software for the simulation. The simulation is meant to create a better understanding of the output wave form.

CATEGORIES OF INVERTERS

Inverters are finding their extensive uses now a day. Previously they were only used in some main applications, which would be large scale and expensive. But now, inverters are like a small compulsory electronic device, on which many of our other main electronic equipment depend.

They are extensively used, not only because of their universal function of converting DC power to AC power, but also because of their high efficiency, reduced power costs and versatile applications.

These days, they are being used extensively in applications where there is a frequent power cut off, because in case of power failures, inverters are a very good and efficient power remedies. For every classification, we form some basis first, depending upon which we can further categorize our results for easier understanding and a better approach (John, 2001). This is done in order to promote better understanding and a more extensive classification of different things.

Inverters are primarily classified on the basis of their output characteristics. So there are three different types of outputs we get from inverters, and hence we classify inverters into three primary classes, which are: (i) Square Wave inverter. A square wave inverter is one of the simplest inverter types, which convert a straight DC signal to a phase shifting AC signal. But the output is not pure AC, i.e. in the form of a pure sine wave, but it is a square wave. At the same time they are cheaper as well. The simplest construction of a square wave inverter can be achieved by using an on-off switch, before a typical voltage amplifying circuitry like that of a transformer fig.1 (a). (ii) Modified Sine wave inverter or quasi sine wave inverter. The construction of this type of inverter is a bit more complex than a simple square wave inverter, but still it is a lot simpler than a pure sine wave inverter. A modified sine wave shows some pauses before the phase shifting of the wave, i.e. unlike a square it does not shift its phase abruptly from positive to negative, or unlike a sine wave, does not make a smooth transition from positive to negative, but takes brief pauses and then shifts its phase fig.1 (b). (iii) Pure sine wave inverter. The electrical circuit of a pure sine wave inverter is far more complex than a square wave or modified sine wave inverter. Another way to obtain a sine output is to obtain a square wave output from a square wave inverter and then modify this output to achieve a pure sine wave Fig.1 (c).

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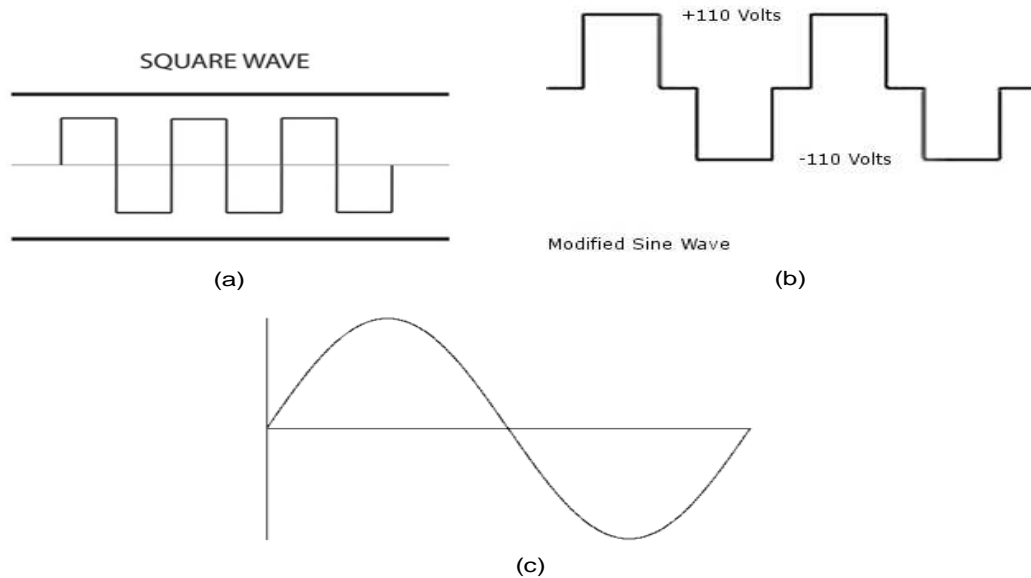


Fig. 1: The output waveform of various inverter system

METHODOLOGY

This project work was undertaken on the net and other source to ascertain the basic operating principle of inverters in general. The block diagram which reflects the basic units of the desire system was then developed using PROTEUS® 8.0 and MULTISIM® Software respectively to ascertain the output wave form before the actual hardware design.

CIRCUIT DESIGN ANALYSIS

This section deals with the design stages of the complete circuit diagram of the electrical inverter. The design took the following stages:

Design Specification

Output power = 500W
 Frequency = 50Hz
 Input voltage = $12V_{dc}$
 Output voltage = $220V_{ac}$

Transformer Rating

Required output voltage (V_2) = 15V
 Input voltage (V_1) = 220v
 Primary turns (N_1) = 300
 Secondary turns (N_2) = X
 $N_2 = N_1 V_2 / V_1$

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$$= 300(15) / 220$$

$$= 20 \text{ turns.}$$

$$\text{Transformer output current} = 2\text{V}$$

$$\text{Output power} = 15\text{V} \times 2\text{A}$$

$$= 30 \text{ W}$$

Transformer Design

Determination of number of turns is calculated using 500W. In order to achieve a good number of turns flux density of 1.531 tesla was assume and the following calculation was made:

$$A = (\sqrt{P/5.58})$$

Where A = Area in square meter (m²), P = power in watts (W) = 500W and 5.58 is a constant $A = \sqrt{500/5.58} = 4.58\text{cm}^2 = 4.58 \times 10^{-4} \text{ m}^2$
 $E = 4.44 f \Phi_m N$ and
 $\Phi_m = B_m \times A$

Where, E = emf of transformer in volt (V)
 f = Frequency in Hertz (Hz) = 50Hz,
 Φ_m = flux in Weber (w)
 B_m = flux density in tesla = 1.531 tesla
 A = Area in square meter (m²) = $4.58 \times 10^{-4} \text{ m}^2$ and
 N = number of turns
 $\Phi_m = 1.531 \times 4.58 \times 10^{-4} = 7.01198 \times 10^{-4} \text{ w} = 70.1198\text{mw}$

Determination of number of turns on primary side, emf per turn E_1
 $E_1 = 4.44 \times f \times \Phi_m = 4.44 \times 50 \times 7.01198 \times 10^{-4} = 0.1557 \text{ V/turn}$

Primary Turn N_1 :
 $N_1 = V_1 / E_1 = 12 / 0.1557 = 77.0881 \text{ turns} \approx 77 \text{ turns}$

Secondary Turns N_2 :
 $(N_1 / N_2) = (V_1 / V_2)$
 $N_2 = (N_1 \times V_2) / V_1 = (36 \times 220) / 12 = 1411 \text{ turns}$

Rectifier Circuit

The bridge rectifier circuit is usually used to rectify the pulses or waveforms of AC to DC voltage using both half cycles of the input ac voltage. The Bridge rectifier circuit is shown in figure 2. The circuit has four diodes connected to form a bridge. The AC input voltage is applied to



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the diagonally opposite ends of the bridge. The load resistance is connected between the other two ends of the bridge.

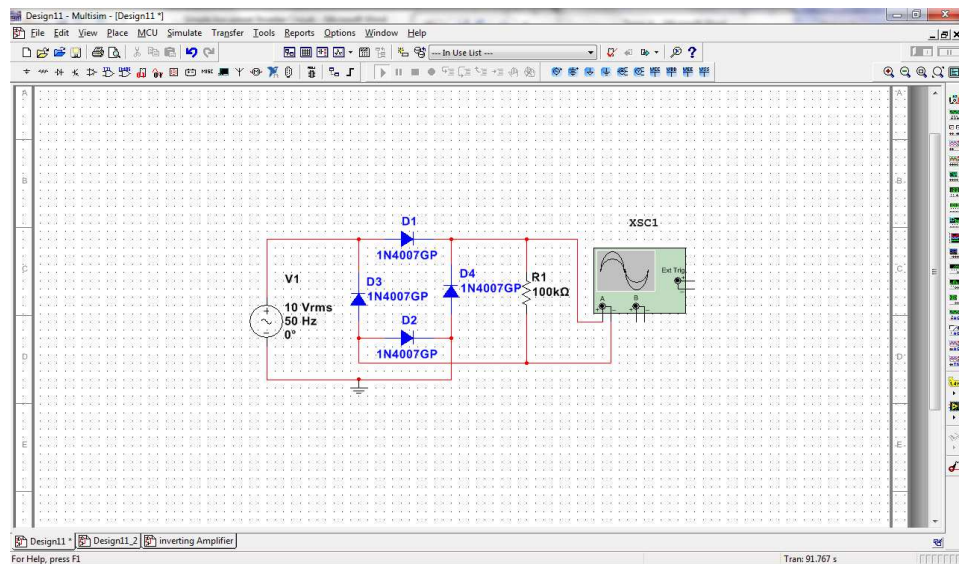


Figure 2: Full wave rectifier circuit diagram

the components used are: (1) Sinusoidal voltage source: 10V, 50Hz (2) 4 diodes: 1N4007 (3) Resistor: 100k ohms and (4) Oscilloscope

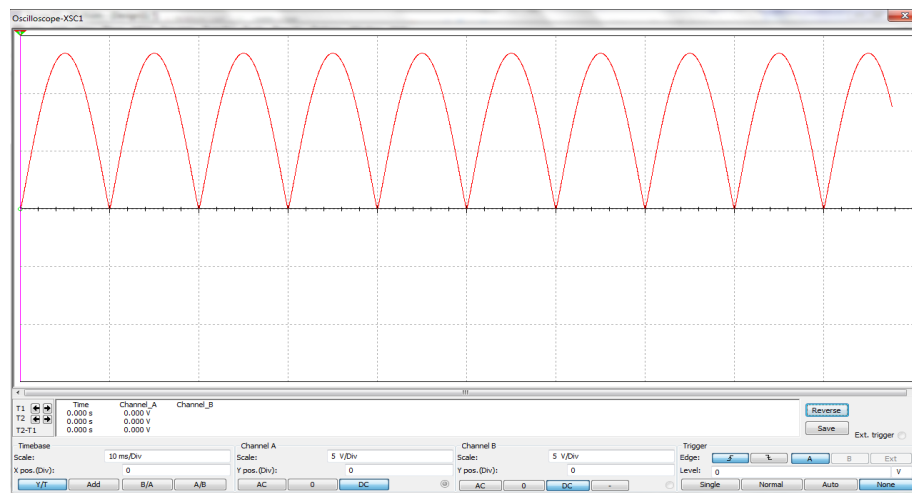


Figure 3: Full wave rectifier output waveforms

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When we ran the simulation, only 2 diodes will conduct in each half cycle and will give rise to a voltage waveform which doesn't contain any negative half of the original sinusoidal waveform. In practical DC application, we can't use a DC with such a heavy ripples. So to reduce the ripples, we can make use of capacitors. These ripple reducing capacitors are often termed as smoothing capacitor of $100\mu\text{F}$. This capacitor performs charging and discharging operation and converts the full wave rectified output to a smooth DC output across the resistor.

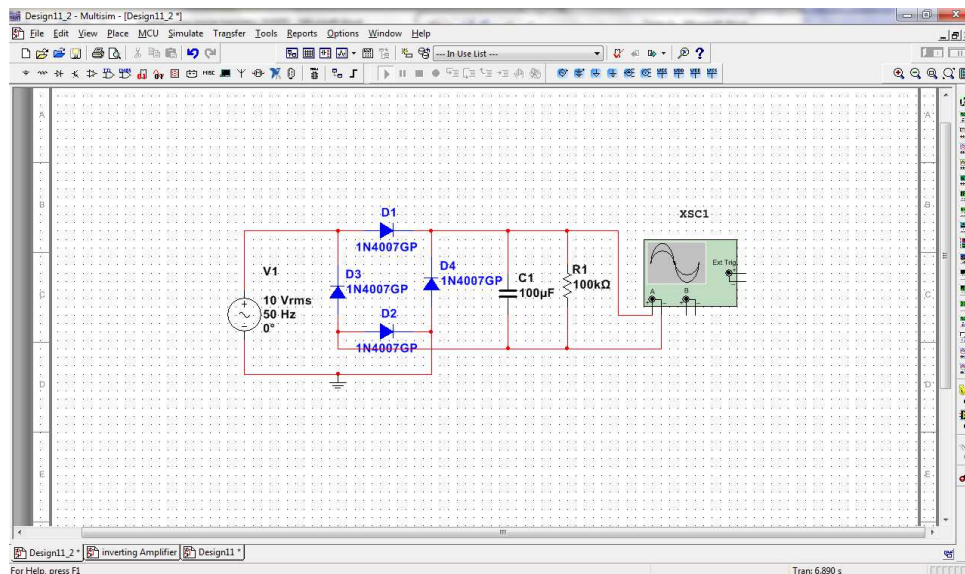


Figure 4: Full wave rectifier using smoothing capacitor

The value of the capacitor shouldn't be very small, otherwise it will not be effective in reducing the ripple to the required extent.

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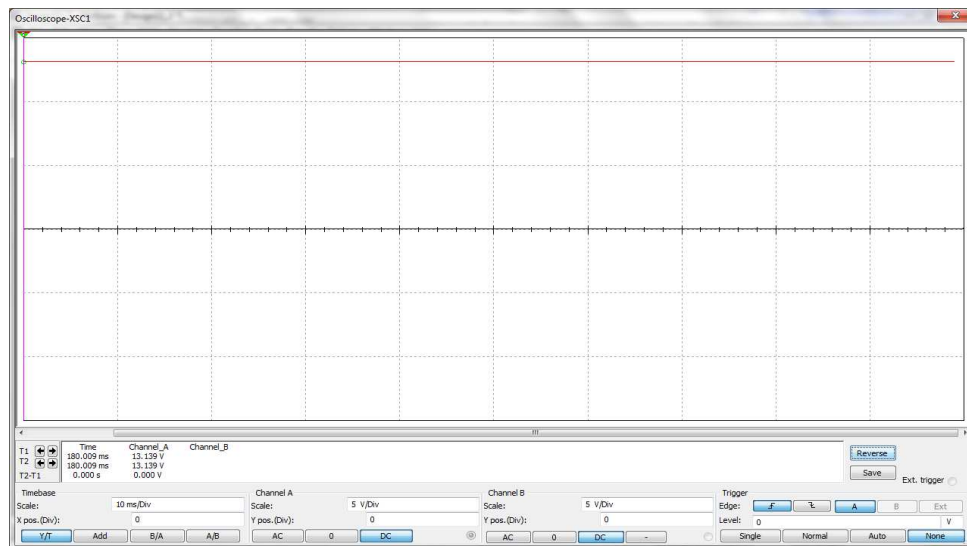


Figure 5: Output waveform of full wave rectifier using smoothing capacitor

THE INVERTER CIRCUIT

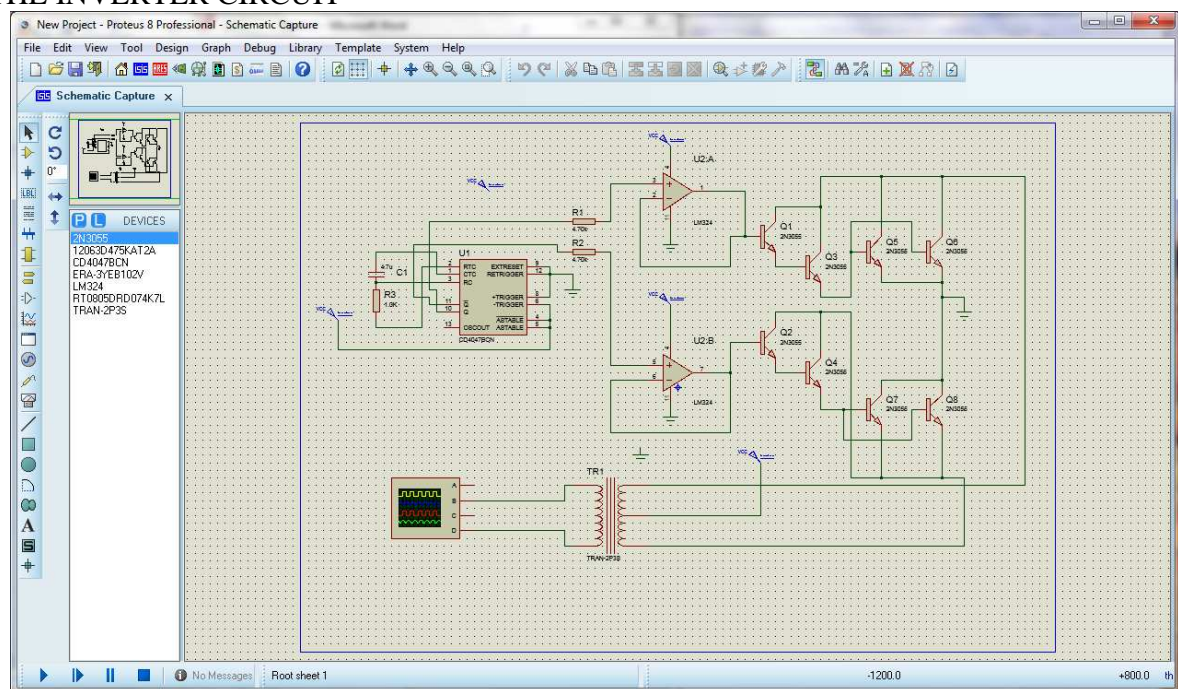


Fig. 6: The CD4047 inverter circuit in proteus 8.0



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Using this circuit you can convert the 12V dc in to the 220V Ac. In this circuit 4047 is use to generate the square wave of 50Hz and amplify the current and then amplify the voltage by using the step transformer.

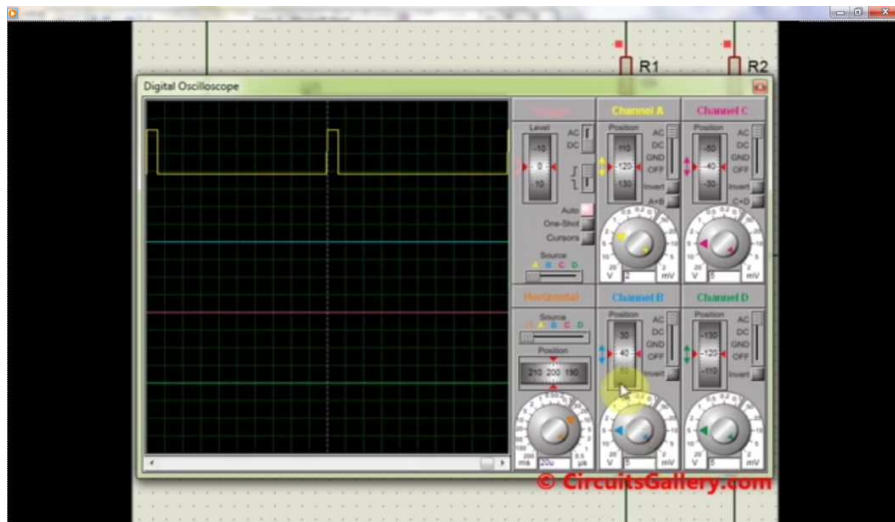


Fig. 7: The inverter circuit output waveform in proteus 8.0

As can be seen from Figure 7, it is observe that the output wave form is a square wave. The IC CD4047 used in this design is an Astable/Monostable Multivibrator and is one of the most renowned multivibrator in the industry. One of the benefits of the 4047 is being able to do so as well, but with fewer external components. Here is the pinout diagram for a 4047:

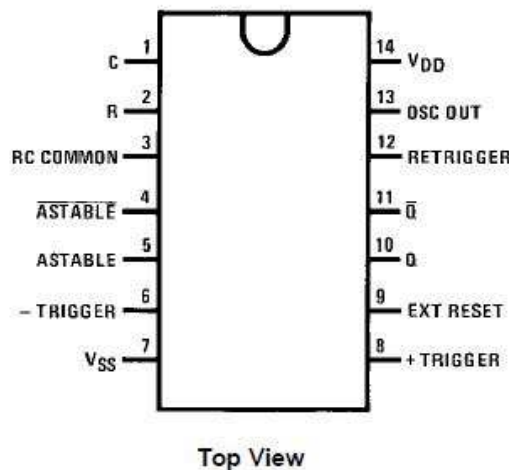


Fig. 8: Diagram of a 4047 Multivibrator

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Note that there are three outputs, Q, \bar{Q} and OSC out. Q is the normal output, \bar{Q} is the inverse of Q – that is if Q is high, \bar{Q} is low – at the same frequency. OSC output provides a signal that is very close to twice the frequency of Q.

The oscillations can be activated in two ways, via a high signal into pin 5 (pin 4 must then be low) or via a low signal into pin 4 (and pin 5 must be low). Setting pin 9 high will reset the oscillator, so Q is low and \bar{Q} is high. The 4047 offers a simple and cheap way to generate a 50% duty cycle square wave or use as a monostable timer. The cost is low and the part is easy to source.

Table 1: Measurement and testing of the inverter system

Measurement	Specified Value	Achieved Value
Output Voltage	220V	220V
Output Power	500VA	495.5VA
Frequency	50Hz	50Hz
Waveform	Square wave	Square wave

The Inverter Installation Diagram

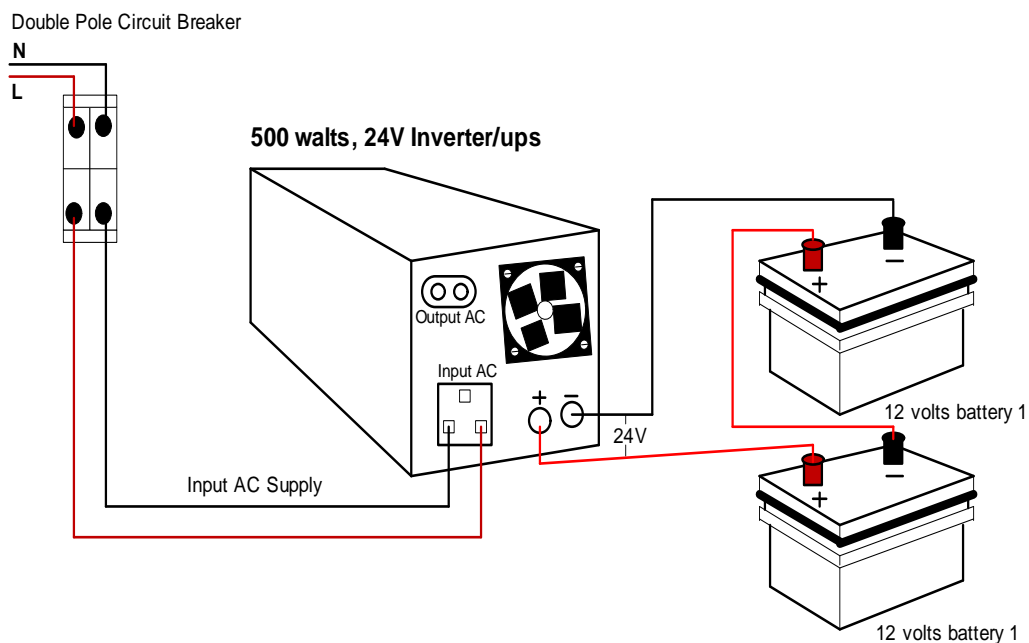


Fig. 9: 24 Volts Inverter battery connection diagram

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CONCLUSION

The design of the electrical inverter was achieved and successfully constructed despite a lot of assumptions and approximations made in the design. The circuit design was able to convert the 12V DC supply from the deep cycle batteries to 220V alternating current. It is to be noted that the efficiency of this project depends on the power rating of the connected batteries and on the total load rating. Thus, the inverter could deliver constant power for a calculated number of hours.

We believe to the best of our knowledge that this design had expose some technical content of designing an electrical inverter, if desired, the same approach can be applied in designing inverter with a better output like the pure sine wave 220V-240V inverter system.

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